Ceatech Hawaii Marine
Shrimp Farm

STATE OF HAWAII

DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION
3060 EIWA STREET, RM. #306
LIHUE, HAWAII 96766

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
LAND DIVISION
STATE PARKS
WATER RESOURCE MANAGEMENT

January 16, 1998

KD-97:0383

Gary Gill, Director
Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu, Hawaii 96813

Subject: *Finding of No Significant Impact for CEATECH USA, INC., Kekaha, Waimea, Kauai, TMK 1-2-2: por. 1*

Dear Mr. Gill:

Having reviewed the comments received on the draft environmental assessment for CEATECH USA, INC., located at Kekaha, Waimea, Kauai, Tax Map key 1-2-2: por. 1, during the thirty day review period which began on October 23, 1997, the Department of Land and Natural Resources, Land Division has determined that this project will have no significant environmental effect and with this letter, issues a finding of no-significant impact.

It is requested that you publish notice of this determination in the **February 8, 1998** issue of the Environmental Notice.

Enclosed is a completed Bulletin publication form and four copies of the final environmental assessment. Please call Michael Laureta at 274-3491 if there are any questions.

Sincerely,

SAM LEE
Kauai District Land Agent

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Encl
c: Dean Uchida, Land Division Administrator
Lynn McCrory, Kauai Land Board Member
Gil Coloma-Agaran, Deputy
Roland Sagum
Ernest Dias

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1998-02-08-KA-FEA - Ceatech
Hawaii Marine Shrimp Farm

FINAL

ENVIRONMENTAL ASSESSMENT

for

CEATECH USA, INC.

TMK: (4) 1-2-02 : por 1
Kekaha, Waimea, Kauai, Hawaii

Submitted by:
Applied Planning Services
P.O. Box 1724
Lihue, Kauai, Hawaii 96766

For:
CEATECH USA, INC.
7 Waterfront Plaza, Suite 400
500 Ala Moana Boulevard
Honolulu, Hawaii 96813

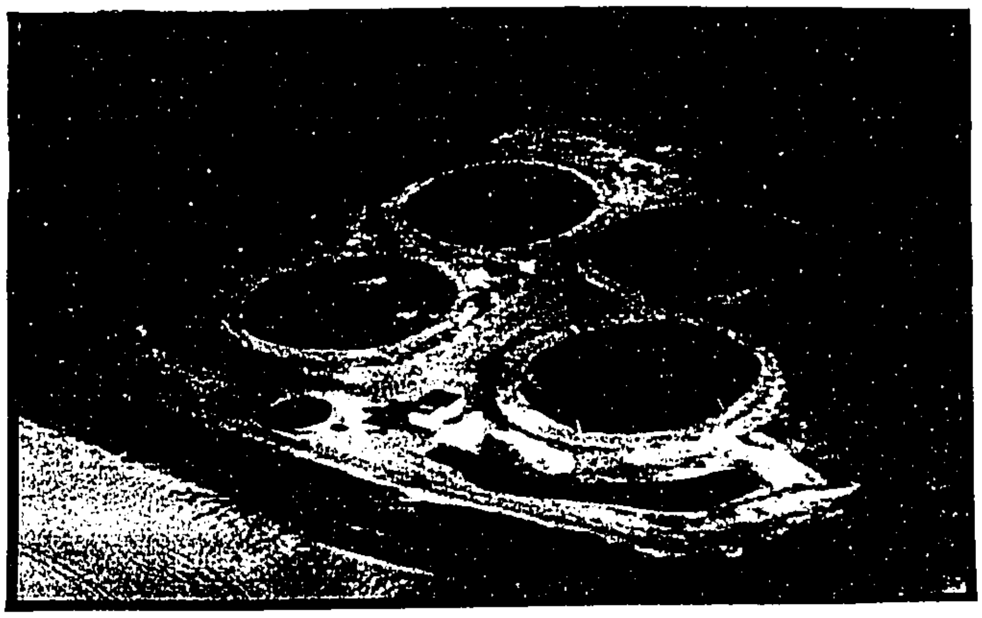
January 1998

FINAL

ENVIRONMENTAL ASSESSMENT

for

CEATECH USA, INC.



CEATECH USA, INC.
7 Waterfront Plaza, Suite 400
500 Ala Moana Boulevard
Honolulu, Hawaii 96813

January 1998

REPORT DOCUMENTATION PAGE

TITLE of PROPOSED ACTION:	CEATECH USA, INC.
DISTRICT:	Kekaha, Waimea, Kauai
TAX MAP KEY:	(4) 1-2-02 : Por. 1
APPLICANT:	CEATECH USA, INC. 7 Waterfront Plaza, Suite 400 500 Ala Moana Boulevard Honolulu, Hawaii 96813 CONTACT: PAUL BIENFANG ERNIE DIAS 808-521-1801
APPROVING AGENCY:	State of Hawaii Department of Land and Natural Resources - Division of Land Management 3060 Eiwa Street, Room 306 Lihue, Hawaii 96766 CONTACT: SAM LEE MICHAEL LAURETA 808-274-3491
CONSULTANT:	Applied Planning Services P.O. Box 1724 Lihue, Hawaii 96766 CONTACT: ROLAND D. SAGUM III 808-246-0399
DEADLINE:	January 1998

ABSTRACT:

CEATECH USA, INC. is proposing to construct and operate a marine shrimp farm on 300 acres of State owned lands. The proposed action consists of 104 lined circular ponds, interior access roads, drainage ditches, brackish groundwater supply wells, retention basins, and accessory structures.

The project is necessary to maintain the integrity of the agricultural infrastructure which drains the Mana plains, to upgrade current discharge filtration mechanisms, and to improve the economic climate of the westside of the island.

That facility will produce 4 million pounds of shrimp annually, which represents just a fraction of the 2.5 billion dollars imported into the U.S. from other countries. Export markets have been organized on the U.S. mainland where 80 % of the total gross harvest is expected to be marketed.

This Final Environmental Assessment (FEA) report for CEATECH USA, Inc. was prepared in accordance with State of Hawaii Environmental Quality Control laws. These include Chapter 343 Hawaii Revised Statutes (HRS), Chapter 200 of Title 11, Hawaii Administrative Rules and the National Environmental Policy Act (NEPA).

This preparation of an EA is a statutory requirement prior to or in anticipation of a general land lease assignment with the State of Hawaii. Its purpose is to assess the environmental impacts that a project may have, should the action be implemented, and to serve as a clearinghouse for collection and dissemination of information. This review process is also a mechanism to evaluate a project's consistency and compliance with State and Federal environmental programs and to propose where possible, appropriate mitigation measures.

The environmental review for CEATECH USA, Inc. consists of a Draft EA (DEA) followed by a Final Report (FEA). The DEA was released for public and agency review in November 1997 and published in the OEQC's "The Environmental Notice", which is a semi-monthly bulletin of the Office of Environmental Quality Control (OEQC). Comments received during the course of the 30-day review period have been incorporated into the Final EA report along with agency correspondence and mitigation measures. The Final EA is set for release in January 1998.

The proposed action is to operate a marine shrimp mariculture facility consisting of nursery ponds, grow-out ponds, saltwater wells, hatchery facility, drainage system, waste recovery basins, and appurtenant accessory uses. The project lands, situated in Kekaha, Waimea, Kauai are owned by the State of Hawaii. The two areas of interest, relative to project impacts, are waste management and maintenance of a disease-free environment. In each instance, appropriate mitigation measures have been identified and have been incorporated into the development plan. For example, a double plumbed waste transport system will allow for collection of the heavier particulate wastes independently from the high volume, aqueous fraction. This mitigation feature is without precedent in commercial aquaculture, and significantly increases effectiveness of the settling basins, and reduces the discharge of wates to the environment which are the centerpiece of the waste treatment system. Aquaculture effluent will be directed to a series of collection basins where it will be naturally aerated, desalted and dessicated. This nutrient rich matter will be collected separately for recyling as a soil amendment or other farm product. The ocean environment affronting the Mana Plain has naturally high advective forces and open coastal character which give the environment a high flushing potential and a low sensitivity to aquaculture discharges. Studies indicate that the adjacent marine biological communities show no indication of deleterious effect to decades of land based discharge. The project includes numerous mitigation measures to minimize waste discharges. These include aspects of farm design, management practices, and best available waste treatment technologies.

Disease prophylaxis is pursued through: (a) the exclusive use of high-health seed-stock from the Company's hatchery, (b) adherence to rigerous quarantine and biosecurity procedures, and (c) continuous application of the Company's pathological surveillance and (d) animal health management program. The proper handling and disposal of waste products, continuous water quality monitoring, and the release into an open, extremely well flushed coastline which has received agriculture effluents for decades without adverse consequence assure the maintenance of a sound oceanic environment.

Based on all available scientific data, industry standards, and mitigation measures presented in the EA, and further supported with extensive experience by the farm operators, it has been shown that the proposal will not have a significant impact on the environment, and therefore it can now be determined that a Findings of No Significant Impact (FONSI) is justified and appropriate.

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SECTION 1.0

PROGRAM OVERVIEW

SECTION 1 : PROGRAM OVERVIEW

1.0 DESCRIPTION of PROPOSED ACTION and ALTERNATIVE

The following section describes the background, purpose and need for the proposed action, and alternatives - including the no-action alternative.

1.1 BACKGROUND

Aquaculture and mariculture are not new or unusual farming concepts in Hawaii, having been practiced here for approximately 600 years. Early Hawaiians carefully constructed coastal and riverine fishponds as a means to insure resource conservation. The "Hawaiian Fishpond Study", by DHM Inc. in 1989, identified eleven (11) sites in the Kona (Waimea) District and a total of thirty (30) island wide (Exhibit A). It is estimated that nearly 360 fishponds existed in the Islands prior to the arrival of Captain Cook in 1778.

Animal and plant aquaculture are regarded as farming methods with potential to substantially increase the world's food supplies. Aquaculture has the potential of farming multiple crops within the 3-dimensional farm, and can represent an efficient use of materials, labor and energy. In contrast to traditional land-based agriculture, aquaculture is less sensitive to climatic changes, such as temperature, drought and flooding. According to June 1997 edition of the Hawaii Magazine, an estimated 200 active aquaculture farms, ranging in farm size and aquatic product, currently exist within the State.

In 1987, the Kauai Economic Development Board (KEDB) prepared a feasibility study entitled "Kauai Ocean Science and Marine Center" (KOSMC). The KOSMC report cites the potential success of a marine shrimp facility on the island. The vision for shrimp farming as a new industry for Kauai is now 10 years old!

In 1993, Sunkiss Shrimp Company (SSC) received its regulatory permit approvals to construct and operate Kauai's first modern marine shrimp facility. SSC is situated on State owned land (TMK: 1-2-2:22), previously leased to AMFAC Sugar (Exhibit B). The site is more commonly referred to, by the locals, as the Radio Noise Control Site which was operated by the

Federal Government during World War II. The five (5) acre site consists of four (4) 1/4-acre lined ponds, a brackish water well, a feed storage building, and associated piping and utilities. SMA and zoning permits (Exhibit C) have been issued by the Kauai Planning Department to construct a 40'X120' hatchery building, a 40'X40' equipment building and a 15'X15' storage building. The building permits for these buildings have been issued by the Building Division of Public Works (Exhibit D).

In 1996, SSC joined forces with CEATECH USA, Inc., with CEATECH USA, Inc. acquiring all of the outstanding stock of SSC in March 1997. CEATECH USA, Inc. organized and incorporated the following wholly owned Hawaiian subsidiary corporations in 1996; CEATECH HHGI Breeding Corp., CEATECH Plantations, Inc., Hawaii High Health Seafood Corp., Sunkiss Shrimp Co. Ltd.

CEATECH HHGI Breeding Corp. will function as the breeding center and broodstock repository responsible for animal maturation, and the production of seed for company growout operations. CEATECH Plantations, Inc. includes shrimp growout facilities, production and harvest of shrimp for processing and sales. Hawaii High Health Seafood Corp. will be responsible for the packing and/or processing, distribution and marketing of whole shrimp and value added shrimp products.

The management of CEATECH USA, Inc. intends to concentrate on two major aspects of their overall business objective: (a) The development of a state-of-the-art shrimp growing agri-business; and (b) The breeding and production of high health, genetically improved shrimp seed primarily for use in its own growing operations, and potentially the sale of surplus seed to other independent growers.

1.2 AQUACULTURE AND HAWAII

The State of Hawaii has actively promoted aquaculture industry development. In the 1970's an Aquaculture Development Program was established within the Department of Land & Natural Resources. Via publication of "Aquaculture Development in Hawaii" in 1978, Hawaii became the first in the nation to formalize its strategies in support of this form of diversified agriculture. The former governor described aquaculture as "a global growth industry ... anchored in traditional practices and rocketed to higher levels of performance by new technologies." The State's support is rooted in the conviction that the benefits of aquaculture will significantly contribute to the economic, social and environmental well-being of the people of Hawaii. Hawaii is a sophisticated seafood market with per capita consumption of more than three times the national average, and two departments within the State of Hawaii which actively promote the sale of Hawaiian seafood outside the state (Aquaculture Development Program in DLNR, and the Marine Resources Division of DBEDT).

Governmental encouragement is set on converting Hawaii's isolation, and high level of resident technical expertise into business advantage. Year-round production potential, isolation from other shrimp farming operations, global demand for high-health shrimp, and proximity to both U.S. and Asian markets are competitive advantages advanced by the state. The annual report by the Governor's Aquaculture Advisory Council described 1996 as the first year that the dollar value of the production segment of Hawaii's dual sector industry surpassed the technology development/transfer segment. A supportive political administration, together with increasing willingness to diversify traditional sugar lands into aquaculture production point toward continued aquaculture growth in coming years. This mirrors the support for the CEATECH USA, Inc. project in particular by the Kauai County government. The 18% increase in Hawaii's aquaculture industry for 1996 paralleled that for the nation.

The growth of controlled environment aquaculture in the State of Hawaii can mitigate economic losses to Hawaii's agri-economy, which has resulted in substantially increased unemployment and serious loss of revenue to the state and its citizens. The declining acreage being utilized in the production of sugar cane actually offers some extraordinary opportunities. Sugar cane plantations not now being fully planted and utilized have traditionally shown an average cash yield per acre over a 24-month period of 12 tons, or a total cash crop of $2,200 per acre per year. These properties are ideally suited and could be converted rapidly and cost effectively, utilizing existing infrastructure, water and drainage supply systems.

Approximately $2.5 billion of the U.S. trade deficit is from the importation of shrimp from foreign sources. Those sources will not easily change to environmentally sound practices or the utilization of high health standards.

A major portion of the state-of-the-art technology in shrimp aquaculture was developed in Hawaii. Hawaiian aquaculturists have achieved worldwide recognition in their field at a time when there is a great need for alternate "crops" to replace the rapidly declining sugar and pineapple agri-business.

1.3 CEATECH PERSONNEL

A distinguishing feature of the CEATECH USA, Inc. project team is that it contains the mix of diverse talents which are needed to start and sustain an aquaculture enterprise. Brief resumes of the directors, officers, and key technical personnel (Appendix 1) show individuals with capabilities in finance, starting developmental stage companies, managing publicly traded companies, shrimp aquaculture, marketing, aquaculture engineering, securities law, environmental science and local land use conditions. The team consists primarily of local residents with deep roots in the Hawaiian community. The prototype operation at the Sunkiss facility was initiated by residents with extensive family histories in the Kekaha community. The design of CEATECH USA, Inc.'s shrimp farming system is centered around the responsibility to preserve and sustain the surrounding natural environment.

The project takes advantage of the heavy investment in advanced shrimp technologies which was made available through the U.S. Marine Shrimp Farming Program. This effort, supported through the U.S. Department of Agriculture, has expended more than $35 million for the research and development essential to establishing profitable and sustainable shrimp farming in the United States. Most of the key technical, management and operating personnel played important roles in that work which was largely developed in Hawaii. The urgency of the corporate plan acknowledges the profound societal implications to rural Hawaii of the impending passing of the sugar industry, and the imposing need to secure replacements for that economic driver. Key personnel of CEATECH USA, Inc. managed and directed the construction and training for the largest aquaculture hatchery and growout facility ever financed by the World Bank.

The company has a Board of Technical Advisors which includes leading experts from a range of disciplines in general aquaculture, shrimp pathology, environmental science, high health shrimp breeding and production systems, aquatic feeds, and environmental policy. These Board members are resources to assist in the design and solution of various challenges in shrimp aquaculture, waste disposal and environmental compatibility.

1.4 PROPOSED ACTION

The Applicant proposes to acquire approximately 300 acres of State land to construct and operate a *state-of-the-art marine shrimp farm* on the Kekaha Plains. The site improvements consist of 104 1-acre lined circular ponds, interior service roads, utilities, seawater wells, underground plumbing, drainage ditches, and retention basins for waste recovery. Several accessory buildings will be constructed to accommodate supplies, equipment, and personnel.

1.4.1 LOCATION

The subject property is located on the west-side of the island of Kauai, along the coastal plains of Mana in the Ahupua'a of Kekaha. The property is more specifically located along the makai side of Kaumuali'i Highway, bordered between Kawaiele Sanctuary to the south, PMRF to the west, and Kekaha Sugar Company fields to the north. This land, further identified as Tax Map Key (4) 1-2-02 : Por. 1 was previously been leased to AMFAC (Kekaha Sugar Company) for its sugar cane operations and is currently fallow (Exhibit E) . The specific area is identified as Kekaha Sugar Company field lot numbers 316, 419, and the portions of lots 420 and 421 which are makai of the highway (Exhibit F). AMFAC has expressed their willingness to cooperate in having these lands removed from consideration for renewal of their lease with the state.

1.4.2 DESIGN

Exhaustive analysis of aquaculture, infrastructural and marketing considerations have concluded that the economically feasible business unit for this facility requires approximately 104 one-acre growout ponds, 12 one-half acre nursery ponds and appurtenant support infrastructure (Exhibit G). Pond geometry and layout constraints indicate that approximately 300 acres are necessary to accommodate this production unit.

Pond design consists of a circular depression surrounded by an earthen berm. Each pond will have a volume of 1.3 million gallons, and a turnover rate of 25 - 40% per day, amounting to a continuous flow of 230 - 360 gpm/pond. A section of the berm typically finds a

32' wide base along the bottom with a 8' wide strip at the top. This design facilitates a 2 :1 slope at the backside and a more gradual taper in the interior (Exhibit H). Each pond bottom will be lined using a rubberized poly-fabric called high density polyethylene The liner will be attached at the pond bottom with reinforced concrete and "tucked" into the top of the earthen berm. This system directs the settled biosolids to the center, where a 16" floor drain is employed to allow easy removal of this sediment for deposit into a reinforced cement collection basin.

1.4.3 CONSTRUCTION

Each of the production ponds will be excavated and formed in the soil-sand substrate. A heavy 25-mil ultraviolet resistant High Density Poly Ethylene (HDPE) fabric will line the bottom of the pond to prevent water loss to percolation, prevent pond contamination from subsurface sources, and to maintain balance to the soil substrate.

1.4.4 ACTIVITY SEQUENCE

Environmental Review

- Submittal of DEA
- Archaeological Report Approved by SHPD
- Submittal of FEA
- FONSI Notice received

Permitting

- Request to BLNR for Right-of-Entry
- Submit Service Application to Kauai Electric
- Well Drilling Permits
- Grading Permit from National Resource Conservation Service
- Obtain Aquaculture Permit from DLNR
- Submit NPDES Permit Application
- Submit Antidegradation Analysis Application
- Submit Zone of Mixing Application
- Zoning Permit
- Submit Building Permit Request

- BLNR withdraws lands for CEATECH USA, Inc.
- Receive General Lease from BLNR
- Issuance of NPDES Permit

Construction

- On-site construction begins
- Property survey completed
- Erosion Control Plan initiated
- Grubbing begins
- Well # 1 drilled
- U/G plumbing installation started
- Flood control berm construction completed
- Pond construction begins
  - Nursery
  - Growout
- Farm fencing/landscaping begins
- Well # 2 drilled
- Well # 3 drilled
- Construct roads
- Install utilities
- Construction of storage sheds completed
- Well #4 drilled
- Construction of pond #104 completed

Operations

- Hiring of new farm staff begins
- Nursery ponds received first stocking
- First nursery ponds harvested
- First 6 growout ponds stocked
- First 6 growout ponds harvested

1.4.5 OPERATIONS

Each of the one-acre growout ponds will produce approximately 40,000 pounds of shrimp per year from 3 fourteen-week growout cycles. Overlapping cycles of nursery ponds, growout ponds and harvesting schedules allows for the continuous, weekly marketing of product.

The company will maintain specific pathogen free shrimp broodstock. These will be used to provide high health, genetically improved shrimp "seed" to stock its shrimp growout operations. Although its principal efforts will be in the growing, processing, and marketing of its shrimp products, excess high health seed from its hatchery may be sold to commercial growers worldwide.

The intensive production protocols to be used result in a much greater efficiency of feed, land, and water use than the style of shrimp farming applied elsewhere. This production technology has substantially better feed conversion ratios than other farming systems. The feed conversion ratio also reflects the amount of uneaten feed which is potentially contributed to the waste pool; better feed conversion ratio therefore reflects also lower waste additions. The land and water use in intensive production systems is intrinsically conservative of these resources. Comparisons indicate that a pound of shrimp produced in this system will require only 10 - 20% of the land and/or water which would be needed by shrimp farming operations as practiced elsewhere.

By relying exclusively on a controlled hatchery system to provide seed animals for its shrimp farming operations, this system avoids any large scale harvesting of native shrimp populations to stock ponds. The feeding protocols avoid any use of highly polluting feeds such as trash fish, or macerated marine animals. The production operation uses no bioactive compounds such as pesticides, antibiotics, fertilizers, or growth hormones. Surface skimmers on each pond both collect an remove any buoyant plant material prior to discharge. Design of the discharge infrastructure also includes screens at multiple locations to prevent escape of animals to the environment. At the Mana location in particular, the effluent also will have to pass through a ditch system which is populated with carnivorous fish; this further reduces any probability that farmed animals would survive to reach the ocean. The approach for reducing the risk of an accidental release of aquaculture organisms and/or associated pathogens into the environment follows the Code of Practice developed by the International Council for the Exploration of the Seas (ICES). This protocol, which relies on rigorous quarantine procedures utilizing first generation progeny, is one of the three widely adopted approaches for avoiding harmful introductions in use around the world.

The exclusive use of high-health animals reduces risk of any contamination to the surrounding environment. All of the shrimp stocks to be used are derived from specific pathogen free populations originating from the U.S. Marine Shrimp Farming Program, supported by the United States Department of Agriculture. These stocks, maintained in captivity for over six generations, have repeatedly been screened by a variety of diagnostic techniques and shown to be free of specific shrimp pathogens of interest. The Company's animal health management system includes a surveillance program, as well as biosecurity protocols. The nation's foremost authority on shrimp pathology will oversee the appropriate application of diagnostic protocols. The design of both the hatchery and production facilities includes numerous features to prevent any transmission of shrimp pathogens between the farm and the environment in either direction.

1.5 PURPOSE and NEED for the ACTION

The project will provide substantial economic development and much needed employment within the diversified agriculture sector. The project relies on climatic and technological features where Hawaii has comparative advantage over other locales. The project takes advantage of an extensive, USDA supported R & D Program which developed and verified advanced shrimp farming technologies for profitable and sustainable farming in the U.S.

This aquafarming effort takes advantage of the availability of land, labor, isolation, and warm climate to produce large amounts of a high value commodity traditionally associated with terrestrial activities, while retaining the rural character of the community. It will compliment and augment current farming in the area, and holds the potential to expand in importance in the future, and provide additional economic stimulus through a primary industry based on existing resources.

The proposed farm will produce 4 million pounds of shrimp annually. Initially, about 80% of this product will be exported to the large U.S. market. For years, shrimp has remained the preferred seafood commodity throughout all regions of the United States. Americans consume over 850 million pounds of shrimp annually, 75% of which is imported. Shrimp is consistently the largest element of the U.S. trade deficit in seafood. In 1996, shrimp imports ($2.5 billion) accounted for 36% of all U.S. seafood imports. The National Fisheries Institute estimates that with the value added by processing marketing, distribution, and servicing, shrimp accounts for more than $10 billion in U.S. consumer spending annually.

Most of this U.S. demand has been met by shrimp which have been aquacultured outside the U.S. The financial success which has historically been enjoyed by foreign aquaculturists, has been tempered by the consequences of unsophisticated breeding and production practices, and impending changes to regulations for the importation of seafood. Collectively, these changes mark major market opportunities for domestic shrimp producers which can reliably supply large quantities of high quality product.

Modern agri-business, such as CEATECH USA, Inc.'s controlled environment shrimp aquaculture, can substantially mitigate the economic losses to Hawaii's slipping economy, and the associated loss of employment tax revenues. Sugar has traditionally shown an average cash yield per acre of approximately $2,200 per acre per year. The proven annual yield of high health shrimp in the area is equivalent to $250,000 per pond per year. Therefore, alternate uses of Hawaii's agriculture lands, quickly becoming fallow due to the progressive changes in the sugarcane market, need to be pursued.

The direct benefits to the community arising from the proposed CEATECH, USA, Inc. program include:

- Long-term protection of prime agricultural lands from being fragmented through subdivision or other sub-platting methods which reduce Hawaii's capacity for future farming opportunities.

- Long-term protection of the existing drainage infrastructure, consisting of ditches, culverts and pumps, which maintain the lower groundwater level and allows the plains to be farmed by the numerous users.

- Reduction of fugitive dust and other erosionary nuisances associated with intensive agriculture.

- Supporting the many goals of the Waimea-Kekaha Regional Development Plan by "creating a new opportunity for a greater diversity of employment", and "to promote the improvement and expansion of the region's economy, by recognizing and carefully utilizing land and water resources".

- Maintaining the "agricultural dedication" designation of the lands through active, responsible and profitable agriculture activities, yet provide greater revenue returns to the State and County governments.

- Does not place further burdens on the precarious and controversial source, storage and transmission of irrigation water, since the vast majority of water requirements are from the salt water aquifer underground.

1.6 ALTERNATIVE CONSIDERED but not CARRIED FORWARD

The main criteria in proper site selection for aquaculture include climate, land use zoning, infrastructure, oceanographic conditions of the receiving coastal waters, and projected pond development costs. Climatic considerations generally restrict shrimp farming sites to the warmer, leeward coasts. Several areas within the Kona and Kohala coasts were considered and dismissed due to zoning conflicts, and high farm development costs of working with lava substrate; areas within NELH are reserved for anticipated expansion by current tenants. Sites along the leeward coast of Molokai were considered and dismissed due to limitations of transportation infrastructure to move the shrimp quantities being projected, availability of farm labor pool, and the restricted flushing characteristics of the nearshore ocean environment. Other locations on Kauai were dismissed for reasons of climate, land availability, and inappropriate nearshore ocean characteristics. On Oahu, the Kahuku site was not considered because of the climate and historical use, and no appropriate sites were available in the Waianae region.

1.7 NO-ACTION ALTERNATIVE

There's no doubt that the project offers the island some hope of financial relief from the current economic doldrums, as there are no other industry, other than tourism, which can offer near term results. Failure to implement the CEATECH USA, Inc. masterplan would result in the area being left fallow since Kekaha Sugar Company has determined these fields to have poor sugar cane productivity due to the high water table. As a result, the State will lose lease land revenue, creating pressures to subdivide these larger parcels into smaller lots. It has always been a concern by planning officials that fragmentation of our larger agricultural parcels will lead to a serious loss of future agricultural potential for the island and the state as a whole. This is currently evident, as many of the larger private land owners, AMFAC Land Company, LTD., Grove Farm Company, and McBryde Sugar Company have been forced to engaged in licensing smaller "parcels" in order to maintain the "agricultural dedication" which allows it to be taxed by the County at a lower rate. Licensing is also necessary to generate rental revenues loss by the reduction or elimination of sugar cane.

Failure to implement this plan will mean that PMRF will continue to be largest employer, but to only highly technical persons. The ever possibility of military base cuts could leave the westside economically devastated if the State and County fail to recognize the need to diversity the economic foundation here. Jobs will be lost as sugar downsizes and other agricultural entities cannot expand, and new ones cannot become rooted.

In short, CEATECH USA Inc. represents the highest and best use for this land.

1.8 REQUIRED ACTIONS

In the preparation of this report, numerous government agencies were interviewed to gain a perspective on their regulatory responsibility and impact on the proposed project. A written response from the Kauai Planning Department confirms the determination that a subdivision application is not a procedural requirement for the reassignment of a lease (Exhibit I).
The property has clear and verifiable boundaries sine it bound by the Kauai Agricultural Park (TMK: 1-02:1), PMRF, Kawaiele Sanctuary, and Kaumualii Highway. Pursuant to Sec. 8-7.2 KCC, (2) Aquaculture, (3) Diversified Agriculture, and (9) Minor Food Processing related to agricultural products, all outright permitted activities and therefore do not require a conditional Use Permit. However, the following permits and regulatory actions are necessary:

- CLASS III ZONING PERMIT

  Chapter 8, Kauai County Code (KCC) entitled the Comprehensive Zoning Ordinance (CZO).
  A zoning permit is required prior to any construction or development or any activity or use which requires a Building Permit.

- BUILDING PERMIT

  Chapters 12, 13, and 14, Kauai County Code.
  Building permits are required for all construction which involve structural, plumbing and electrical improvements.

- NATURAL RESOURCE CONSERVATION SERVICE (NCRS) CONSERVATION PLAN

  Agricultural grading and grubbing is regulated with assistance from the U.S. Department of Agriculture, Natural Resource Conservation Service.

- WELL CONSTRUCTION PERMIT
  PUMP INSTALLATION PERMIT

  Section 13-168, DLNR Administrative Rules Department of Land & Natural Resources, Commission on Water Resource Management.

- NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT

  Clean Water Act of 1977, and Chapter 342, Part III, Hawaii Revised Statutes (HRS) State of Hawaii, Department of Health.
  The NPDES permit system is designed to regulate the discharge of wastewaters from known points sources into surface waters.

SECTION 2.0

PHYSICAL ENVIRONMENT

SECTION 2 : PHYSICAL ENVIRONMENT

"Greater Efficiency Means Less Waste & A Cleaner Environment"

CEATECH USA, INC.

2.0 OVERVIEW

This section describes the affected physical environment, discusses the significance of potential environmental consequences of the proposed action and identifies appropriate mitigation measures. Consequences or impacts are categorized as not significant, significant but mitigable, or potentially significant.

2.1 CLIMATE

A. Existing Setting

Winds generally blow offshore of this leeward coast. Prevailing NE tradewinds are typical, and are generally strongest in the summer. During calm weather a diurnal land-sea breeze cycle, typical of coastal locations, often occurs. Strong winds, associated with low pressure systems (Kona storms) may occur occasionally during winter months. The climate is typified by high temperatures, high solar radiation, low cloud cover, and low rainfall. The Mana Plain is considered one of the warmer and sunnier and drier areas of the State, having an average temperature of 78 degrees F, and average daily insulation which is 90% of the highest insulation anywhere in Hawaii, and an average rainfall of less than 15 inches annually. The State Aquaculture Master Plan identified the Mana Plain as having optimal climatic conditions for aquaculture development in Hawaii.

B. Consequence - NOT SIGNIFICANT

No negative impacts are anticipated.

C. Mitigation

No mitigation measures are proposed here.

2.2 GEOLOGY and SOILS

A. Existing Setting

Kauai is the oldest of the eight major Hawaiian Islands. Together with Niihau they comprise the County of Kauai. Kauai covers approximately 552.3 squares miles, and Niihau , Lehua and Kaula contains 69.5, 0.444 and 0.247 square miles respectively. The highest point is at Kawaikini which is 5,243 feet, followed by Waialeale at 5,148 feet high.

Kauai initially began it existence as a shield volcano, the soils of which are referred to as the Waimea Volcanic Series. This Volcanic Series can be further classified into the Napali, Olokele, Haupu, and the Makaweli formations. Later the Koloa flows began, followed by the Palikea Formation.

The project area is typical of the nearshore environment of the westside of Kauai. The subject properties are located in an area characterized as a low-lying coastal plain consisting of alluvium, and lagoon deposits. The topography is flat, and well drained, and soils have little erosion hazard. The area has been plowed, planted, leveled and graded throughout its agricultural history. Subsurface conditions are stable and surface soils have been flattened and stabilized by agricultural ground cover. According to the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) Soil Survey for the Island of Kauai (Exhibit J), the Kekaha soils within the Mana coastal plain are silty clays (KoA and KoB types), and Jaucus loamy fine sand. These soils are mildly alkaline to neutral, at least 60 inches thick, and have moderate permeability.

B. Consequence - NOT SIGNIFICANT

The creation of ponds for this aquafarming project will occur in areas historically disturbed by sugarcane cultivation. The ponds will be excavated to a depth similar to that achieved by plantation plowing. Short-term impacts are expected relating to soil erosion and fugitive dust dispersions associated with the construction activities. No long-term impacts are anticipated.

C. Mitigation

All earth disturbing activities will be coordinated the U.S. Department of Agriculture, Natural Resource Conservation Service programs to protect the land from natural erosionary forces and to insure compliance with State and Federal Air and Water quality programs. Water trucks, hoses and sprinklers are necessary to mitigate dust and to insure proper soil compaction.

2.3 AIR QUALITY

A. Existing Setting

The climate and weather patterns generally influence the dispersion of air pollutants from uses in adjacent areas, and thus affect the air quality of an area. The air quality in the project vicinity is generally excellent. The prime sources of air emission comes from the practice of sugarcane burning; other less prominent emission sources occasionally include diesel generators, aircraft, and vehicular traffic.

B. Consequence - NOT SIGNIFICANT

During construction, emissions of fugitive dust from short-term construction and miscellaneous aquaculture-support activities may slightly degrade local air quality; impacts are expected to be negligible, temporary, and insignificant since there are no residential settlements near this area. The termination of open burning activities in these fields would have certainly improved the air quality here.

C. Mitigation

Unlike aquaculture, most of the other agriculture operations on the Mana plains require complete crop removal during harvesting time. Sugar cane is burned and the earth deeply tilled. Corn is mechanically removed from the stalks and the remaining organic material is tilled back into the earth. This is not the case with aquaculture. Once the utilities and the ponds are constructed, there will be very little excavation activities - limited to maintenance and repair. Landscaping will limited to erosion control materials. Buffering will in include bouganvillia, dwarf varieties of banana, and ti leaves. During the construction phases, water trucks will be used for dust control and soil compaction.

All internal combustion engines and equipment shall be properly serviced and maintained to reduce the levels of unspent hydrocarbons caused by incomplete combustion.

2.4 BIOLOGICAL RESOURCES

A. Existing Setting

Vegetation in the area is dominated by introduced plants consisting of sugarcane, low scrub (e.g., *Acacia farnesiana, Pluchea symphytifolia, Lantana camara*, and *Prosopis pallida*), and a weedy mixture of grasses (e.g., *Cyodon dactylon, Pennisetum purpureum, Eragrostis tenella, Akmeranthus spinosus, Tridax procumbens, Portulaca pilosa*, and *Chamaesyce birta*). Forty species of birds have been identified in the region. Avifauna in the area (i.e., migratory birds, resident indigenous waterbirds, resident indigenous seabirds, and/or introduced birds) are typical of those inhabiting the drainage ditch habitats throughout the entire Mana Plain, and are abundant throughout Kauai.

B. Consequence - NOT SIGNIFICANT

Implementation of the project will not involve any previously uncultivated land, and is not expected to displace or adversely impact avian, fauna, or botanical resources in the area. The project also will not adversely affect wildlife habitats, sanctuaries, or wetlands. Construction of the aquaculture ponds is restricted to areas previously used by sugarcane.

C. Mitigation

The man-made drainage ditch habitats in the area will continue to be maintained by periodic clearing to prevent overgrowth, and propagation of grasses on the sides to reduce erosion, and augment the removal of nutrients and sediment. The project plans to use lined, round ponds having steep sides; previous experience in the area by Sunkiss Shrimp Co. indicates that this design deters use conflicts with local avifauna. In the event that the effectiveness of this declines over time, the installation of bird nets over the ponds is planned.

2.5 HISTORICAL/CULTURAL RESOURCES

A. Existing Setting

The Mana plain, in general, is one of the most dramatically altered landscapes on the island of Kauai. The project area has under-gone modifications via leveling, grading, plowing, planting, harvesting, terracing for irrigation, and construction of drainage ditches and roads. The project area was previously used for both agriculture and aquaculture purposes. To insure this land use, the area has been designated by the State, and zoned by Kauai County specifically for these purposes.

An archaeological investigation was performed by Scientific Consultant Services (SCS) to determine the presence of historic sites and/or cultural material. Due to the low probability of finding anything significant within the project area, the scope was broadened to include the research of archival information and the conduct and collection of oral history from local informants who lived and worked there. Archival research included a study of references to the project from previously published accounts, an analysis of land records, and a review of the archaeological studies that were conducted in the past. The purpose of this effort is to describe how the project area may have been used by earlier inhabitants, and of how it functioned with the context of the larger ahupua'a.

Archival research confirmed, through early journals (Dixon 1789) that the area was a swamp. Hawaiian traditions also

refer to its swampy condition (Pukui 1983). No claims were recorded during the Mahele for lands. Supplanted by waters from springs, rice was grown in certain section of the Mana and Kawaiele ponds at the same time as cane. Sugar cane took over when the leases for the rice lands expired. The swamp areas were filled to extend the agricultural lands.

Early archaeological studies previously reported the presence of 12 sites on the plain between Kekaha and Mana. Recent research has identified dune burials, a possible cultural layer from the PMRF region, and early date from Majors Bay (770+ 60 years BP). None of these reports located any sites within the project area.

A field reconnaissance was conducted on August 20, 1997. Man-made canals and modified drainages were closely examined for cultural deposits. None were found. The periphery was observed to be areas for stockpiling rocks or to establish property lines. In addition to cane activities, the area was heavily disturbed by sand mining, road construction, and military use.

There are no known or previously identified historic sites within the project area. The many alterations of the landscape, together with the negative results of recent surface and subsurface investigations adjacent to the subject property indicate little possibility of finding archaeological remains.

Most recent archaeological studies performed in the area include:

Scientific Consultant Services...........Sunkiss Shrimp Co.
Cultural Surveys Hawaii...................Kauai County Landfill
Advanced Sciences............................PMRF

B. Consequences - SIGNIFICANT BUT MITIGABLE

The probability of find historical sites within the project limits is very low. However, the possibility does exist that cultural material and burials may be present. An archaeological study has been performed to inventory the site and to determine the significance.

C. Mitigation

An archaeological survey and assessment was conducted by Scientific Consultant Services (SCS) in mid August. The scope of their work was to perform a site reconnaissance to record all above ground sites. The work also involved a review of historical literature to unite previous studies performed in the area in order to provide a larger picture of the activities which occurred in the area and to answer certain scientific questions. SCS conducted interviews with local informants to record their intimate experiences as persons who have a life-long connection to the area, having lived and/or worked there. The results of this work shall be compiled into a written report for review and approval by DLNR-State Historic Preservation Office (SHPD) (Appendix 2).

A preconstruction meeting would inform all personnel of the legal responsibilities relating to historic sites and burials as they pertain to Chapter 6-E of the Hawaii Revises Statutes (HRS). Construction personnel will cease work in the area of any inadvertent burials and/or historic sites should they be discovered during the course of construction. The State Historic Preservation Division shall be notified immediately for a determination of how to proceed with the find.

2.6 WATER QUALITY

This section discusses both the surface, nearshore ocean, and groundwater quality related to the project area.

2.6.1 SURFACE WATER QUALITY

A. Existing Setting

Surface water in the project area consists of a network of man-made ditches to provide drainage of irrigation water and storm water runoff from the area to the ocean. This ditch system, together with various pumps and outfalls, serve to convey irrigation water, prevent flooding, and eliminate agriculture wastewater from the area. Typically, the surface water within the ditch system is brackish, and does not meet drinking water standards for chorides.

B. Consequence - SIGNIFICANT BUT MITIGABLE

Pond construction on the aquaculture land is not anticipated to cause significant impacts to the surface water quality, flooding of project lands, and the continued transit of present agriculture discharge to the ocean.

C. Mitigation

CEATECH USA Inc. has developed a plan to prevent flooding of subject lands, provide for continued transit of the agriculture discharge to the ocean, and allow for independent monitoring of the effluent streams from both projects. This is done by the construction of berms around the property, the rerouting of a small portion of the agriculture effluent, and the installation of several pumps.

A berm at least five feet above property, and along both sides of the interior drainage canal. The aquaculture effluent will be routed along the makai boundary of the property, adjacent the berm. The portion of the present agriculture effluent now transported along this path will be rerouted into the existing canal along the mauka side of the Kaumualii Highway; this canal will be used exclusively for the agriculture drainage/ discharge. Additionally, the berm, which is now located just makai of the Kinikini bridge and serves to prevent seawater intrusion and provide for emergency drainage, will be moved north approximately a hundred yards to permit the independent monitoring of the two discharge streams.

The plan also includes the installation of several pumps and siphons to convey the treated aquaculture discharge effluent around the berms into the drainage system, and provide emergency capability to mitigate the amount of runoff which would be associated with the 8" in 24-hour storm event.

2.6.2 GROUNDWATER QUALITY

A. Existing Setting

Typical to the leeward side of the Hawaiian Islands, the Kekaha Aquifer System is the driest for the island. The systems consists of a clearly defined basal lens that is protected by a large sedimentary caprock.

At Mana plain the basal volcanics of the area are highly permeable and contain brackish groundwater that floats on the denser seawater. The overlying alluvial sediments act as caprock because of their low permeability. These sediments in the area are saturated, but the groundwater is not exploitable as a freshwater aquifer because of the unfavorable hydraulic characteristics. The groundwater, originating from seepage from irrigation water and rainwater, becomes progressively more saline with increasing proximity to the ocean.

B. Consequence - NOT SIGNIFICANT

Migration of organic byproducts into the groundwater table which could leach into the nearshore waters.

C. Mitigation

The complete success of this project, and the livelihood of those associated with its incubation, are relying on a system that is healthy and which will continue to improve with the initiation of the farm. The quality of the farm's water is only as clean and healthy as its source. The employment of polyethylene pond liners, enclosed PVC piping , and retention basins will prevent the seepage of wastes into the groundwater.

2.6.3 NEARSHORE OCEAN WATER QUALITY

A. Existing Setting

The coastal marine waters affronting the project are classified as "Class A, open coastal waters" by the Hawaii

Water Quality Standards. Protected uses within this classification include the propagation of fish and wildlife and recreation; all evidence indicates these uses are being fully maintained.

Flood tidal currents are offshore from O'omana Point, and flow parallel to shore on either side of this Point; ebb currents are predominantly easterly. The site is directly exposed to long-period swells generated by Pacific storms in both summer and winter. The shoreline is sandy beach; seaward of the beach is a limestone bench which extends 75 feet offshore. The underwater landscape characterized by a limestone platform which is predominantly flat with little vertical relief.

The pre-dominant biota are low algal turf of various species of benthic algae; living corals are sparsely distributed and when present, occur as flat encrustations on the flat bottom. Recent monitoring concluded that there is no evidence of any negative impact to the water quality, or aquatic flora or fauna from the historical discharges to the area.

The coastline is open and extremely well flushed by prevailing wind, wave, and currents, and it displays a low sensitivity to land-based discharge inputs. The coastal environment has received agriculture effluents for over a hundred years with little evidence of negative impact to water quality, aquatic flora, or fauna. Ground-water and irrigation water are continually pumped from the Mana Plain, which is predominantly in sugarcane production.

There are several zones of mixing in place at areas affronting several such agriculture discharges; the area is currently fully permitted for agriculture use and discharge to the nearshore ocean. The previous use history of the receiving waters is a relevant feature of appropriate site selection for aquaculture because it reflects the degree of pristine character represented by a given site and thus the potential for resource compromise. The long history of the coastal environment as receiving waters for land-based discharges minimizes the danger of wilderness loss in the environment.

B. Consequence - SIGNIFICANT BUT MITIGABLE

Discharge from the project will contribute dissolved nutrients and suspended particulate waste to the coastal ocean. The effluent from the project is expected to have generally better water quality characteristics, and half the permitted volume than the current agriculture discharge. A hydraulic analysis showed that at maximum flow, the aquaculture discharge would comprise less than four one-hundredths of one percent of the seawater flow naturally passing through the Zone of Mixing that is due solely to natural tidal currents. The aquaculture discharge is also to be permitted to a Zone of Mixing under a NPDES permit, wherein a detailed Antidegradation Analysis will be done. The discharge is to occur at an existing outfall entrance (#002) at the shoreline, located at 22 degrees, 1' 01" N latitude and 159 degrees 47' 20" W longitude. The discharge content and subsequent water quality affects of the project have been studied extensively via applied design/operation research and hydraulic dispersion models, respectively. There will be no persistent signature from the aquaculture effluent outside of a Zone of Mixing affronting the discharge point. The project is not anticipated to adversely affect the water quality in the adjacent ocean, or compromise the currently protected uses pertaining to preservation of aquatic biota, fisheries, and recreation.

C. Mitigation

A significant number of mitigation measures have been included into the current project to establish the best available system to minimize waste discharges and to insure that the effluent from the farm will not have a deleterious impact to the ocean environment. These include aspects of site selection, farm design, best management practices, and best available technologies. The controlled environment farming system to be used includes numerous features for preserving the surrounding environment which are unprecedented in commercial aquaculture. This system minimizes the amount of waste discharged per unit of production, and mitigates the environmental effect from that discharge.

1. The use of lined ponds prevents seawater seepage into the groundwater, eliminates any addition of terrigenous sediments to the discharge stream, and avoid sediment pulses to the environment during harvest and draining events.

2. The aeration component prevents anoxia, and/or noxious odors in the pond discharge stream.

3. Daily water quality monitoring within all ponds optimizes the water quality not only for the aquatic animals being farmed, but also for those exposed to the subsequent discharge waters.

4. The intensive production protocols to be used result in a much greater efficiency of feed, land, and water use than the style of shrimp farming applied elsewhere. The better feed conversion ratios also indicate smaller amounts of uneaten feed, and thus lower waste additions.

5. By relying exclusively on a controlled hatchery system to provide seed animals for its shrimp farming operations, this system avoids any large scale harvesting of wild shrimp populations to stock ponds.

6. The feeding protocols avoid any use of highly polluting feeds such as trash fish, or macerated marine animals,

7. Surface skimmers on each pond collect and remove any buoyant plant material prior to discharge.

8. Design of the discharge infrastructure, also includes screens at multiple locations, to prevent escape of animals to the environment

(Appendix 3). At the Mana location in particular, the effluent also passes through a ditch system populated with carnivorous fish; this further reduces any probability that farmed animals would survive to reach the ocean.

9. The approach for reducing the risk of an accidental release of aquaculture organisms and/or associated pathogens into the environment follows the Code of Practice developed by the International Council for the Exploration of the Seas (ICES). This protocol, which relies on rigorous quarantine procedures utilizing first generation progeny, is one of the three widely adopted approaches for avoiding harmful introductions in use around the world.

10. The exclusive use of high-health animals reduces risk of any contamination to the surrounding environment. All of the shrimp stocks to be used are derived from specific pathogen free populations originating from the U.S. Marine Shrimp Farming Program, supported by the United States Department of Agriculture. These stocks, maintained in captivity for over six generations, have repeatedly been screened by a variety of diagnostic techniques and shown to be free of specific shrimp pathogens of interest.

11. The company's animal health management system includes a surveillance program, as well as biosecurity protocols (Appendix 4). The nation's foremost authority on shrimp pathology will oversee the appropriate application of diagnostic protocols.

12. The design of both the hatchery and production facilities includes numerous

features to prevent any transmission of shrimp pathogens between the farm and the environment in either direction.

13. A prime focus of CEATECH USA, Inc.'s waste treatment design is the recovery and reuse of settled particulates which accumulate on he pond bottoms. Discharge of this material, which comprises the majority of total particulate waste, is the most functional facet of a prudent aquaculture waste management strategy. A key feature of this farm design is the opportunity for the collection and removal of these settled bio-solids. The round pond system to be used permits self-cleaning through the periodic removal of material which settles to the bottom. Paddlewheels circulate water and collect sediments near a central drain. The circular pond shape and centrally located drain optimize water circulation and subsequent sediment removal. An important consequence is the capability to separately handle this low-volume, high-concentration fraction from the overlying fraction, having high-volume, low-concentration characteristics. This waste mitigation feature is without precedent in commercial aquaculture, and greatly increases effectiveness of the settling basins, which are the centerpiece of the waste treatment system.

14. Periodically during the production cycle, the settled material is purged from the pond. This material is to be routed to a collection sump, resedimented, and pumped into settling troughs for desalting, concentration, and desiccation. The subsequent processing of this settled fraction is similar to that used to handle sludge in conventional waste treatment systems. CEATECH USA, Inc.'s waste management strategy calls for the recovery and reuse of these

biosolids as a soil enhancement for agriculture. The proximity of agriculture operations makes the economical transport and use of this material a feasible opportunity.

15. Numerous studies have shown that there are currently no practical, reliable and economical treatment technologies to completely remove the dissolved and suspended microparticulate wastes from aquaculture discharges. Release into a Zone of Mixing under the authority of an NPDES permit has been required by both agriculture and aquaculture operations. Nonetheless, the company intends to evaluate on-line several strategies to reduce constituent levels within the discharged waters. The seeding and propagation of salt-tolerant, vascular plants along the sides of the drainage canals leading to the ocean targets reduction of dissolved inorganic nutrients. Another option to assimilate dissolved inorganic nutrients is to pass effluents through aggregations of marine macroalgae. The aquaculture effluents will be routed into the drainage canal leading to the ocean. This canal system further acts as a elongated settling basin to remove additional materials, via sedimentation or assimilation, during the resident time prior to discharge.

2.7 VISUAL RESOURCES

A. Existing Setting

The visual resource of an area, including both natural and man-made features that give an environment its aesthetic quality, are a matter of concern when views are rare, unique, or special in someway. The physical setting of the project area is predominantly that of a large flat coastal plain consisting of diversified agriculture production, abruptly transitioning into mountainous lands which encompasses natural habitats, scenic and cultural attractions, and educational and recreational activities. There are no protected views within the Kaumualii Highway corridor fronting CEATECH USA, Inc.

B. Consequence - NOT SIGNIFICANT

Under the proposed project, the current visual character of the area will be maintained. The project's ponds, fences, and signs (similar to no-trespassing signs in the cane fields currently) will provide little vertical relief, and will be largely screened by concurrent sugarcane operations in the area. Overall, no significant impacts from the proposed action are expected to the visual resource.

C. Mitigation

Landscaping and berming will be introduced along the Kaumualii Highway frontage to screen the farming activities and assist with the visual transitioning with the adjacent agricultural setting. All accessory structures will be low scale and conform to the zoning requirements for the district. Massing of structures will be softened using vertical landscaping material. The use of earth tone colors will be used as appropriate, as well as the avoidance of bright and reflective materials.

2.8 NOISE

A. Existing Setting

Noise is unwelcome, unwanted sound, usually from human activity, that disrupts normal activity or diminishes the quality of an environment. In the present setting the prime sources of noise come from cane harvesting, and occasional aircraft and road traffic.

B. Consequence - NOT SIGNIFICANT

Unacceptable noise levels, relating to construction activities, are expected to be temporary. The noise associated with earth moving equipment, back-up beeping, and other gas and diesel combustion engines will terminated upon completion of the site improvements and the noise levels will return to pre-construction levels.

C. Mitigation

Noise during construction will be minimized by using properly muffled equipment. These impacts are unavoidable during periods of construction. Properly muffled equipment will reduce ambient noise levels which could affect neighboring tenants (PMRF, Pioneer Seed Company and beach users). In addition, properly serviced combustion engines will reduce unspent hydrocarbon emissions.

2.9 DRAINAGE

A. Existing Setting

Historical agriculture use of the area has required the establishment and maintenance of a series of canals and drainage ditches. This ditch network, together with various pumps and outfalls, serve to convey irrigation water throughout land parcels, prevent flooding, and eliminate agriculture wastewater from the property. Kekaha Sugar Company pump excess brackish water to two outfalls which are situated at the north west end of the Mana plain. These are identified as the Kawaiele Drain and the Nohili Drain. According to Kekaha Sugar officials, the surface water runoff from mauka are collected and transported through a series of ditch and pond systems. This conveyance mechanism allows for the particulates to settle-out as the water passes from pond to pond, so that the quality of this drainage water is high as it reaches the ocean.

B. Consequence - SIGNIFICANT BUT MITIGABLE

Surface storm waters could submerge the aquaculture farm and contaminate the ponds with silt, freshwater, and chemicals from other agricultural activities.

C. Mitigation

To prevent flooding of the lands to be used for aquaculture, provide for continued and unaffected transit of the present agriculture discharge, and to allow for independent monitoring of the two effluent streams, CEATECH USA, Inc. will implement the following drainage plan:

1. Berm Construction

Land targeted for the operation consists of fields 316, 419, 420, and portion of 421. A berm at least five feet above mean sea level in height will be constructed along the property. This berm will run along the entire makai boundary of the property from the northwestern end of field 421 to the southeastern end of 316. It will also border sides of the canals which separate fields 420 - 419, and 419 - 316. The mauka boundary of the subject property is bermed by the highway, which is graded to at least eight feet above mean sea level.

2. Cooperative Agriculture and Aquaculture Discharges

The aquaculture effluent will be routed along the makai boundary of the property, adjacent the berm. That portion of agriculture effluent which would now be transported along this path will be rerouted into the existing canal extending along the mauka side of the highway; and will continue to be used only for agriculture discharge. Additionally, the berm, which is now located just makai of Kinikini bridge and serves to prevent seawater intrusion and provide for emergency drainage during heavy rains will be moved north several hundred yards to permit the independent monitoring of the two discharge streams.

3. Pump Installation and Infrastructure Maintenance.

The plan includes the installation of several pumps to convey the treated aquaculture discharge effluent around the berms into the drainage ditch system, and to provide emergency capability to mitigate the amount of runoff which would be associated with the 8" in 24 hour storm event. Consistent with the function of assuring the uninterrupted conveyance of runoff to the shore, the plan includes a share in the responsibility to maintain that portion of the ditch system within those lands targeted for aquaculture.

SECTION 3.0

SOCIO-ECONOMICS

SECTION 3 : SOCIO-ECONOMICS

3.0 SOCIO-ECONOMIC OVERVIEW

The project is expected to yield substantial positive effects to the island's welfare. The potential exists for significant development and export capability, which leads to economic development and the island's improved socio-economic health.

The creation of export markets for the farmed aquaculture products will increase economic development in the community while maintaining the rural character. The farming of marine shrimp promotes the State's goals for agriculture diversification and technology-based employment opportunities in areas where Hawaii has a comparative advantage. The project's compatibility with adjacent land uses, and availability farming labor pool provide a sustaining effect to the county plans for the area.

3.1 TRAFFIC

A. Existing Setting

The subject property obtains its vehicular access directly from Kaumualii Hwy. which is under the jurisdiction of The State of Hawaii, Department of Transportation (DOT), Highways Division. Kaumualii Highway is classified as a major roadway providing two-way traffic via an asphaltic concrete surface. The shoulders of the road in the area of the project site are grassed and adequate to accommodate large trucks. Vertical and horizontal sight-distances are excellent.

To avoid vehicular conflicts with ingress and egress movements CEATECH USA, Inc. will work with the DOT to determine safe points of entry - these will very likely follow the existing plantation cane haul roads. The primary mode of transportation on-site will be will pick-up trucks, tractors, and all-terrain vehicles. As expected, the vast majority of vehicle movements will be conducted through the project's interior road system. The project's highway traffic will restricted to employees, delivery of supplies, and the delivery of product to the wholesalers (4-times per week). The traffic in the area is expected to increase by approximately 70 vehicular movements per day The applicant expects the facility to operate 24-hours per day.

B. Consequence - NOT SIGNIFICANT

The proposal will place additional vehicular traffic in Kekaha. However, there will be no significant adverse impact since the majority of farm traffic will be moving opposite to the heavy morning and evening rush hour movements to and from Lihue.

C. Mitigation

The staggering of work shifts will further reduce the number of vehicles on Kaumualii Highway at one time. Carpooling may also offer mitigating solutions.

3.2 HOUSING

A. Existing Setting

Kekaha is a plantation community with a strong commitment to sugar and diversified agriculture. The nearest residential settlement is in the Kekaha Gardens Subdivision which is comprised of single family residential units. PMRF consists of approximately 76 Bachelor Quarters for enlisted military personnel. The nearest plantation camp was at Mana, but it no longer exists.

B. Consequence - NOT SIGNIFICANT

No significant impacts determined.

C. Mitigation

The project will not impact housing in the area since the employees of the project will be selected from a pool of existing island residents.

3.3 EMPLOYMENT

A. Existing Setting

The largest employers on the westside are PMRF and Sugar (Kekaha Sugar and Gay & Robinson). Tourism related positions are at Waimea Plantation Cottages, charter tour boat operators, and in the retail shops. Specialized employment exist at Kauai Veterans Memorial Hospital (KVMH) and at the Pacific Missile Range Facility (PMRF).

B. Consequence

Downsizing by Kekaha Sugar Company and the closure of McBryde Sugar Company has increased unemployment in the area. Concern has been expressed that the farm will require personnel with technical training and specialized experience in aquaculture, which may exclude many persons having only sugarcane qualifications.

C. Mitigation

Farm personnel will be comprised of Kauai residents. Preference will be given to those who have excellent work ethics and working experience in the aquaculture field. However, many of the farming tasks and duties can be performed by inexperienced persons that are willing to participate in training programs. Technical personnel will be available at all times providing guidance and overseeing the day-to-day operations.

CEATECH USA, Inc.. expects to employ approximately 60-70 people of the Waimea-Kekaha-Mana area. This figure is derived from estimates for the following operational sub-components: Sunkiss hatchery (8 employees), a 52-pond growout unit (32 employees), packaging/distribution (20-30 employees), and security (2-4 employees).

SECTION 4.0

LAND USE

SECTION 4 : LAND USE

4.0 LAND USE OVERVIEW

The Hawaii State Plan, the Kauai General Plan, and the six Regional Development Plans are long-range planning documents which offer broad-based initiatives, through goals and objectives, for each community. The CZO, subdivision Ordinance, SMA rules & regulations, shoreline setback rules, and the Urban Design Guidelines are the short-range or implementation tools which govern the day-to-day planning functions. The purpose of land use planning is to insure compatibility and proper integration within a community of uses. Chapter 8, KCC, states that the zoning ordinance is "intended to promote development that is compatible with island's scenic beauty and environment and to preclude inadequate, harmful or disruptive conditions that may prove detrimental to the social and economic well-being of the residents of Kauai."

4.1 ZONING

Planning laws, statutes and ordinance should not be viewed as a regulatory program aimed at restricting development, but rather as a process which sets minimum standards and performance criteria, and assists proposed development in the accomplishment of their goals, within the context of promoting public health, safety and welfare.

A. Existing Setting

Land use designations for the parcel are:

COUNTY	-AGRICULTURE/OPEN (Exhibit K)
GENERAL PLAN	-AGRICULTURAL/OPEN (Exhibit L)
SLUD	-AGRICULTURAL (Exhibit M)

The construction and operation of the proposed marine shrimp aquaculture farm is consistent with its zoning and State land use designation. One of the primary purposes for the adoption of Kauai's zoning ordinance is "to promote, maintain and improve the agriculture potential of land located in the

County." It is clear in this statement of purpose that it is in the best interest of the island residents to protect the inventory of agricultural lands. And when possible, to extend the boundaries of this district. Section 8-7.1 KCC states that the purpose of the Agriculture District (A) is:

(a) To protect the agricultural potential of lands within the County of Kauai to insure a resource base adequate to meet the needs and activities of the present and future.

(b) To assure a reasonable relationship between the availability of agriculture lands for various agriculture uses and the feasibility of those uses.

(c) To limit and control the dispersal of residential and urban use within agriculture lands.

Some of the agricultural activities occurring within the Mana plain are sugarcane, seed corn, sunflower seed, watermelon, lettuce and the pasturing of livestock. Proposed crops include alfalfa, soy beans, bananas, dryland taro, aquaculture, melons, tropical flowers, ti leaves, and trees.

B. Consequence - NOT SIGNIFICANT

None.

C. Mitigation

No significant land use impacts have been identified.

4.2 CONSTRAINTS

According to Chapter 8 of the Kauai County Code (KCC), the purpose of the Constraint District is for establishing special standards of development to assure public health, safety, and welfare in areas containing unusual and unstable conditions.

A. Existing Setting

The following are the constraint districts for the County of Kauai, and as they exist on the subject property:

SLOPES	-	None
DRAINAGE	-	Yes
FLOOD	-	Yes
SOILS	-	None
SHORE	-	None
TSUNAMI	-	None

B. Consequence - NOT SIGNIFICANT

Storm waters could flood the farm, breach pond walls and contaminate pond contents.

C. Mitigation

In conjunction with the existing drainage ditch systems, an earthen berm along the eastern perimeter boundary will intercept mauka storm flows and direct them to the existing plantation basins and outlets. All pond and berm wall construction shall require proper compaction of 95% for stabilization. The construction and placement of farm structure will conform to CZO and FEMA standards. No residential units are proposed for this facility.

4.3 FLOOD INSURANCE RATE MAP (FIRM)

A. Existing Setting

The project are is situated with an area that has been determined be the Federal Emergency Management Agency (FEMA) to be situated within the 100 year flood zone (Exhibit N). Designated as Zone A on the Federal Flood Insurance Rate Maps (FIRM), these areas typically receive flood waters from non-velocity sources. VE zones are inundation areas which are found along coastal high hazard areas and along drainageways which exhibit velocity force flows.

According to these maps, the project site is slightly lower in elevation than the surrounding lands, including those seaward. The ponding characteristics of this area has made these fields undesirable to Kekaha Sugar Company.

B. Consequence - NOT SIGNIFICANT

Same concerns as those expressed under Sec. 4.2 which relate to flood damage to farm improvements and the contamination of the ponds.

C. Mitigation

Storm water from mauka lands will be directed into the preexisting sugarcane drainage ditches. Some of the flood water can be retained on-site and allowed to dissipate. However, all structures will be elevated as required by FEMA standards. There are no residential settlements nearby, and no residential structures are proposed. Farm dwellings are a permitted activity, however they are perceived as being accessory in nature to the agriculture activity.

4.4 HAWAII STATE PLAN

The Hawaii State Plan was adopted into law in 1978. It was designed to serve as a guide for future development for the State. It is a long-range comprehensive plan which sets forth the State's goals, objectives, policies, priority guidelines, and development strategies. Implementation is achieved through several State Functional Plans. The Function Plans promote coordination between State, County, and the private sector towards achievement of a common state wide interest. It is applicable to general plan and development plan amendments; development and implementation of State programs; appropriation of budgets and funds under the CIP program; decisions of the Land Use Commission; and decisions of the Board of Land & Natural Resources. The emphasis of the Agriculture Functional Plan is to increase agriculture development in Hawaii through two fundamental objectives:

(1) Continued viability in Hawaii's sugar and pineapple industries.

(2) Continued growth and development of diversified agriculture throughout the State.

CEATECH USA, Inc. is consistent with Hawaii State Plan and the Agriculture Functional Plan by :

(1) Promoting an industry and a product that can provide optimal contribution to the State in the form of taxes, lease payments, employment, and commerce. Other benefits include basic and applied research information.

(2) Promoting an agricultural commodity through cultural farming practices and modern management practices.

(3) Promoting an agricultural farming technique which effectively protects Hawaii's natural resources without jeopardizing agricultural production.

(4) Promoting one form of agricultural use which maximizes productivity, yet not create further burdens to the irrigation water supply.

(5) Intends to support current infrastructure and facilities which are necessary to support other agricultural enterprises.

4.5 KAUAI GENERAL PLAN

Established in 1971, the Kauai General Plan was designed to govern organized growth for the island. The plan call for the preparation of an agricultural masterplan which allocates resources based on productivity rating, ownership, and economic feasibility; encourages agriculture production through tax incentives, and discourages subdivision of agricultural land based on productivity rating.

CEATECH USA, Inc. is consistent with the goals of the Kauai General Plan in that:

(1) Proposal is consistent with the General Plan designation for the property.

(2) Promotes and protects the health, safety, and welfare of all residents and visitors.

(3) Seeks to create opportunities for a greater diversity and stability of employment for residents of Kauai.

(4) Promotes the improvement and expansion of the island's economy, by recognizing and carefully utilizing land and water resources.

(5) Encourages and supports efforts aimed at attaining self-sufficiency in food production and energy for the County.

(6) Encourages an economy and a population composition that will encourage the youth of Kauai to live in the County and contribute to society.

4.6 WAIMEA-KEKAHA DEVELOPMENT PLAN

The Waimea-Kekaha Regional Development Plan was adopted in 1977. It discusses the issues and the opportunities that are unique to this planning region. Waimea and Kekaha are communities with heritages that date back to the early sugarcane plantation. CEATECH USA, Inc. is consistent with the following objectives of the Waimea-Kekaha Development Plan:

(1) To maintain and, if possible, expand agriculture lands.

(2) To provide opportunities for new industries that do not bring dramatic changes to the environment or the social fiber of the community.

(3) To provide opportunities for economic development adjacent to PMRF.

(4) To diversify the economy to provide a full range of employment in professional, skilled, semi-skilled, and unskilled positions.

(5) To assure the preservation and protection of reefs, off-shore habitats, beaches, and sand dunes.

(6) To assure development of compatible land uses.

(7) To maintain a program for water management in the region.

4.7 URBAN DESIGN PLAN

The project site falls outside of the boundaries of the Kauai Urban Design Plan, and is therefore not subject to its development criteria.

4.8 SPECIAL MANAGEMENT AREA

The Coastal Zone Management Program (CZMP) is concerned with impacts a development may have within the boundaries of the Special Management Area (SMA) of the County of Kauai - with respect to cultural, social, recreational and open space resources, coastal eco-systems, and coastal hazards.

The site is located outside of the Special Management Area (SMA) of the County of Kauai and well outside of the 40 ft. setback area, and therefore not subject to the rules and regulations of the SMA or the Shoreline Setback.

However, the proposal is consistent with the objectives of the Special Management Area Rules and Regulations of the County of Kauai and can be properly integrated with its surroundings, in that:

1. The development is in harmony with the County General Plan, Comprehensive Zoning Ordinance, and other applicable local ordinances.

2. The development is consistent with the Objectives and Policies of Chapter 205-A HRS (HCZMP), and the SMA Rules and Regulations of the County of Kauai, in the Development will not:

    a. Involve dredging, filling or otherwise altering any bay, estuary, salt marsh, river mouth, slough, or lagoon.

    b. Reduce the size of any beach or other area usable for public recreation.

c. Reduce or impose restrictions upon public access to tidal or submerged lands, beaches, portions or rivers and streams within the Special Management Area and the mean high tide line where there is no beach.

d. Interfere or detract from the line of sight towards the sea from the State Highway nearest the coast, or from existing public views to and along the shoreline.

e. Adversely affect water quality, existing area of open water free of visible structures, existing and potential fisheries and fishing grounds, wildlife habitats, estaurine sanctuaries, potential or existing agricultural uses of land.

Therefore, the proposal will not have any substantial adverse environmental or ecological effects, and will not adversely affect any wetland, submerged lands, tidal basins, or navigable waters..

4.9 AGRICULTURE

The proposal is consistent with the agricultural designation for the area, and does not displace active and commercially land based crops. Nor does the proposal reduce or eliminate the inventory of important agricultural lands to the State of Hawaii. The proposed action conforms to sec. 205-4.5(3) HRS which defines the activities that are permitted within the agricultural district, specifically: "Raising of livestock, including but not limited to poultry, bees, fish, or other animal or aquatic life that are propagated for economic or personal use."

4.10 DESIGN

A. Existing Setting

As a result of site selection, farm design, best management practices, and best available technologies, the aquaculture effluent discharged from the farm will not have a deleterious impact to the ocean environment. There will be no persistent signature from this aquaculture effluent outside of a Zone of Mixing affronting the discharge point. The quality of effluent now discharged is expected to improve over its current condition.

Many features of this project's design and operation make this system a model for aquaculture husbandry which is compatible with responsible environmental stewardship. The use of lined ponds prevents seawater seepage into groundwater supplies, and also eliminates any addition of terrigenous sediments to the discharge stream. It also avoids sediment pulses to the environment during harvest and draining events. The aeration component prevents any anoxia, or noxious odors in the discharge stream. Daily water quality monitoring within all ponds optimizes the water quality not only for the aquatic animals being farmed, but also for those exposed to the subsequent discharge waters.

B. Consequence - NOT SIGNIFICANT

No significant impacts determined.

C. Mitigation

In addition to the protection measures for waste collection and animal containment, CEATECH USA, Inc. proposes to construct farming structures that are low scale in nature. They will be painted with earth-tone colors and will not utilize highly reflective materials. All improvements shall conform to Chapter 8, KCC relative to development standards for the agriculture district.

4.11 CONSTRUCTION

A. Existing Setting

The area will receive limited grading to accommodate the pond, piping, and berm infrastructure needed to maintain positive drainage. No significant effects are expected to existing topographical conditions. A series of berms will be constructed to protect against runoff and flooding. The project will apply dust control measures during construction. All pond construction will involve ground level work, and as such will create no visual impact.

B. Consequence - NOT SIGNIFICANT

No significant impacts determined.

C. Mitigation

All structures will be constructed to UBC standards and shall conform to FEMA flood requirements.

SECTION 5.0

PUBLIC FACILITIES

SECTION 5 : PUBLIC FACILITIES

5.0 OVERVIEW

Much of the utility infrastructure in the Mana-Kekaha area is old and sub-standard. A comprehensive plan is needed to upgrade these services in order to attract more hi-tech agriculture farms .

5.1 POTABLE WATER

A. Existing Setting

Water is provided to the area from three different sources. The County Department of Water provides potable water from its Paua Valley tank where it is distributed to the Navy via 3 miles of 4" asbestos/cement line. Kekaha Sugar Company which owns the Mana well also provides water to PMRF from 2 miles of 4, 6, and 8" pipeline.

Irrigation water is also available from the Kekaha Sugar Company surface ditch system.

B. Consequence - NOT SIGNIFICANT

Residential units are not planned for the CEATECH USA, Inc. project and therefore the potable water source is not a requirement. Drinking water shall be purchased from a water distributor.

C. Mitigation

CEATECH USA, Inc. shall work with the County of Kauai and PMRF to obtain water from the Paua Valley tank site when it becomes necessary.

5.2 SOLID WASTE

The Kekaha Landfill is located approximately 1 mile from the project site. All waste generated will be processed at the Kekaha

Landfill Recycling Center. CEATECH USA, Inc. shall work with Kekaha Sugar Company to accept the high-density low-volume material for use as a soil amendment.

5.2.1 HAZARDOUS MATERIAL AND WASTE

A. Existing Setting

Hazardous materials include substances that because of present quantity, concentration, physical, chemical or infectious characteristics, may present substantial danger to public health or welfare of the environment when released. There are no known waste sites or releases of hazardous materials within the project area.

B. Consequence - NOT SIGNIFICANT

There will be minimal quantities of hazardous waste retained on-site since the farm does not intend to store diesel or other petroleum based fuels on-site. The company's farming style uses no bioactive compounds such as pesticides, antibiotics, fertilizers, or growth hormones in its production operations.

C. Mitigation

The service trucks shall be fueled off-site to avoid spillage and contamination.

5.3 WASTEWATER TREATMENT AND DISPOSAL

A. Existing Setting

The nearest County operated sewage treatment plant is in Waimea town. PMRF processes its own wastewater on-site through 2 main sewage treatment facilities.

B. Consequence - NOT SIGNIFICANT

No significant impacts determined.

C. Mitigation

CEATECH USA, Inc. intends to construct its own wastewater disposal system which consists of a storage tank and a leach field. In this system, the solids are collected within the storage tank and the effluent is conveyed through a series of pipes into the leaching field where the water is percolated and evaporated.

5.4 POWER AND COMMUNICATIONS

A. Existing Setting

Electrical service is available to the project site via overhead power lines along Kaumualii Highway. According to Citizens Utilities, Kauai Electric Division engineers, the project site is conveniently located to the Mana substation which can provide CEATECH USA, Inc. with sufficient electrical service. A main distribution line currently exists along the highway and can provide 3-phase 4 wire 12 KV service to the project

B. Consequence - SIGNIFICANT BUT MITIGABLE

CEATECH USA, Inc. will be responsible for bringing electrical into the property, from the distribution line along Kaumualii Highway, and branching off to the individual ponds and pumps. The use of overhead lines could attract birds to perch there.

C. Mitigation

All electrical service lines will be placed underground to prevent the perching of birds. This measure will also preserve the natural appearance of the landscape and protect the infrastructure from storms.

5.5 POLICE AND FIRE

A. Existing Setting

The proposed project is not expected to increase the demand for these services. The subject property falls within an existing service area.

The nearest County Fire Station is at Waimea, at the intersection of Menehune Road and Kaumualii Highway. This station consists of a twenty (20) foot Seagrave Fire Engine 6 Truck, a rescue truck and a staff of five (5) fire fighters on duty each 24-hour shift. The station is located approximately 8 miles from the project site.

Police and Ambulance service is also available from Waimea town, with the Police substation co-located at the Waimea Fire Station. The nearest medical facilities are at Kauai Memorial Veterans Hospital (KVMH).

The neighboring PMRF range is equipped with its own fire fighting and security force.

B. Consequence - NOT SIGNIFICANT

The project site is not currently serviced by a fire standpipe.

C. Mitigation

CEATECH USA, Inc. consists primarily of ponds and low-growth vegetation, and materials which are fire resistant. However, the potential for fire is always present and therefore standard operation procedures (SOP) will be developed to provide personnel with safety procedures for safe conduct of farm operations. Fire extinguishers will be located near the entrance of all buildings and in each farm vehicle.

5.6 SCHOOLS

A. Existing Setting

The Waimea District consists of Waimea Canyon, Elementary, and Waimea High School. The nearest private school is St. Theresa's in Kekaha.

B. Consequence - NOT SIGNIFICANT

The proposed project will not significantly impact the school system on Kauai. Employees of CEATECH USA, Inc. will be Kauai island residents.

C. Mitigation

The CEATECH USA, Inc. project is expected to provide substantial tax and lease revenues to the State of Hawaii. These monies can be appropriated towards education and school expansion as necessary.

5.7 PARKS AND RECREATION

A. Existing Setting

Kauai can boast that approximately 137,000 acres of recreational space is available for hunting, hiking, biking, as well as passive and active recreation. Significant recreation resources of this area include Polihale State Park, Kokee State Park, and Waimea Canyon State Park. Kekaha has the longest sand beach in the state, covering approximately 15 miles of shoreline from Kekaha to Polihale, and measures approximately 300 feet wide depending on the season. As a comparison, Waikiki Beach on Oahu is 2 miles long.

B. Consequence - NOT SIGNIFICANT

The proposed project will not have any appreciable impact on current park or recreation facility. The project does not displace any such facility, existing or proposed. Furthermore, the proposal will not restrict access to any beach activities since the project is not situated along the shoreline.

C. Mitigation

The proposed project will not place additional burdens upon existing recreational facilities in the Waimea-Kekaha planning area since it does not increase the population size or require the importation of labor. It is anticipated that revenues to the State can be redirected to improve the beach park infrastructure at Polihale or at the boating facilities at Kikiaola Harbor.

SECTION 6.0

RESPONSES TO COMMENTS

CEATECH USA

Controlled Environment Aquaculture Technology, Inc.
7 Waterfront Plaza, Suite 400
500 Ala Moana Blvd. Honolulu, HI 96813
Tel: (808) 521-1801 / Fax: (808) 537-1307
ceatech@aloha.net

January 29, 1998

John T. Harrison
Environmental Coordinator
University of Hawaii at Manoa
Environmental Center
2550 Campus Road
Crawford 317
Honolulu, HI 96822

Dear Dr. Harrison:

Subject: Environmental Assessment,
CEATECH USA, TMK: 1-2-2:por.1 Waimea, Kauai

The attached material is provided in response to your letter of November 24th, 1997 (EA:00168). This information will be incorporated into CEATECH USA, Inc. Final Environmental Assessment (FEA) (Section 6).

The FEA is believed to be fully responsive to all comments received during the public review. The subject of discharge to the ocean environment, which was addressed in your letter, was answered in an especially complete manner. In addition to the specific responses (attached), the FEA now includes supplemental materials consisting of a rigorous Antidegradation Analysis as well as several years of comprehensive monitoring reports from the adjacent coastal environment. These materials provide a more thorough environmental analysis than provided in the DEA, and substantiate positions taken within the original document concerning the lack of significant environmental impacts.

We hope that our response to your review satisfies all your concerns.

Sincerely,

Paul K. Bienfang, Ph.D.
Senior Vice President
Environmental Compliance and Technology

Enclosures

CEATECH USA

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January 29, 1998

Gary Gill
Director
State of Hawaii, Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu, HI 96813

Dear Mr. Gill:

Subject: Environmental Assessment for CEATECH Hawaii Marine Shrimp Farm, Kekaha; TMK: 1-2-2:por.1 Waimea, Kauai

The attached material is provided in response to your letter of November 4th, 1997. This information will be incorporated into CEATECH USA, Inc. Final Environmental Assessment (FEA) (Section 6).

In addition to the attached, the FEA is fully responsive to all verbal and written comments received during the review period from government agencies, community input and public review.

We hope that our response to your review satisfies all your concerns.

Sincerely,

P. Bienfang

Paul K. Bienfang, Ph.D.
Senior Vice President
Environmental Compliance and Technology

Enclosures

CEATECH USA

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January 29, 1998

John Corbin, Manager
Aquaculture Development Program
State of Hawaii, Department of Land and Natural Resources
1177 Alakea Street, Room 400
Honolulu, HI 96813

Dear Mr. Corbin:

Subject: Technical and Feasibility Assessment of the CEATECH USA Development Plans for Shrimp Mariculture in Kekaha, Hawaii

The attached material is provided in response to your letter of November 21st, 1997 (EA:00168). This information will be incorporated into CEATECH USA, Inc. Final Environmental Assessment (FEA) (Section 6).

The FEA is believed to be fully responsive to all comments received during the public review. In addition to the specific responses (attached), the FEA now includes supplemental materials consisting of a rigorous Antidegradation Analysis as well as several years of comprehensive monitoring reports from the adjacent coastal environment. These materials provide a more thorough environment analysis than provided in the DEA, and substantiate positions taken within the original document concerning the lack of significant environmental impacts.

We hope that our response to your review satisfies all your concerns.

Sincerely,

P. Bienfang

Paul K. Bienfang, Ph.D.
Senior Vice President
Environmental Compliance and Technology

Enclosures

SECTION 6 : RESPONSES TO COMMENTS

6.0 OVERVIEW

This section provides responses to comments gathered from public sources and government agency review. This section is organized with the comment listed first, followed by the response and/or mitigation.

1. U.H. Environmental Center Ltr. dated November 24, 1997.

WATER REQUIREMENTS

A. COMMENT: *" The DEA fails to provide detailed data on sources and quantities of water required to operate the 104 ponds. How will this sea water be obtained?"*

RESPONSE: The project plans to acquire all of the needed seawater from wells, rather than from direct intake from the coastal waters. By not deriving the seawater directly from the surface ocean, the project avoids numerous environmental problems. Avoiding direct intake also removes the continuous uncertainty over the microbial and chemical quality of the water being drawn into the farm. Drawing the intake waters from subterranean wells, although more costly, coveys the advantage that all water is free of extraneous particulate materials and microbes, and is of constant water quality.

The aquifers of the Hawaiian Islands are everywhere surrounded by seawater which rather freely penetrates the substrate wherever the aquifer is exposed below sea level, and fluid pressure gradients permit. Because of density differences between fresh and salt water, fresh water floats on the heavier seawater underneath, and generally there is little mixing between the two waters. Notwithstanding site-site variability owing to distance from the shore, tidal influence, and permeability of the surrounding substrate, the encounter of the seawater resource is usually achieved by simply drilling beyond the depth where fresh and brackish are encountered. Seawater is recharged to the subterranean resource by the influx of seawater, driven by the pressure gradient exerted by the ocean. The constancy of the hydraulic processes controlling this phenomenon conveys unparalleled temporal constancy to the quality of seawater to be withdrawn from a given location.

B. COMMENT: *"If drawn from the ocean, where will the intakes be located?"*

RESPONSE: Per the above, seawater will not be drawn directly from the ocean.

C. COMMENT: *"Will the intakes be at the beach or on the reef?"*

RESPONSE: Per the above, seawater will not be drawn directly from the ocean.

D. COMMENT: *"How will these intakes be protected from storms?"*

RESPONSE: Per above, seawater will not be drawn directly from the ocean. There will be no intake pipes crossing the reef or beach. The subterranean well will not require any special protection from the storms.

E. COMMENT: *"If taken from ground water wells, where will the well, or wells be located and what will be the effect of the water table and lens in this area?"*

RESPONSE: Seawater for the project is to come from a number of 24" diameter wells each having an estimated depth of greater than 140 feet. For optimum drawdown hydraulics, the wells are to be located as close to the ocean as possible, i.e., along the makai boundary of the project. The tentative location of the seawater wells is shown on the figure in Exhibit N. The actual well number and location will depend in part on empirical input that will be gained from drilling of the initial wells. This is because of uncertainty concerning the exact yield from any given well; this arises from uncertainty about subterranean formations which cannot be precisely predicted. By generally conforming to predicted outcomes in terms of water quality and yield, the results from other seawater wells drilled in the area, however, have provided substantial assurance. The Table (Exhibit N) entitled "Impact Well Drilling" provides a vertical profile of the substrate composition that was encountered throughout the depth of a well drilled at the nearby Sunkiss Shrimp Farm facility, and are thought to be representative of the Mana coastal plain. The accompanying Figure (Exhibit N), "Salinity Profile and Temperature Profile", shows that the encounter of appropriate seawater occurs at a depth > 130 feet, where S ~ 34 /oo and T ~ 76 F. The hydrological information from this well indicated that the majority of seawater yield came from the coral stratum > 130 feet. Because of the extreme depth from which the seawater is withdrawn in this area, no effect to the water table or lens is anticipated.

F. COMMENT: *"Are brackish ground water anoxic, or elevated in sulfides or nitrates?"*

RESPONSE: The project's interest is in the seawater resource which lies at a depth below the "brackish" water interface. Based on drillings at the Sunkiss site, the seawater derived from wells in the area is not anoxic. The presence of some oxygen is common in the Sunkiss incoming well water; this precludes elevated sulfide levels, which are restricted to anoxic conditions. Water quality analyses have shown that phosphate is nearly undetectable, and nitrate and silicate levels (80uM and 180uM, respectively), are on the similar to concentrations found in deep ocean water.

G. COMMENT: *"What treatment or aeration facilities are needed to condition the water for aquaculture?"*

RESPONSE: Experience with the seawater well water at the nearly Sunkiss Shrimp Farm has shown that no aeration or conditioning of the water is required prior to its use for aquaculture.

H. COMMENT: *"What will be the location and the number of pumps needed to provide the necessary quantity of sea water to the ponds?"*

RESPONSE: The location and number of pumps is identical to the location and number of wells needed (see figure, Exhibit N). As stated above, the actual well location and number will depend on empirical input that will be gained from drilling of the initial wells.

I. COMMENT: *"How much electricity will be required to operate these pumps, and is this electricity currently available?"*

RESPONSE: Pumping requirements amount to eleven horse-power per pond. Sufficient on-line electrical capacity is available for the pumps. Kauai Electric Co., which recently signed contracts which would add a maximum of 37 megawatts to its total generation capacity by 2002, services the areas adjacent to the project. Additionally, the project will have back up generator capacity that is sufficient to operate all its pumps, in the event of a shutdown, or as a stand alone operation.

DISCHARGE WATER CONTENT AND TREATMENT

J. COMMENT: *"The present DEA does not provide sufficient data on contents of the discharge water or its treatment for evaluation of the project's environmental effects. It is certain that the discharged seawater from the facility will be adding dissolved and particulate nutrients (nitrogen and phosphorous) to the water which flow to the ocean. How will these aquaculture waste products be treated and delivered to the site of disposal?"*

RESPONSE: Attached as Appendix 5 to this reply is a complete copy of the Antidegradation Analysis which more thoroughly addresses this point than the discussion within the DEA. The Antidegradation Analysis was performed in support of an anticipated NPDES permit application. Specifically, pages 4 through 10 address the project's waste management strategy, aquaculture waste treatment, and the expected water quality of the aquaculture effluent. Additionally, pages 21 to 23 describe the practical limitations that preclude the application of several other forms of waste treatment processes that were also considered. Discussion referring to the solid waste aspect of the "treated and delivered of the site of disposal" question is offered below under the section **Solid Waste Disposal.**

K. COMMENT: *"Since aquaculture wastes represent an "enriched medium" conducive to the growth of microbial as well as plant and animal life, what steps will be taken to monitor the changes that will occur?"*

RESPONSE: A general overview of the proposed monitoring program within subcomponents of the waste treatment operation, the effluent stream prior discharge, the adjacent Zone of Mixing, and the coastal environment outside the Zone of Mixing is presented on page 24 of the appended Antidegradation Analysis. The monitoring effort will embrace the parameters, sampling frequencies, stations and transacts that are needed to verify compliance with the as yet unspecified requirements of the NPDES permit. The project also expects to continue and coordinate regular assessments of the extent biological communities which are currently performed by the permit holder.

It is helpful to qualify the term "Enriched Media" as used in this situation because of the irrigation water and runoff water presently discharged from the sugar cane operation on adjacent lands. The coastal environment, long a receiving water for land-based discharges, is currently a Zone of Mixing under an NPDES permit. Although the aquaculture effluent would be enriched relative to typical coastal waters, it is of comparable water quality to the currently discharged agriculture effluent. The projected concentration and loading values from various parameters in the aquaculture effluent are compared with those in the existing agriculture effluent in Figures 8-9 and Table 3, found on pages 13-14 of the appended Antidegradation Analysis. In general, the projected water quality from the aquaculture farming is as good or better than that from the existing agriculture farming.

SOLID WASTE DISPOSAL

L. COMMENT: *"CEATECH USA intends to recover and reuse settled particulates which accumulate on the pond bottom. The project proposes that this solid waste be used as a soil amendment by the Kekaha agricultural community. However, this might not be a realistic proposal due to the high content of salt."*

RESPONSE: An expanded discussion of the aquaculture solid waste recovery process is contained in the several paragraphs in pages 6 to 8 of the Antidegradation Analysis (Appendix 5). The relatively large particle size and high settling rates of the solid waste recovered from the pond bottom permit processing by mean similar to those sanitary waste treatment systems. After the water volume containing the solid waste is transferred to one of the sedimentation basins and the solid allowed to settle, the overlying seawater is decanted. The nitrogenous content, and organic content of this solid waste make it attractive to farmers. Additionally, the inclusion of shrimp carapaces (from molts), which are reported to have nematocidal properties, are of interest to the farmers because of the potential to eliminate use of a costly pest-specific pesticide. Irrigation water from the ditch network running adjacent the project is then applied and mixed to dilute the salt content associated with the solid waste. The overlying water is again decanted, and the residual solid waste transferred to a drying trough for partial desiccation. At this point the waste by-product may be alternatively processed in several direction to differing end products. The process which has attracted the most interest to date, and which has the large volume potential demand is that the desalted/desiccated pond waste would be admixed with terrestrial green waste materials and used on banana and papaya farms (Appendix 6). The appended letters represent just three expressions of interest in the aquaculture solid waste by farmers in Kauai County. The project has also received a verbal expression of interest from one of the large sugar cane operations on the West side of Kauai for use of the nitrogenous solid waste on their fields.

M. COMMENT: *"What alternative disposal methods have been considered, and what is the expected volume of solid waste requiring disposal?"*

RESPONSE: As indicated above, there have been expressions of interest from banana, papaya, and sugar cane farming operations in Kauai County. The project has also had exploratory discussions with Division of Forestry and Wildlife concerning the evaluation of the solid waste in support of creating feeding environments (away from the project) for avian populations in the region. This idea involves the use of the aquaculture waste as the organic substrate in feeding microcosms which would provide a variety of insects and invertebrates upon which the birds could feed *ad libidum*.

Tests performed at the prototype operation (Sunkiss Shrimp Farm) have indicated that the amount of solid waste purged from the bottom is on the order of 40 to 60% of the total weight of feed applied to the pond during the period between purges. Given the feeding rates anticipated this would amount to an average rate of 700 to 1000 pounds per pond per month. Individuals familiar with farming operations in the area believed that the handling of such volumes is entirely tractable. Because of the potential variability from site infrastructure, transit, and collection efficiencies the actual recovered amounts will be better known from empirical determinations made during operations. Nonetheless, it is apparent that a substantial amount of the solid waste material is expected to be recoverable and reuseable.

THE EFFECTS OF DISCHARGE ON NEARSHORE WATER QUALITY

N. COMMENT: *"The information provided on the oceanography of the receiving water is very general and insufficient to make a proper analysis of possible impacts."*

RESPONSE: Included with this reply is the following oceanographic information, which collectively support various statements, made within the DEA.

a. Section III (pages 11-17) of the Antidegradation Analysis (Appendix 5) gives a descriptive summary of the physical oceanography of the receiving environment, and the context of its historical use and applicable Hawaii Water Quality Standards.

b. Appendix 7 contains the 1997, 1996, 1995, and 1994 monitoring reports performed as part of the compliance requirements for the NDPES permit. These reports contain quantitative analysis of coral, algal, invertebrate, and fish communities within and outside the Zone of Mixing in the adjacent coastal environment. These monitoring data were collected as part of the assessment of effect of the Kekaha Sugar Company discharges on adjacent marine communities.

c. Appendix 8 contains 9 tabular summaries of water quality chemistry, taken between January 1991 and August 1997 from the adjacent coast as part of the NPDES permit requirements.

Other resources used in performing the analyses summarized in the DEA include the following:

a. The database of Doppler current profiles for the area, these records contained on 4 - 3.5" computer disks, were obtained from the Naval Oceanographic Office at the Stennis Space Center, MI.

b. The Hawaii Institute of Geophysics Technical Report HIG-69-15 by Wyrtki at al., describing coastal circulation for the area.

c. The USDA CTSA Technical Report #Y1 by Ziemann et al. (1990) which concluded that the ocean environment affronting the Mana plain has a low sensitivity to aquaculture discharges because of its high advective forces and dynamic, open coastal character.

d. Coastal current data from the corporate files of the marine hydrodynamic consultant (E. K. Noda and Associates, Inc.) which performed the hydraulic modeling effort predicting resultant water quality conditions. Though access to these records can be arranged, the physical form of these records precludes the convenient reproduction for inclusion with this response.

O. COMMENTS: *"Although reference is made (pg. 24-B) to dynamic and hydraulic modeling of shoreline effluent discharges, discussion and presentation of specific algorithms and parameters are not provided. Hence, our reviewers cannot evaluate the appropriateness of the modeling efforts, nor can we assess the validity of the asserted modeling results."*

RESPONSE: The complete consultant's report of the hydraulic modeling effort is contained in the Antidegradation Analysis, given in Appendix 5. This rigorous hydraulic moduling effort was performed for the CEATECH discharge. The model selected for evaluating the mixed effluent discharge was the three-dimensional PDS Model, which was developed under EPA sponsorship. This model incorporates all the appropriate hydrodynamic processes for addressing the mixed effluent discharge. There were several objectives of these analyses: (a) to assess whether the existing Zone of Mixing, established for the Kekaha Sugar Company's discharge from the Kawaiele drainage channel, is sufficient to accommodate the addition of CEATECH's discharge, and (b) whether the existing Zone of Mixing would appropriately accommodate CEATECH's discharge alone, exclusive of any agriculture discharge. Water quality data for the aquaculture effluent, the agriculture discharge, and receiving environment were used as input to the model.

Numerical modeling techniques evaluated the dilution characteristics for these discharges, to assess whether the water quality parameters at the boundary of the Zone of Mixing would be in compliance with applicable standards. The complete graphic and tabular model outputs for both the combined effluents, and the CEATECH effluent alone are in the appended report. In both cases wherein the plume momentum is dissipated prior to reaching the Zone of Mixing radius, a Brooks-type solution was applied to account for the additional dilution of the passive plume between the termination point of the PDS model and the radius. The resultant water quality concentrations at the boundary of the existing Zone of Mixing for both the combined effluent case, and for CEATECH's effluent alone are also shown.

The results indicate that water quality at the Zone of Mixing boundary will meet the Hawaii Water Quality Standards for all discharge scenarios considered. The model results show that in both cases the Hawaii Water Quality Standards for TN, TP, Ammonia-N, and Nitrate + Nitrite are met at the boundary of the existing Zone of Mixing. Even in the case of TN and TP, where concentrations in the aquaculture effluent will exceed those of the agriculture effluent, the model shows that the combined discharge meets Hawaii Water Quality Standards at the Zone of Mixing boundary. The model's quantitative results are very conservative, considering that there is extensive mixing/dilution of the initial discharge at the shoreline (due to wave energy and physiography of the coastal bench) which are not accounted for in the modeling technique. Thus, actual concentration at the boundary of the Zone of Mixing are likely to be lower than those predicted by the numerical model. It is also apparent that the addition of CEATECH's saline effluent to the brackish agriculture effluent, actually improves dilution/dissipation of the parameter concentrations, and improves the water quality at the boundary of the Zone of Mixing.

P. <u>COMMENT</u>: *"Lacking detailed descriptions of the regional physical oceanography and the precise chemistry of the effluents, the DEA offers no substantiation for its claim that discharges from the facility will be inconsequential. Therefore, statements such as "the project is not anticipated to adversely affect the water quality in the adjacent ocean (pg. 24-B), and "...there is no evidence of any negative impact to the water quality, or aquatic flora or fauna from the historical discharges to the area." (pg. 23-A) are unsubstantiated."*

RESPONSE: The appended documents cited (appendix 5, 7, and 8) above contain the detailed physical, chemical, and biological information in support of various statements offered in the DEA.

Physically, tidal currents dominate the nearshore circulation. The predominant current flow is northwesterly and southeasterly directions, and generally parallel to bottom contours, due to the semi-diurnal and diurnal tidal components. The semi-diurnal tidal current amplitude is 21 cm/sec, and the diurnal tidal current amplitude is 10,3 cm/sec. A net drift to the east - southwest (8.5 cm/sec) occurs, with superimposed semi-diurnal reversing tidal currents. At the project site specifically, tidal current speeds are expected to be similar, but parallel with local bottom contours offshore of the site. USGS and NOAA charts shows the bottom contours generally paralleling the coastline. The perimeter of the existing Zone of Mixing reaches 200-300 feet depths offshore of the Kawaiele discharge site. This open, well flushed coastal setting displays a low sensitivity to land-based discharge inputs. An analysis of the coastal environments surroundings all of the major islands was conducted in 1990 to assess the relative potential for impacts from aquaculture discharges for all shoreline ares. The key parameters used in this analysis included the dominant biological community type, the nearshore physiography, the prevailing wind direction, and the location of the wave breakpoint. More detailed analyses considered the near-shore current patterns to ascertain the natural capability of the environment to flush the area, and the historical use of the area which reflects the degree of pristine character at the time that effluent effects are being evaluated. This work concluded that the ocean environment affronting the Mana plain of Kauai has a low sensitivity to aquaculture discharges (see page 17 of the appended Antidegradation Analysis). This finding, indicating a low probability for negative ecological effect from aquaculture discharge, reflect the naturally high advective forces, and open coastal character which give this envirnment a high self-cleaning potential.

The relevant water chemistry is found in the historical summaries of nearshore water quality (Appendix 8), and in the Antidegradation Analysis (Appendix 5) which compares the present agriculture and projected aquaculture concentrations, and uses these data to predict resultant water quality in the surrounding waters.

Baseline information on the nearshore biological communitiesis given in the monitoring reports for the last four years (Appendix 7). The following statements,from the most recent of these reports, support various statements made in the DEA:

a. "Examination of the survey results indicated that these does not appear to be any pattern of coral community structure that are functions of distance from the sugarcane water discharges... it appears that there has been no decrease in coral cover... It can therefore be implied that there is no effect to coral community structure from Sugar Mill discharge."

b. "There was no indication of any effect on algal communities from sugarcane discharge."

c. "Reef fish community structure appears to be largely determined by the topography and composition of the benthos. All of these results suggests that there has been no negative effect to fish abundance as a results of discharges from Kekaha Sugar Company."

d. "None of the data obtained in the monitoring surveys indicates any impacts from the Kekaha Sugar Company discharges to marine communities on the reefs adjacent to the discharge. Such a result is not unexpected as the discharge plumes are observed to mix rapidly with ocean water to background concentrations by natural turbulent conditions. Rather, marine communities appear to be primarily controlled by natural physical factors associated with wave energy, sediment scour and substrate complexity"

Q. COMMENTS: *"These statements do not seem to take into consideration that the project will almost certainly be discharging a more nutrient-rich effluent than is presently discharged, and that it will be a continuous discharge of salt water, not fresh water. Agricultural wastes and effluents, except for the presence of toxic chemicals (which are not as prevalent in the sugar cane industry), are a lot "cleaner" than aquaculture waste which contain a greater amount of organic waste. Therefore the statement that "...the quality of the effluent discharge will improve over its current condition..." is unsubstantiated without any support documentation."*

RESPONSE: The replies offered above under the sections Discharge Water Content and Treatment, and The Effects of Discharge on Nearshore Water Quality are germane to this comment. They indicate that the project water quality of the proposed aquaculture effluent is similar to that of the existing agriculture effluent (Note especially pages 13 -14 of Appendix 5). The historical monitoring studies (Appendix 7) indicate that the biological communities in the adjacent coastal ocean show no indication of a deleterious effect from the chronic agricultural discharge. Because addition of saline (i.e., 34 o/oo) aquaculture effluent to the current brackish (i.e., 10 o/oo) agriculture effluent improves the speed with which mixing and dissipation occur in the surrounding waters, chemical concentrations more rapidly attain background levels. Hydraulic modeling of the system predicts that combined discharge of agriculture and aquaculture difference would result in similar water quality conditions as those which currently prevail, which have not shown negative impacts.

AVIAN LIFE AND SMALL WILD-LIFE

R. COMMENT: *"The DEA does not provide a study on precautions or controlled measures that need to taken to handle changes in avian life and small wild-life populations. Since there will be a greater attraction of avian life both in numbers and possibly different species, there is a potential for transmission of infectious diseases by avian hosts, rodents and other fauna."*

RESPONSE: The entire area of the proposed project occurs on land that was previously under sugar cane farming. The lack of using any uncultivated lands mitigates the likelihood for habitat elimination or the possible encounter of some special or unique habitat, since all project lands have been actively and recently farmed. The landfill site several miles from the project has been an attractant to avian populations and associated with several instances of waterbird botulism, however the conspicuous differences between that operation and this marine aquaculture project preclude much appropriate comparison. Information from specialists familiar with the area's avian populations indicate that by far the preferred habitat in the immediate area is the extensive network of ditches which are used to convey irrigation and flood waters through the area. Virtually all of this ditch network is unaffected and resides upstream or mauka of the proposed project. The project plans to continue the practice exercised by the existing agriculture tenant of maintaining the ditch environments to prevent overgrowth in those ditches abutting the project. No significant loss of habitat is anticipated.

The physical design of the lined, round pond does not provide an environment that is conducive to successful feeding by avian populations. This feature marks a salient difference from the traditional, gently sloping, dirt bottomed shrimp ponds with which most people are familiar; these ponds did indeed attract birds by providing successful feeding encounters. The slick liners covering the steeply sloping berms, do not promote casual habitat exploration by birds, and deters successful foraging, feeding and reinforcement when feeding is attempted. The operation of the nearby Sunkiss Shrimp Farm, that uses this same pond design, confirms the ponds' lack of a pronounced attraction factor to birds. The Sunkiss operation has not even seen fit to install the protective birdnet equipment, reserved as a contingency for the farm. The experience there had been that birds did indeed initially display a heightened interest to the new water environment. This interest was a limited duration when they were unsuccessful at accessing food (shrimp or feed), and the birds lost interest in the farm. The ease with which the birds moved elsewhere may also be due in part to the extensive areas for suitable foraging, such as the ditches and seedcorn farms, that exist in the proximate surroundings. The project has had discussions with the Wildlife Manager of the Division of Forestry and Wildlife concerning various implications to avian issues by the project.

One topic, concerning the newly created environments represented by the solid waste settling and drying basins, confirmed that these impoundments would be constructed in such a way that they could be covered in the event that avian access was subsequently deemed to be a problem. The other topic explored the opportunity to cooperatively evaluate whether and how the settlable aquaculture solid waste material might be positively applied off the project site to the creation of feeding areas for birds which are transiting the region. The bird attraction that occurred in other shrimp farms is not expected to occur.

Evidence of feral mammals in the vicinity is restricted to rats, field mice, and the feral cats that feed upon them. The habitats of these animals are the sugar cane fields in the area. Since the project will occupy only a small fraction of the adjacent land in sugar cane, the vast majority of the preferred habitat for these animals will remain unaffected. The feral rats, mice and cats are expected to exert their preference for the seclusion offered by the sugar cane fields to the open exposed environment of the aquaculture ponds. Experience at Sunkiss Shrimp Farm in the area confirms the absence of a pronounced encounter with feral animals. The careful storage of shrimp feed in enclosed rooms, eliminated this potentially significant attractant from creating an interest for the area by these populations. A pet cat of that operation returns from hunting with "a trophy" only about once a month, and it is not certain that all of those encounters occur on the farm site itself of in adjacent fields. In the prospective operation, feed will be stored in enclosed refrigerated containers at all times and for both financial and sanitation reasons will not be allowed to become an attractant to these populations.

SPECIFIC PATHOGEN FREE SHRIMP

S. COMMENT: *"Our reviewers also noted that exclusive use of even the sixth generation of specific pathogen-free high health shrimp does not preclude the presence of other infections agents. Such SPF animals are only monitored for some eleven infectious agents, and may carry other infectious agents not currently monitored."*

RESPONSE: This is obviously true. Use of SPF animals does not preclude the presence of other, as yet unidentified, infectious agents. Years ago, the nomenclature "specific pathogen free" was selected over the term "disease-free" on the advice of agriculture's high health animal breeders for that very reason, i.e., it is intractable and unreasonable for a breeder/supplier to imply the exclusion of all infectious agents, both known and unknown. These SPF populations do represent the state of the art in shrimp genetic stock. Those infectious agents that are included in the list avoided by the series of challenges to attain the specific pathogen free status do, however, identify those important pathogens that have been associated with shrimp aquaculture and/or native shrimp populations. This list of infectious agents screened for SPF was prioritized to include those prominent in other culture experience. The infectious agents included in the SPF screening also could be expanded, should future research or culture experience (anywhere) indicate that its prudent to do so.

In addition to use of SPF stocks, biosecurity measures to be applied by CEATECH include design of facilities and operational protocols. All SPF shrimp stocks are screened on a regular basis to repeatedly confirm their SPF status; this is performed at multiple stages of the life cycle.

It is the generally accepted position of the pathological experts in the field that the screening methods contained within CEATECH's animal health management system provide the most effective and sound means to assess the health status of shrimp stocks routinely. The design of hatchery and production facilities is also to prevent transmission of shrimp pathogens in either direction. Use of the enclosed hatchery structure is identical in design to a quarantine facility operated successfully for years by the U.S. Marine Shrimp Farming Consortium. Similarly, control of both pedestrian and vehicular access, accompanied by routine decontamination protocols are designed to continuously mitigate contamination risk. The production units also include a regimen of regular screenings for a variety of animal quality, vigor, and performance criteria to continuously confirm the high health status of animals being farmed.

TURTLES

T. <u>COMMENT</u>: *"One of our reviewers noted the presence of a large population of endangered sea turtles in the proposed discharge area. What will be the effect of effluent rich in organic and inorganic waste on the coastal environment and subsequently on the turtle colony."*

<u>RESPONSE</u>: The green turtle population (Chelonia mydas), the principal specie of sea turtle in the Hawaiian Island, is genetically discrete and geographically isolated. Published information from the National Marine Fisheries Service indicates that the Hawaiian population has responded favorably to twenty years of recovery, due to the cooperative conservation efforts of several State, Federal, and private agencies/organizations. The number of sea turtles nesting and the number of sea turtles observed in Hawaiian waters has increased each year.

The first part of the reply addresses the issue of turtle presence/abundance in the area. In an attempt to identify scientific studies to support the anecdotal report of a "large population...in the discharge area", we contacted the National Marine Fisheries Service

(NMFS) because they are frequently regarded as the scientific authority on sea turtles. NMFS personnel indicated that there are no turtle abundance data for the Mana shoreline specifically. They also said that the Mana area was not one of the study sites that were selected for regular monitoring in their ongoing statewide survey effort. NMFS personnel suggested that we examine the popular diving literature to determine if recreational divers were being directed the Mana are for the purpose of sighting turtles. The examination of such literature showed no recommendations of the Mana area for its turtle siting potential. We then also pursued the issue through interviews with recreational divers on Kauai, this source did indicate that they had seen turtles during dives along the Mana coastline. Thus, although scientific data could not be found, anecdotal reports did confirm that it's reasonable to expect at least occasional presence of turtles along the Mana coastline.

The second part of the reply addresses the likely effect of an aquaculture discharge to animals in the vicinity. Addition of an aquaculture discharge to the agriculture discharge entering the coastal ocean is not expected to effect the reproduction, feeding, interaction with commercial fishing vessels, or the incidence of fibropapiloma disease. Reproduction should not be impacted because nesting is understood to occur exclusively at the French Frigate Shoals in the Northwest Hawaiian Island, not on shores within the main Hawaiian Islands. Turtles observed around the main Hawaiian Islands are mostly immature animals in the forming process. As herbivores, they gaze on benthic algae. The predominant algal benthic algal biota re sparsely populated low-relief turfs of various species of benthic algae; corals are also sparsely distributed and occur predominantly as flat encrustations on the low-relief bottom. The ocean environment adjacent the proposed aquaculture discharge point has a long history as recipient of discharge from agriculture operations in the watershed. That turtles are reported as being observed in the vicinity suggests that this prolonged period of land based discharge has not discouraged individuals from transacting and/or foraging in the area. The projected water quality from the aquaculture farm is anticipated to be as good or better than that from the agriculture operation. and at smaller loading rates. A hydraulic modeling effort was performed for the combined agriculture and aquaculture discharge scenario (see Section 4.2 of the Antidegradation Analysis attached Appendix 5). This effort confirmed that, at the boundary of the existing Zone of

Mixing, the concentrations of various water quality parameters would meet the Hawaii Water Quality Standards as is the present case. Thus, addition of the aquaculture discharge is not anticipated to change the water chemistry or aquatic biota along the adjacent coast, and therefore is not expected to alter the foraging environment for feeding turtles in the area. Commercial fishing interactions, a prime mode of turtle mortality, has no relationship to the proposed land-based culture activities, and thus should not be affected.

Ongoing field work assesses fibropapilloma infection rates at turtle foraging pastures throughout the Hawaiian Islands. These studies show that the highest prevalence within the Hawaiian Island occur at area of Oahu, Maui, and Molokai; currently, the island of Kauai is not mentioned among those locals. For as long as comparative data are available, the island of Kauai has had the lowest reported incidence of stranded, injured or diseased turtles of any Hawaiian island, except Molokai. Recent data also show that green turtle populations associated with Kauai are among those with the lowest incidence of disease. These data suggest that the present discharge situation and prevailing history of land-based discharge is not reflected in any higher incidence of the principal disease concern for turtles. The addition of seawater of similar water quality to the brackish irrigation water being discharged is not expected to influence this, and no effect is anticipated.

KAUAI ECONOMY

U. COMMENT: *"The DEA does not provide a detailed study on wider impacts of the proposed action on the island of Kauai. By their own admission CEATECH USA anticipated changes in the economic status of the community (pg. 54-4), but discussion of social and economic impacts in the long term is generally lacking."*

RESPONSE: The project will provide economic development and much needed employment within the diversified agriculture sector. The project relies on climatic and technological features where Hawaii has comparative advantage over other locales. This aquafarming effort takes advantage of the availability of land, labor, isolation, and warm climate to produce a high value commodity while retaining the rural character of the community. The phased growth effort is expected to compliment and augment current farming in the area, and has every potential to provide additional economic stimulus through a primary industry that is based on existing resources. The project will result in increased job opportunities and spin-off businesses from increased activity in farming and crop production.

The project is expected to improve the island's export capability, and general socio-economic health. This shrimp farming can help mitigate the economic losses to Hawaii's slipping economy, and the associated loss of employment tax revenues. Sugar has traditionally shown an average cash yield per acre of about $2,000 per acre per year. The proven annual yield of this shrimp technology in the area would be equivalent to gross revenues of about $250,000 per acre pond per year. Such alternate uses of Hawaii's agriculture lands, becoming available because of progressive changes in that industry, need to be pursued for the economic future of the area. Revenues from a full 104 pond operation are estimated to exceed $20 million annually. Total construction costs for ponds and necessary infrastructure are expected to exceed $8 million. Such figures suggest that the economic impact going into the island's community can be substantial. Using a multiplier of 2.1 (the Hawaii input/output model uses 1.97 for agriculture and 2.23 for fishing) of the indirect economic activity, the total going into the community from the operation is estimated to be over $40 million, Hawaii is at a critical stage of industry and economic development. Though tourism and military will likely continue as flagships of our economy, the agriculture component, which for years was sustainable, will benefit from new stimulus and development. Establishing Hawaii as a new, principal supplier of a superior high-value product to an established seafood market for shrimp is lined to that economic opportunity.

Unfortunately, the island and especially the West side of Kaui, currently has a high availability of a farming labor pool. This is due to economically difficult times. Downsizing by Kekaha Sugar Company and McBryde Sugar Company has increased unemployment in the area. New CEATECH farm personnel are expected to consist primarily of Kauai residents with experience in farming operations and who are willing to participate in training programs. This additional farming operation is expected to have a sustaining effect tot the employment perspective for Kauai and, to a modest degree, the State *in toto*. the first phase of 52 ponds is expected to create more than 50 jobs, a portion of which would be full-time positions. Similar numbers are expected at completion of the subsequent phase. The project offers a new dimension to the perspective of farming which may be more attractive to the younger generation of farming families who are increasingly eschewing the farming lifestyle. Also, results of an informal Hawaii Farm Bureau Federation survey indicated that potential entrants to farming tend to prefer windward locations; this mitigates the likelihood for competition with new agri-farmers for farm sites in this specific.

The continental U.S. is the target market for most of the shrimp to be produced. Americans consume over 850million pounds of shrimp annually, 75% of which is imported. At an annual level of $2.5 billion, shrimp is consistently the largest element of the U.S. trade deficit in seafood. A substantial portion of this domestic demand has been met by aquacultured shrimp produced outside the United States. It has been the intent in the years of federal funding for shrimp technology development that the shrimp component of the fisheries trade deficit could be reduced through domestic production.

The State of Hawaii has actively promoted aquaculture industry development. In the 1970's, and Aquaculture Development Program was established within the Department of Land and Natural Resources. Via publication of the State's Aquaculture Development Plan in 1979, Hawaii became first in the nation to formalize its strategies in support of this form of diversified agriculture. The former governor described aquaculture as "a global growth industry...anchored in traditional practices and rocketed to higher levels of performance by new technologies". The State's support is rooted in the conviction that the benefits of aquaculture will significantly contribute to the economic, social, and environmental well being of the people of Hawaii. Hawaii is a sophisticated seafood market with per capita consumption more than three times the national average, and two State departments which actively promote the sale of Hawaiian seafood outside the state.

Governmental encouragement has been set on converting Hawaii's isolation, and high level of resident technical expertise into business advantage. Year-round production potential, isolation from other shrimp farming operation, global demand for high quality shrimp, and proximity to both U.S. and Asian markets are competitive advantages advanced by the State. The annual report of the Governor's

Aquaculture Advisory council described 1996 as the first year that the dollar value of the production segment of Hawaii's dual sector industry surpassed the technology development/transfer segment. A supportive political administration, together with increasing willingness to diversify traditional sugar lands into aquaculture production point toward continued aquaculture growth in coming years. This mirrors the positive support for the CEATEACH project in particular by various agencies in the Kauai county government, and several prominent business organizations on Kauai. This support is reflected in part by several letters of support which are included in this summary of communications on the DEA.

There are several other socio-economic benefits to the community arising from the proposed project. In the log-term, prime agriculture lands are protected from being fragmented through subdivision or other sub-plotting methods that would otherwise reduce Hawaii's capacity for future farming opportunities. By providing an additional tenant, the project assists in long-term protection of the existing drainage infrastructure that consists of ditches, culverts, and pumps, which maintain the groundwater level and allows the plans to be farmed by the various users.

The project supports the goals of the Waimea-Kekaha Regional Development Plan by "crating a new opportunity for greater diversity of employment", promoting "the improvement and expansion of the region's economy, by recognizing and carefully utilizing land and water resources". The project will help to maintain the "agricultural dedication" designation of the lands through active, responsible and profitable agriculture, and in so doing will provide greater revenue returns to the State and County governments.

The project offers much needed economic impacts to Kauai's West side in particular which is one of the most economically disadvantaged regions on the island.

The project is a positive component of Kauai's continuing efforts to recover from the devastating losses incurred by Hurricane Iniki, and pursuit of its economic sustainability and social stability.

DRAINAGE

V. COMMENT: *"The absence of detailed maps made it difficult and sometimes impossible to follow the location of the proposed drainage system, and to evaluate the site location as it related to tsunami and flood hazard zone."*

RESPONSE: The attached trio of maps (Exhibit O), the overview of the drainage history of the Mana Plain (below), and an elaboration of the construction details of the drainage plan (below) better describe the existing drainage ditch network and its relationship to the proposed aquaculture operations. Figure (1) (Exhibit O) shows the series of canals and drainage ditches that historical use of the area has required.

Kekaha Sugar Company Ltd.. has been farming the Mana Plain for approximately 100 years. Through this period extensive efforts have been undertaken to reclaim lands that were previously flooded. It is estimated that 1000 to 1500 acres my have been submerged at one time or another. Three major swamps (Kawaiele, Nohili, and Kolo) comprised the much of this area. In the early 1900's an aggressive plan to drain these swamps as undertaken to promote agricultural expansion. The plan included a series of ditches, canals, diesel pumps and outfalls. All of this would eventually prove to be very successful not only in draining theses swamps, but also in conveying irrigation water throughout the field parcels, preventing flooding, and purging the area of agricultural wastewater or tailwater.

This system work fine for most of the time, but had is limitations, The Mana Plain acts like a large sponge sitting in the middle of a huge bowl. The land can absorb (i.e., percolate to the water table) great amounts of water, but when it receives too much at one time, it overflows. Historically this overflow would find its way to the ocean through natural channels such as those at Kinikini and Nohili. However, the plantation realized early on that these natural channels not only channeled water off the property, but also permitted seawater intrusions. Such seawater intrusion would pervade the canal system and cause salt accumulation in soils toward more mauka reaches of the property than were deemed acceptable because of the reduce crop yield it caused. This was remedied via the blockage of natural channels to prevent seawater intrusions and the subsequent reliance upon pumping to transport the drainage water in a controlled way over the berm to the channels leading to the ocean, Occasionally, a rainstorm of the twenty-year magnitude would deposit more water into the basin than the pump capacity. When the inflow from rains and runoff exceeds the outflow capacity of the pumps, the canal levels rise about their banks and into the farm fields. To further improve the system, additional pumps including attendant infrastructure would have to be added to increase the discharge capacity, but the financial state of the plantation has not allowed for such a costly undertaking. Therefore periodic flooding has continued to occasionally occur, especially during very severe Kona storms. Understanding this basin behavior was extremely important to the way in which the CEATECH project developed its drainage and flood control plan.

The land targeted for CEATECH's aquaculture operation consists of field plot numbers 316, 419, 420, and the portion of 421 that is makai of the Kaumualii Highway. Figure 2 illustrates (in green) the areas to be bermed. A berm of at least five feet above mean sea level will be constructed along the entire seaward boundary of the prospective property. Professional knowledge about the area indicates that water levels have never exceed four and one-half feet above mean sea level; this occurred in 1992 during Hurricane Iniki, and was also associated with the interruption of power to the pumps. Berms will also be made to border the sides of the canals which separate filed plats 420 and 419, and 419 and 316. By constructing the berms and dikes o the five to six four level, a freeboard of soundness and impermeability during periods of maximal loading, these berms will be approximately twenty-five feet wide, constructed to a slope of 3:1, and compacted to a minimum of 90%. Via construction of the berms and dikes surrounding the subject property, the risk of flooding is eliminated or greatly reduced without disrupting the agricultural drainage flow. Dikes will be instructed with materials derived on site. The mauka boundary of the subject property will be graded to at lease eight feet above mean sea level. The aquaculture effluent will be routed along the makai boundary of the property, as shown in red on the attached Figure 3.

Surface waters and aquaculture discharge will be evacuated via the series of canals and ditches using booster pumps that are controlled by probes. The probes will be adjusted to maintain canal water levels between 2.0 and 2.5 feet below mean sea level Several booster pumps will also be equipped with variable speed motors to insure effective water management within the canal. Backup boosters are also planned to handle the amount of runoff which would be associated with an eight inch in twenty-four hour storm event. The consolidated discharge is to be direct to the point commonly known as Kinikini i ditch, where there is an earthen berm designed to prevent seawater intrusion. This berm will be relocated several hundred feet mauka (i.e., north) to a point near the makai boundary of CEATECH property to receive the seawater discharge. This relocation of the berm also allows for the independent monitoring of the agricultural and aquaculture discharges as a matter of routing. In emergency conditions (i.e., storms so severe as to cause canal waters to reach a height of 2.5' above mean se level) this plan also allows for the temporary removal of the berm to greatly augment the floodwater transit.

Additional safeguards will be employed within CEATECH's property bounds to storm-proof its growout operation. Each one acre pond is to be given a surrounding berm constructed using fill and compact methods. In so doing, the height of the individual pond berms will be similar to the height of the protective dike at approximately 6.0' above mean sea level. The majority of the project's land area lies at 3.0 to 4.0 feet above mean sea level; therefore the fill/compact construction method, is the logical choice.

The plan accomplishes several major objectives. (1) It prevents the flooding of lands to be used for aquaculture. (2) It provides for the continued and unaffected transit of the present agricultural discharge. (3) It provides for and will likely improve the capacity b which flood waters can transit the Mana Plain during severe storm events. (4) It provides for the independent monitoring of the agriculture and aquaculture discharge streams. Success of the plan requires cooperation by the sugar company and the State, and the timely enactment and proper installation of all major components. This plan was developed through the input and direction of an individual with more than twenty years experience as irrigation systems supervisor and manager of agriculture operations for the Kekaha Sugar Company. During this time he devised and supervised many drainage improvement project. This background provides to CEATECH's plan a profound understanding of the Mana Plain drainage and the interrelated workings of its ditch and canal network. The project is also working with the USDA Natural Resource Conservation Service in the final design of facility layout to mitigate erosion.

V. COMMENT: *"The DEA discusses the site location and Best Management Practices as it relates to the project being located in the flood zone, but there is no discussion to the fact that the project site is within the Tsunami inundation zone."*

RESPONSE: Section 4.3 discusses the Federal Insurance Rate Maps as they relate to the subject property. Portions of the property are situated with the VE zone which is characterized as inundation areas supported by high velocity flood waters.

2. Office of Environmental Quality Control Ltr. dated November 4, 1997

A. COMMENT: *"Many of the maps are quite old and/or unclear. Please provide updated maps for the following:*
   * *FIRM Map*
   * *Land Use Commission Map does not show the portion of the project site which falls in the Conservation District, as mentioned in Section 4.1 Zoning*
   * *Site Map; also indicate the project location on the regional map, Exhibit A"*

RESPONSE: The FIRM Map has been revised (Exhibit M). The LUC Map correctly shows that the project site does not fall within the State Land Use Conservation District. Additionally, the clarity of all maps have been upgraded.

B. COMMENT: *"Section 1.4.1, Location, states that this sanctuary (Kawaiele Sanctuary) lies to the south of the project site. In the final EA, give a full description of the sanctuary and indicate what measures will be taken to protect the sanctuary from both construction and operational impacts, such as runoff, impacts to the underground and surface water systems, and impacts affecting viewplanes of the sanctuary from mauka locations."*

RESPONSE: The Kawaiele Sanctuary was re-established as a bird habitat in the early 1990's. It was improved in conjunction with a sand mining project by the Department of Land and Natural

Resources. The sanctuary consists largely of dune formations surrounding an exposed brackish surface water area. Long-range conceptual plans include a visitor center, walking trails and signage.

According to Division of Fish and Wildlife personnel, the underground and surface water systems should not be affected since the sanctuary is considered "uphill" and adjacent to the project. This will cause water to move along a gradient away from the direction of the sanctuary.

Relative to viewplanes, there will be no conflicts since the two projects lie side by side along Kaumualii Highway, and are visible to passersby. The ponds will have low vertical relief and will not intrude upon the sanctuary experience. Visually, both projects consist of natural materials, (i.e., sand, soil, and water); this similarity promotes visual compatibility.

C. COMMENT: *"When the adjacent Pacific Missile Range Facility prepares to launch, will Ceatech have to cease operations temporarily or evacuate the premises, as had happened in the past to the immediate neighbors? Are there any other impacts on Ceatech from PMRF activities?"*

RESPONSE: CEATECH USA, Inc. understands and intends to comply with the provisions of the Safety Zone Agreement which was established for the pre-launch and launch activities at PMRF. The purpose of the safety zone is to create a situation for public health, safety and welfare during missile launches.

Aside from occasional periods of evacuation, there are no other negative impacts that are expected from PMRF activities. CEATECH USA, Inc. anticipates PMRF to continue to be excellent neighbors as they have demonstrated in the past.

D. COMMENT: *"In the final EA include copies of any correspondence with consulted agencies, organizations or individuals."*

RESPONSE: See Appendix 9.

3. Department of Land and Natural Resources - Aquaculture Development Program Ltr. dated November 21, 1997

A. COMMENT: *"Disadvantage of round pond technology include; it uses a lot of water relative to other technologies..."*

RESPONSE: When water use is normalized per pound of shrimp, water useage per unit shrimp is actually less. The round pond production technology uses on the order of 10 to 20 percent of the water needed to produce a pound of shrimp compared to the other methods. This makes it intrinsically conservative relative to water consumption. In addition, the farms use of seawater rather than fresh water avoids additional burdens upon the fresh water aquifer.

B. COMMENT: *"A National Pollution Discharge Elimination System (NPDES) permit and Zone of Mixing (ZOM) permit has been granted by the State Department of Health (DOH) to Kekaha Sugar Company (KSP) for direct discharges of 100 MGD for the dry season and 200 MGD for the wet season."*

RESPONSE: CEATECH USA, Inc. is simultaneously pursuing acquisition of a separate NPDES Permit to allow discharge from outfall 002 into the established zone of mixing. The physical separation of discharge streams prior to release will allow for the independent monitoring of effluent compositions.

SECTION 7.0

CUMULATIVE IMPACTS SUMMARY

SECTION 7 : CUMULATIVE IMPACTS SUMMARY

Human activities regardless of the type, involve a potential to affect the surrounding. Human activities usually revolve around the need to provide shelter, food, education and clothing for families. The CEATECH USA, Inc. project is no primarily about technology or scientific farming innovations, but rather about participating in the Kauai economy to improve the quality of life on the island. It brings to the area a type of farming which is consistent with the community setting, the manpower availability, and the historical uses for which the area has bee planned and zoned. This participation takes on the form of employment to residents, improved revenues to State and County coffers, diversification to the agriculture industry, and broadens the island's economic base. Equally important, the project offers the introduction of "new" money, from outside the State to the Kauai economy.

The costs at which these benefits are derived appear to be very modest. Project evaluation show that most of the impacts associated with the operation are not significant. The most salient concern relates to the treatment and disposal of the marine aquafarming wastes. The project has proposed a system to optimize waste recovery and use. Modeling analysis indicate the rapid dilution and dissipation of constituent concentrations within the nearshore ocean. The quality and quantity of the effluent anticipated from the aquaculture project are generally better than those of the current agriculture use, the latter of which has operated for years without significant adverse environmental impact. The additional aquatic discharge will not compromise the protected uses of the nearshore area. Cumulatively, the project does not pose a prominent threat to the surrounding climatic, visual, terrestrial, aquatic, historical, or biological setting.

The proposed project is consistent with the historical and cultural land use setting. It is basically a farming project which is to be located in a rural, agricultural setting. The project will blend seamlessly into the surrounding agricultural setting, environmentally, socially, and economically. Cumulatively, the project offers much needed positive impacts to the employment and economic climate. It is a positive and necessary component of Kauai's continuing efforts to recover from the devastating losses incurred by Hurricane Iniki, and to assure its future economic sustainability and social stability.

SECTION 8.0

FONSI DETERMINATION

SECTION 8 : FONSI DETERMINATION

To assist in this determination, the "significance criteria", Section 12 of the Hawaii Administrative Rules, Title 11, Chapter 200, were reviewed within the context of the project. After careful analysis, the following was concluded:

1. *The proposed project will not involve an irrevocable commitment to loss or destruction to any natural or cultural resources.*

   Response

   The entire project site was historically cultivated with sugarcane. As a result, the soil received rigorous grubbing, grading and deep tilling earthwork every 1-2 years. Any natural or cultural resources which may have existed on the property is believed to have been lost. All construction for the proposed aquaculture activity will occur in areas previously disturbed, utilizing existing drainage ditches as appropriate. A Comprehensive Archaeological Survey conducted on the site did not reveal any cultural material or sites.

2. *The proposed project will not curtail the range of beneficial uses of the environment.*

   Response

   The proposed action represents the highest and best use for the property. Upon implementation, the farming operation is expected to enhance the presently unproductive lands by diversifying the agri-business economy of westside Kauai through higher employment, higher tax revenues, and improved environmental conditions.

3. *The proposed project will not conflict with the State's long-term environmental policies.*

   Response

   The proposed action is consistent with the State of Hawaii's environmental policies, in that the near-shore marine environment is expected to improve with reduced siltation, reduce fresh water discharge and improved water clarity.

4. *The proposed project will not substantially adversely affect the economic welfare, social welfare, or public health of the community.*

Response

To the contrary. The proposed project is expected to improve the economic status of the community by providing employment and improved tax revenues. Social welfare often reflects the community's economic condition - when money is available, social problems tend to disappear. Public health is served when improved tax revenues are invested into public facilities and services.

5. *The proposed project will not involve substantial secondary impacts, such as population changes or effects on public facilities.*

Response

The proposed project will stimulate new employment opportunities for local island residents. CEATECH USA, Inc. does not intend to import off-island labor, but rather to take up the slack created by the reductions of sugarcane operations, and the available labor pool on Kauai, which has the highest unemployment rate in the State.

6. *The proposed project will not involve a substantial degradation of environmental quality.*

Response

The proposed drainage system is expected to control the discharge of wastewater and floodwaters from mauka lands from emptying directly into the ocean a series of retention ponds will allow the retained water to evaporate, oxidate wastes, and settle out particulates prior to reaching the ocean.

7. *The proposed project will not have cumulative impacts or involve a commitment for larger actions.*

Response

The proposal is a self-contained stand-alone facility. All impacts associated with the operation are either temporary or can be properly mitigated on-site.

8. *The proposed project will not substantially affect any rare, threatened or endangered species of flora or fauna or habitat.*

   Response

   The project site is not designated as a protected area for endangered terrestrial species. It is very likely that with the abandonment of traditional cane harvesting methods (grub and burn), indigenous birds and mammals could return to the area. In addition, native plants previously found in the area could be reintroduced into the landscape.

9. *The proposed project will not detrimentally affect air or water quality or ambient noise levels.*

   Response

   The air quality in the area will be temporarily affected due to construction activities. Fugitive dust, hydrocarbons, and particulates will be dispersed into the atmosphere. It is expected to return back to pre-construction levels once the improvements are complete. These are minor perturbations compared with the historic cane cultivation and harvesting activities. These minor impacts can be controlled by watering the site with sprinklers and water wagons and hoses. It is also expected that hydrocarbon emissions would be quickly dispersed by the tradewinds. There are no residential settlements in the area.

10. *The proposed project is not located in an environmentally sensitive area (e.g., flood plain, tsunami zone, coastal area).*

   Response

   Relative to the Federal Flood Insurance Rate Map (FIRM) Panel 100 of 225 for Kauai County, the subject property lies within Zone A, which is identified as a special flood hazard area inundated by the 100-year flood. Zone A does not have base flood elevations determined and flooding is more riverine in nature, versus coastal flooding forces which exhibit a velocity hazard. A review of the FIRM map indicates that land formations both landward (highway) and seaward (PMRF) are higher in elevation, having been designated Zone X-unshaded which are those areas to be outside the 500-year flood plain.

11. *The proposed project will not substantially affect scenic vistas and viewplanes identified in county or state plans or studies.*

Response

The project site is not within an area designed as having special view corridors. The views towards the ocean are not particularly great, bearing in mind that the PMRF facility sits between the affected site and the ocean. Once completed, however, the project will provide and interesting sight for locals and visitors passing by. The primary views, when viewed from the highway, is to the foothills and mountains.

12. *The proposed project will not require substantial energy consumption.*

Response

The proposed project does not create a burden on the utility company to upgrade its existing infrastructure to provide electrical service. Power is required to run circulation pumps, aeration equipment, lights and usual maintenance equipment. Where possible, energy saving features shall be incorporated into the system.

SECTION 9.0

CONCLUSION

SECTION 9: CONCLUSION

Having examined all of the evidence gathered for the Draft EA and Final Report, it can be concluded that the proposed action will no have a significant negative environmental impact, the proposed mitigation measures will ameliorate anticipated concerns and therefore will not create cumulative negative effects upon the natural resources of the area. All cultural concerns have been mitigated with the preparation of an Archaeological Inventory Survey study. The facilitation of a pre-construction meeting will inform all participants of the importance and the process for treating cultural material discoveries uncovered during construction activities. Inadvertent burials will be treated under Chapter 6E HRS Provisions and DLNR-SHPD programs.

The preparation of an Antidegradation Study demonstrates through modeling methods that the nearshore water quality will comply with State of Hawaii water quality standards. The introduction of CEATECH saline effluent to the existing brackish water discharges improves the dilution/dissipation of total freshwater concentrations and further improves the water quality at the boundary of the Zone of Mixing.

SECTION 10.0

CONSULTED PARTIES

SECTION 10 : CONSULTED PARTIES

FEDERAL:

U.S. Army Corps of Engineers
Pacific Missile Range Facility
Senator Daniel Inouye
Soil Conservation Services

STATE:

Department of Education
Department of Land & Natural Resources
Department of Transportation
Office of Environmental Quality Control
State Historic Preservation Division
Department of Health
Department of Agriculture
Office of State Planning
Office of Hawaiian Affairs
Department of Hawaiian Home Lands

COUNTY:

Office of the Mayor
Planning Department
Department of Public Works
Department of Economic Development
Kauai County Council
Fire Department
Department of Water
Police Department

SECTION 10 : CONSULTED PARTIES (cont'd)

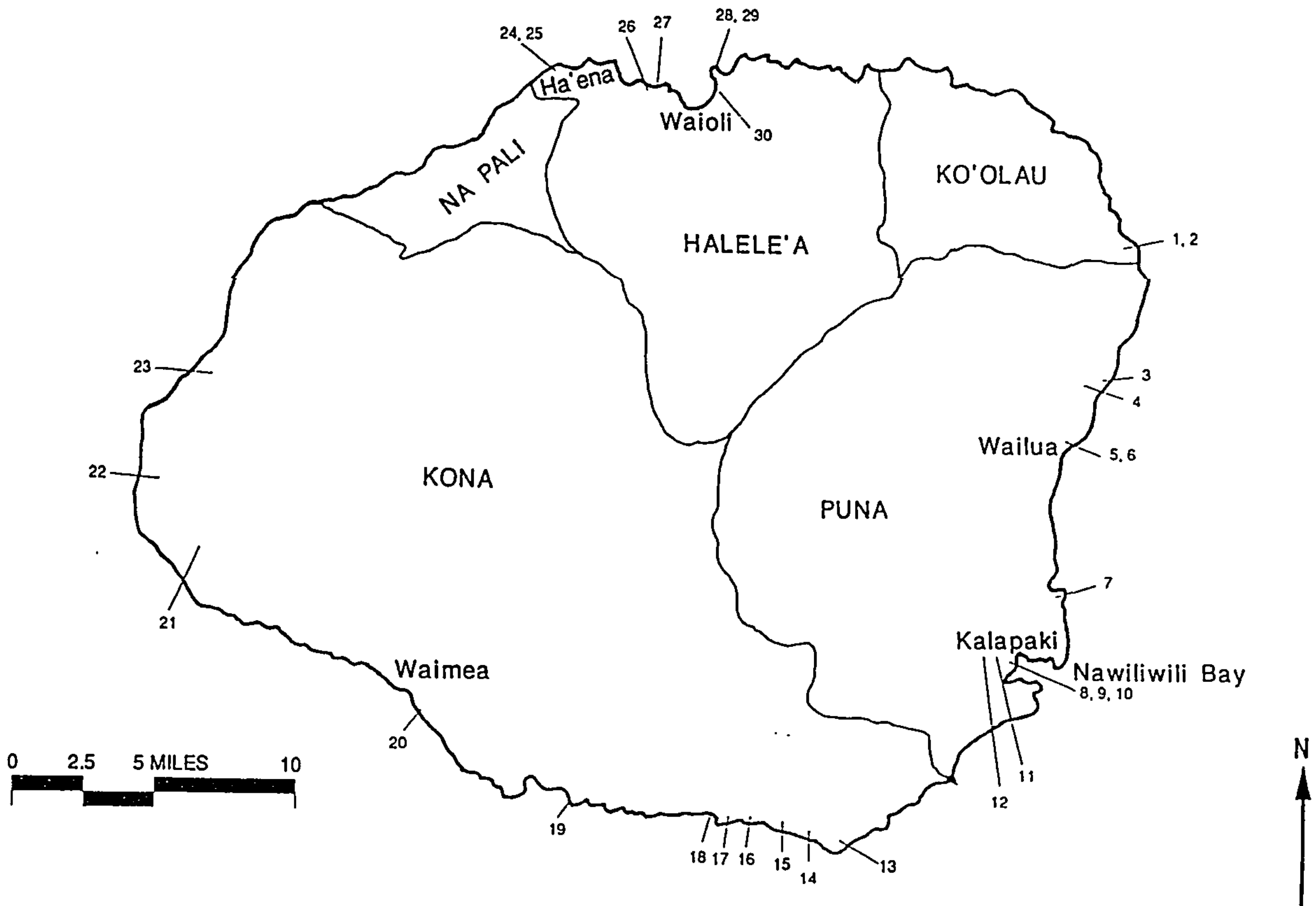
INDIVIDUALS & ORGANIZATIONS

Mike Faye
Bertha Kawakami
Wendee Van Gieson
Wood & Marlene Cole
Buddy Wilson
Kaupena Kinimaka
Ronald Dela Cruz
Joe Arruda
Jim Bartlett
Rochele Washburn
Paul Taba
Cookie Robinson
Alfred Kupo
Lester Yoshimura
Judy Stewart
Arthur & Martha Kruse
Joe Alvarez
Lauae Arashiro
Jose & Barbara Bulatao

Waimea Mainstreet Program
KVMH Hospital
Northrup King Co.
Pioneer Hi-Bred International
AMFAC Land Co., Ltd.
Big Save, Inc.
Kauai Electric
Big Save, Inc.
A & B Land Co.
Grove Farm Land Co.
Knudsen Trust
Kauai Paging & Communications
Kauai Economic Development
Board

EXHIBITS

EXHIBIT - A



HAWAIIAN FISHPOND STUDY, DHM Inc.

DRAWING NUMBER

KAUA'I FISHPONDS

FISHPOND NAME	MAP #	SITE # (50-30-)	'ILI, AHUPUA'A/TMK	CLASS	TYPE	OWNER
Kamaloko	-		Ha'ena / 5-9 / 5-8	IV	?	?
Kanaele	-		Ha'ena / 5-9 / 5-8	IV	IV	?
Keaweloko	-		Ha'ena / 5-9 / 5-8	IV	?	?
Malupo	-		Ha'ena / 5-9 / 5-8	IV	?	?
Paki	-		Makakanaulua, Ha'ena/ 55-9	IV	IV	?
Waikoko	26		Waikoko / 5-6-4:	III	?	P
Nameless (BPBM 50-Ka-D8-7)	27	03-433	Waipa / 5-6-03:	III	II	P
Kamauaelpilau	-		Waipa / 5-6-04:	IV	?	P
Ahau	-		Waioli/5-5	IV	IV	?
Kaaikahala	-		Waioli / 5-5	IV	?	?
Kuloko	-		Waioli / 5-5	IV	?	?
Maikai	-		Waioli / 5-5	IV	?	?
Momona	-		Waioli / 5-5	IV	?	?
Opahale	-		Waioli / 5-5	IV	?	?
*nameless (or Kanoa)	28		Hanalei / 5-5-01:2	IIB	III	P
*Kanoa (or Muliwai of Waiula; BPBM 50-Ka-D10-8)	29	03-452	Hanalei / 5-5-01:2	IIA	III	P
Kamo'omaikai (or Pu'u Poa; BPBM 50-Ka-D10-9)	30	03-303	Hanalei / 5-4-04:1	III	I / II	P

KAUA'I FISHPONDS

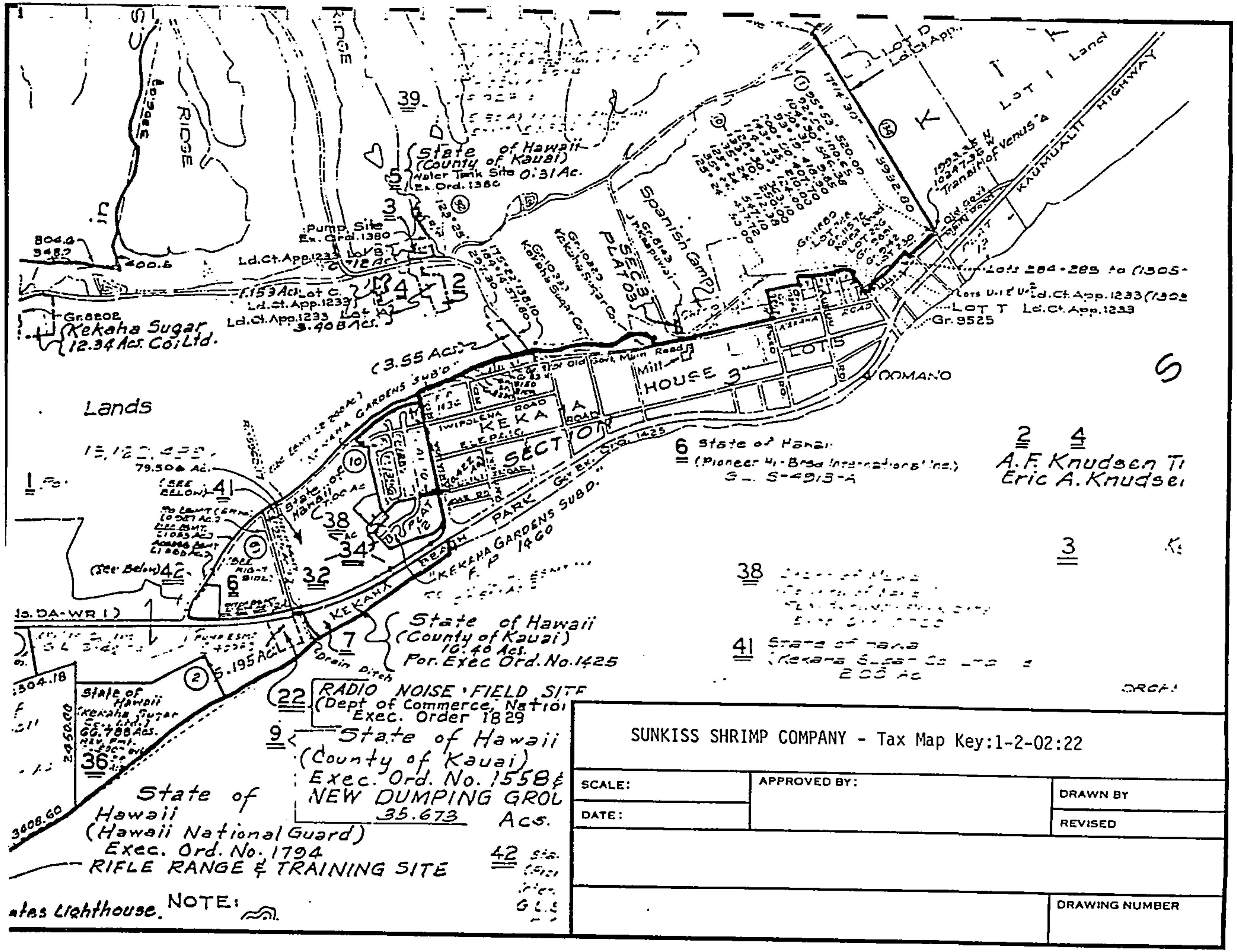
FISHPOND NAME	MAP #	SITE # (50-30-)	'ILI, AHUPUA'A/TMK	CLASS	TYPE	OWNER
KONA DISTRICT						
nameless (or Nukumoi)	13		Paa / 2-8-2:	IIA?	IV	P
nameless	14	10-77	Koloa / 2-8-17:25	III	II	P
nameless (Weliweli ponds; BPBM 50-Ka-B4-7)	15.1	10-77	Koloa / 2-8-16:6	IIA	II	P
nameless (Weliweli ponds; BPBM 50-Ka-B4-7)	15.2	10-77	Koloa / 2-8-16:6	IIA	II	P
nameless (Weliweli ponds; BPBM 50-Ka-B4-7)	15.3	10-77	Koloa / 2-8-16:6	IIA	II	P
nameless (Ho'ai; BPBM 50-Ka-B4-5)	16	10-75	Koloa / 2-6-06:2	IIA	II	P
Koloa	17	10-404	Koloa / 2-6-05:	IIB	II	P
*nameless (Lawa'i-kai)	18		Lawa'i / 2-6-02:1	IIB	III	P
*Nomilu (Nomilo; BPBM 50-Ka-B6-1)	19	10-67	Kalaheo / 2-3-10:2	IIA	III	P
*Kekupua	20		Makaweli / 1-7-05:01	IIB	II	P
nameless	-		Waimea / 1-3-05?	IV	III	?
Kawaiele	21		Mana, Waimea / 1-2-2:	III	II	?
Nohili	22		Mana, Waimea / 1-2-2:	III	II	?
Kolo	23		Mana, Waimea / 1-2-2:1	III	II	S
HALELEA DISTRICT						
Ke'e (BPBM 50-Ka-D5-4)	24	03-467	Ha'ena / 5-9-08:18	IIB	II / IV?	S
Naia	25	03-467	Ha'ena / 5-9-08:?	III	IV	S
Esetera	-		Ha'ena / 5-9 / 5-8	IV	IV	?
nameless	-		Ha'ena / 5-9 / 5-8	IV	II	?

KAUA'I FISHPONDS

(in-depth study completed for fishponds preceded by an asterisk *)

FISHPOND NAME	MAP #	SITE # (50-30-)	'ILI, AHUPUA'A/TMK	CLASS	TYPE	OWNER
KOOLAU DISTRICT						
nameless	1		Anahola / 4-8-13:12	IIB	II?	HHL
nameless	2		Anahola / 4-8-03:8	III	III	HHL
PUNA DISTRICT						
Ka'upena	3		Kapa'a / 4-5-	III	II	P
Kawaihau	4		Kapa'a / 4-3-03:	IIA	III	P
nameless	5		Wailua / 4-1-03:16	IIA?	II	P
nameless	6		Wailua / 4-1-03:16	IIA?	II	P
nameless	-		Wailua / 4-1 / 4-2?	IV	II	?
nameless	7		Hanamalu / 3-7-3:	III	III	?
nameless ponds	-		Kalapaki / 3-5-01:	IV	?	?
Papalinahoa	-		Nawiliwili / 3-2-6:	IV	III	?
*nameless	8	11-3027	Niumalu / 3-2-02:26	IIA	III	P
*nameless	9	11-3028	Niumalu / 3-2-02:2	IIB	III	P
nameless ponds	10	11-3031 11-3032 11-3033 11-3034	Niumalu / 3-2-02:	III	IV	P
*Alekoko (or Menehune; BPBM 50-Ka-A3-5)	11	11-501	Niumalu / 3-2-01:1	IIA	III	P
Kalalalehua (or Pepe'awa)	12	11-3013	Niumalu / 3-1-02:1	III	III	P

EXHIBIT - B



SUNKISS SHRIMP COMPANY - Tax Map Key:1-2-02:22

SCALE:	APPROVED BY:	DRAWN BY
DATE:		REVISED
		DRAWING NUMBER

EXHIBIT - C
SMA Approval Ltr
Sunkiss Shrimp CO.

MARYANNE W. KUSAKA
MAYOR

DEE M. CROWELL
PLANNING DIRECTOR

IAN K. COSTA
DEPUTY PLANNING DIRECTOR

TELEPHONE (808) 241-6677
FAX (808) 241-6699

PLANNING DEPARTMENT

Roland Sagum
Applied Planning Services
P. O. Box 1724
Lihue, HI 96766

February 5, 1997

Subject: Special Management Area Minor Permit SMA(M)-97-11
Shrimp Hatchery
TMK:1-2-02:22
Kekaha, Kauai

Based on the information submitted, we have completed our review and assessment of the subject proposal and hereby issue a Special Management Area Minor Permit authorizing construction of a 30 foot high, 40 foot wide, 130 feet long shrimp hatchery with concrete foundation and canvas outer cover, at an existing shrimp farm on land leased from the State.

Approval of the application is subject to the following conditions:

1. As represented by the applicant, all work shall be conducted clearly outside of the 40 foot shoreline setback area, as identified on the site plan submitted with the application.

2. As recommended by the State Division of Aquatic Resources and as represented by the applicant in the May 1991 Environmental Assessment, all effluent from the hatchery and ponds shall be screened using fine filters, infiltration basin, and other methods as appropriate to insure that the non-native shrimp species are not introduced into the native marine ecosystem.

3. Should human burials or other archeological, cultural or historic resources be discovered during construction, work in the area of the resources shall cease and the County of Kauai Planning Department, and the Department of Land and Natural Resources-Historic Preservation Division shall be contacted at 1-808-587-0047.

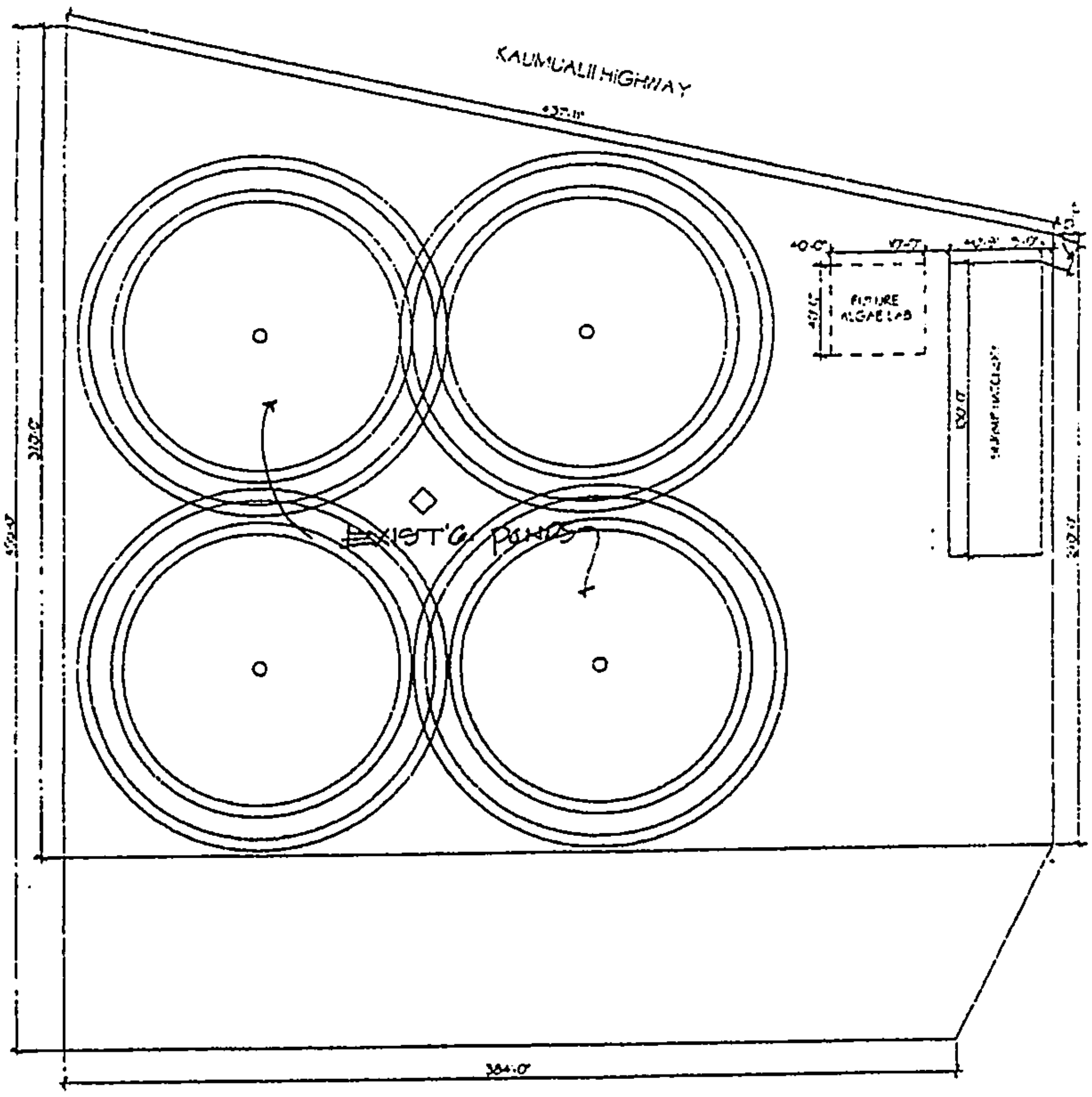
Also be informed that other permits or conditions from other agencies may be required. The applicant is responsible for resolving those conditions with the other respective agency(ies).

Dee M. Crowell
Planning Director

c: Historic Preservation Division
Division of Aquatic Resources
Landis Ignacio

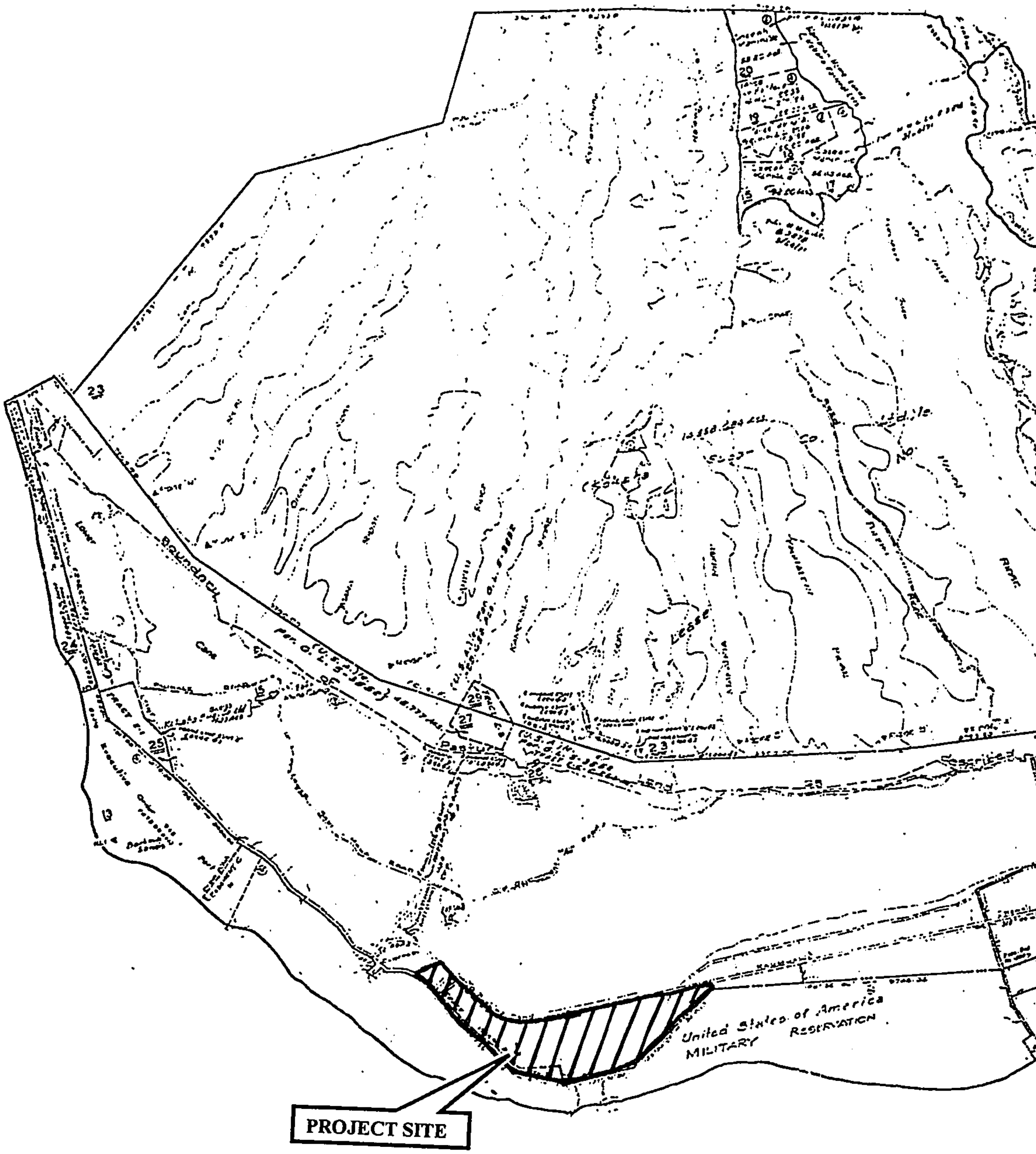
EXHIBIT - D

Sunkiss Shrimp Co.



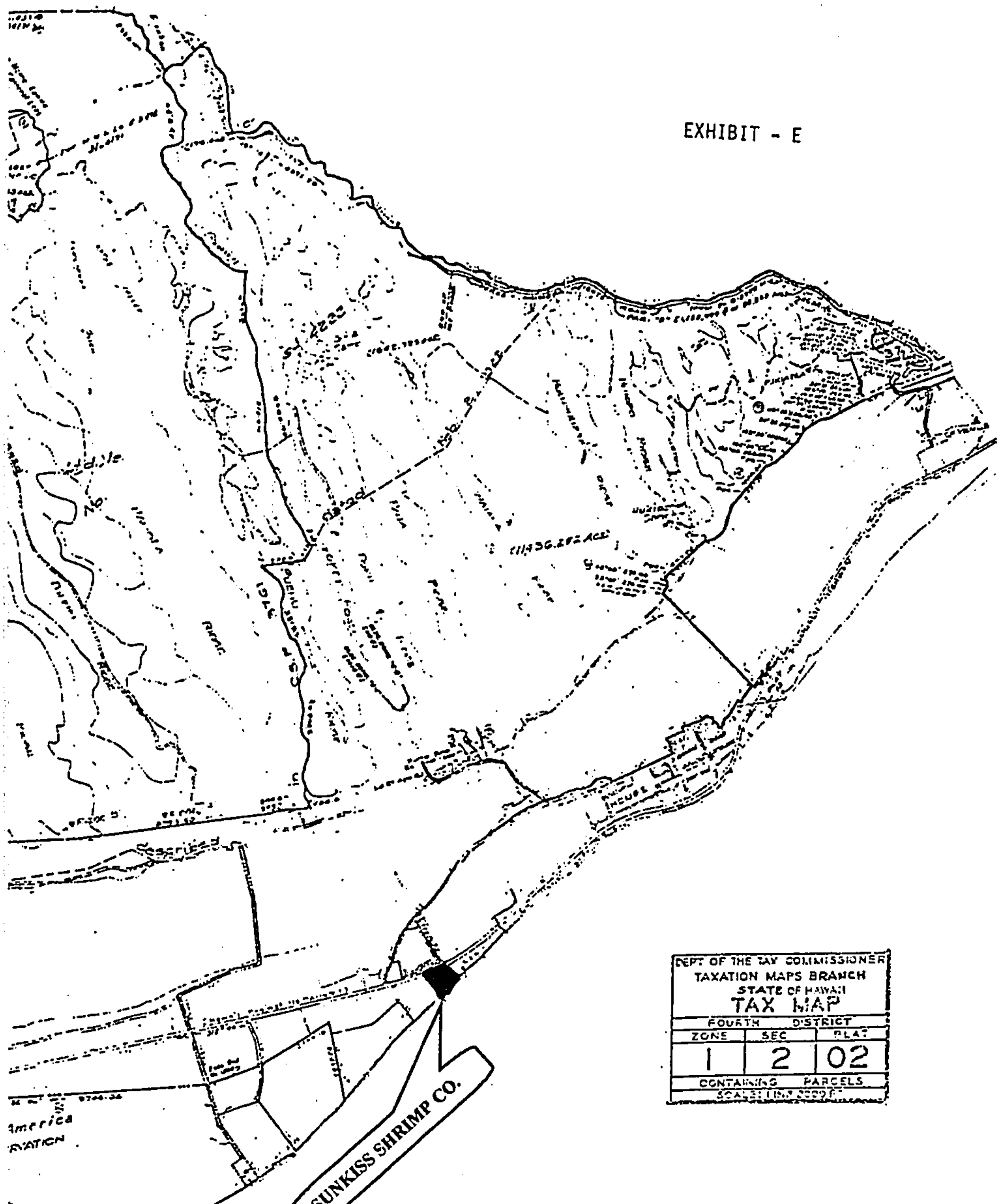
SITE PLAN

SCALE: 1" = 80'



United States of America
MILITARY RESERVATION
PROJECT SITE

EXHIBIT - E


DEPT OF THE TAX COMMISSIONER
TAXATION MAPS BRANCH
STATE OF HAWAII
TAX MAP
FOURTH DISTRICT
ZONE 1
SEC 2
PLAT 02
CONTAINING PARCELS
SUNKISS SHRIMP CO.

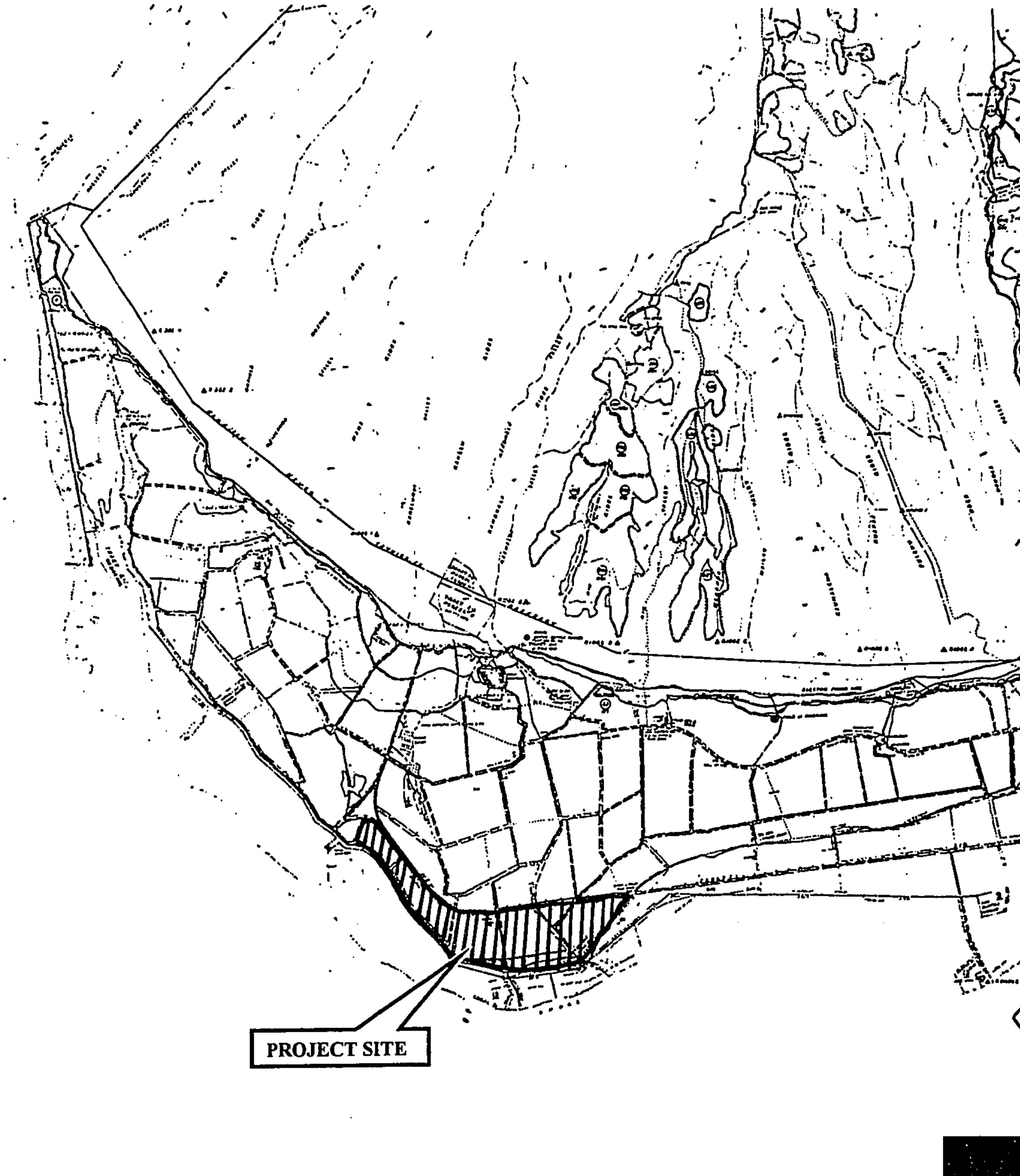
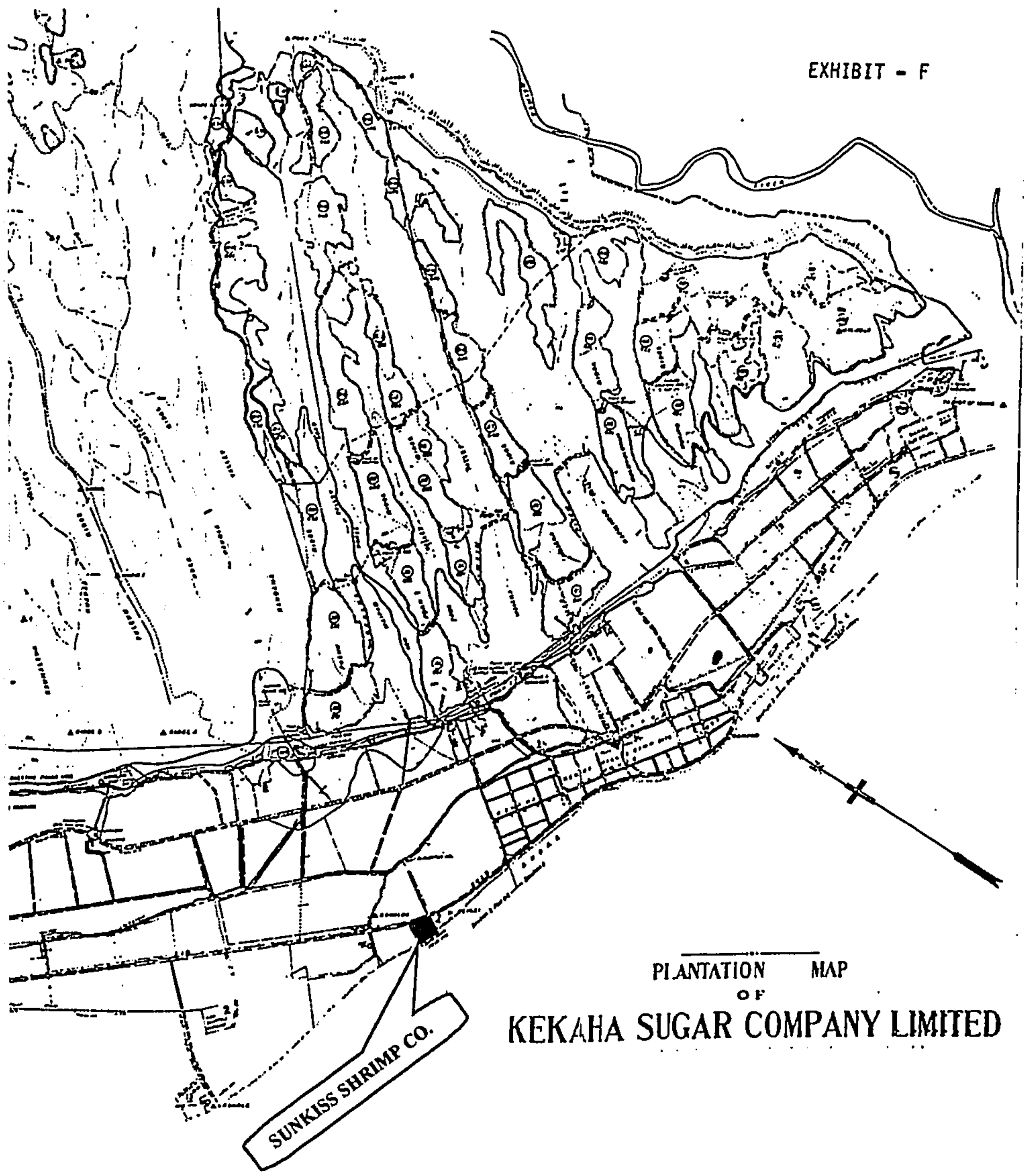
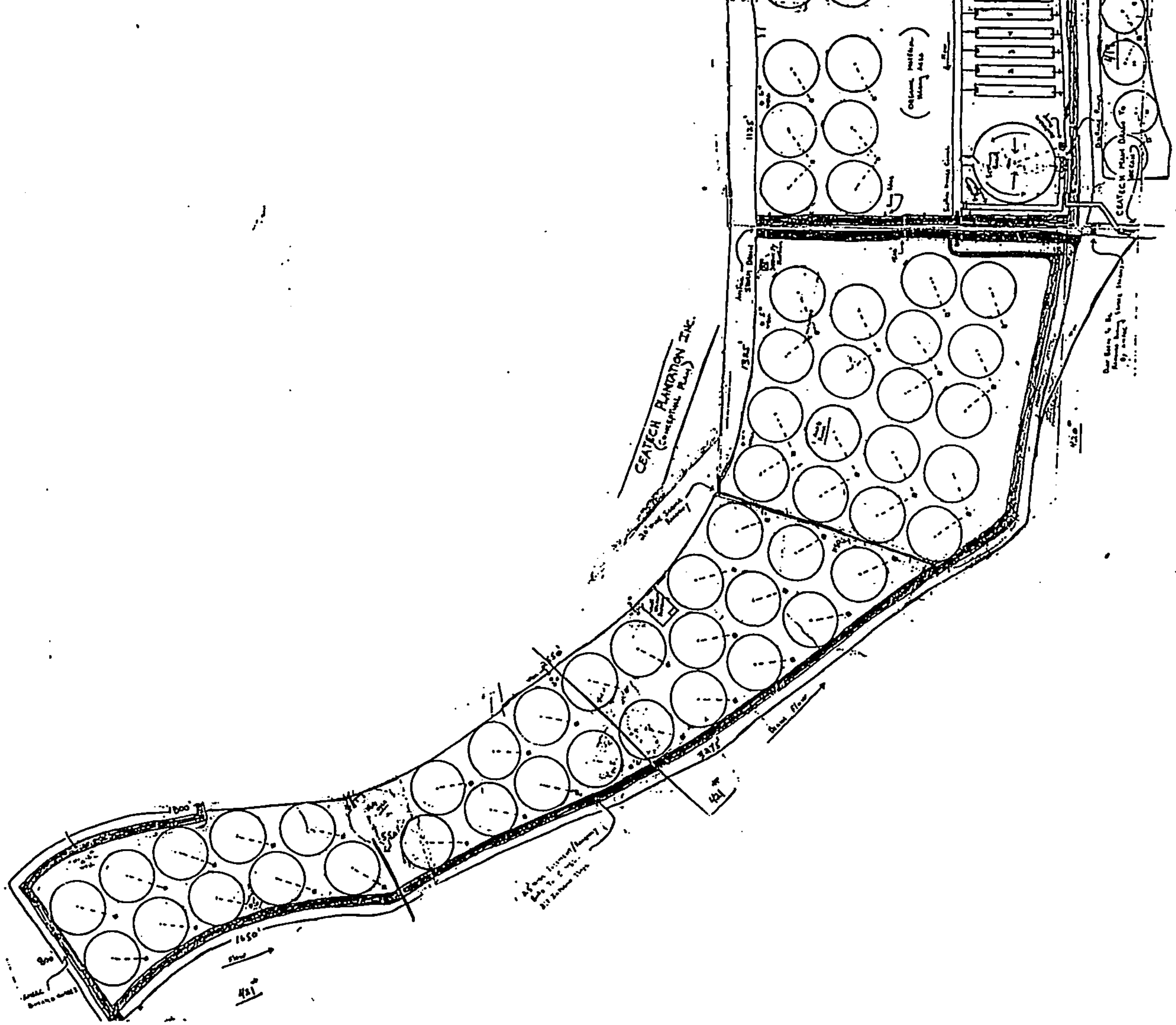

PROJECT SITE

EXHIBIT - F



PLANTATION MAP OF KEKAHA SUGAR COMPANY LIMITED



CEATECH PLANTATION INC.
(Conceptual Plan)
1125'
1325'
2375'
1650'
Flow
Brine Flow
420'

EXHIBIT - G

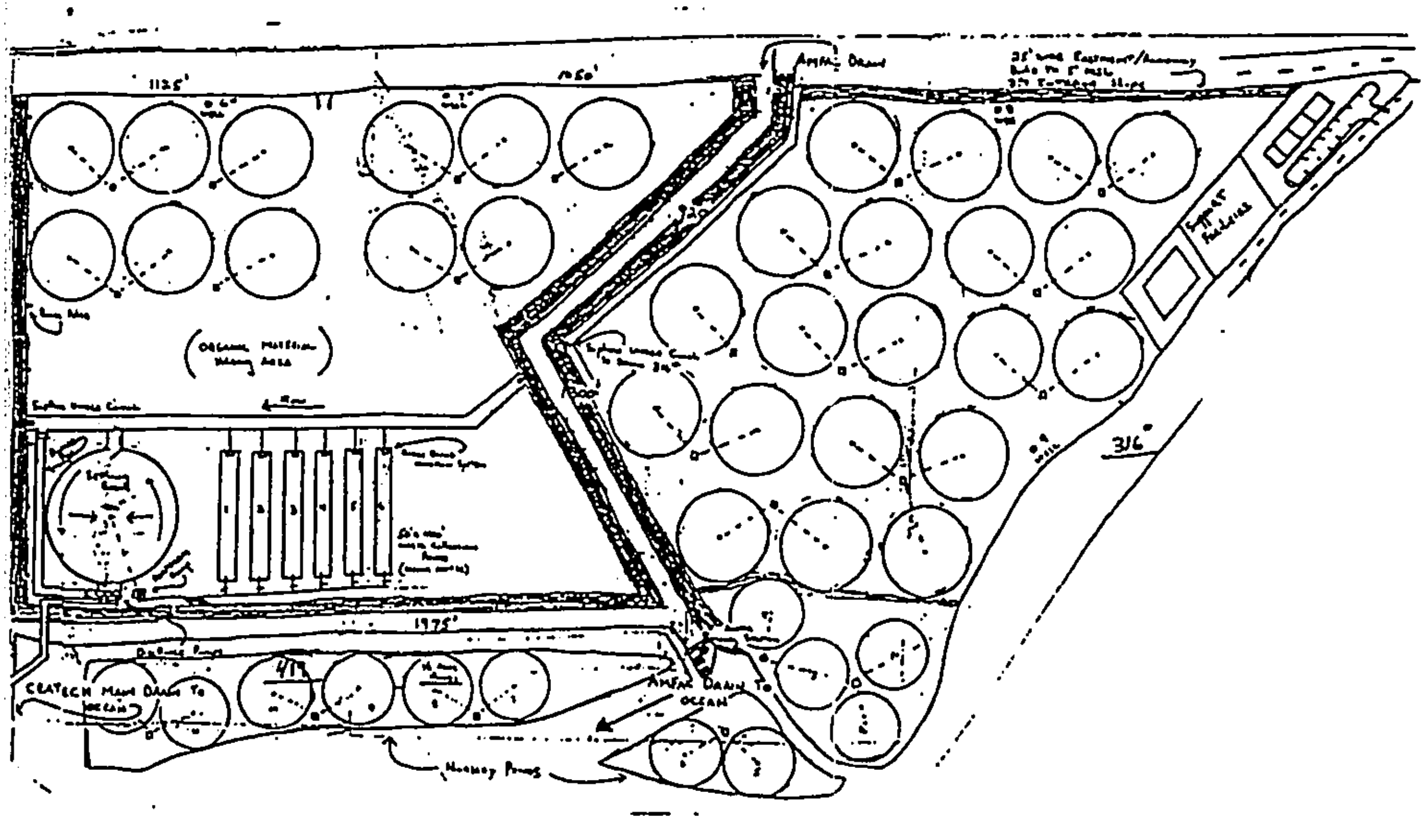
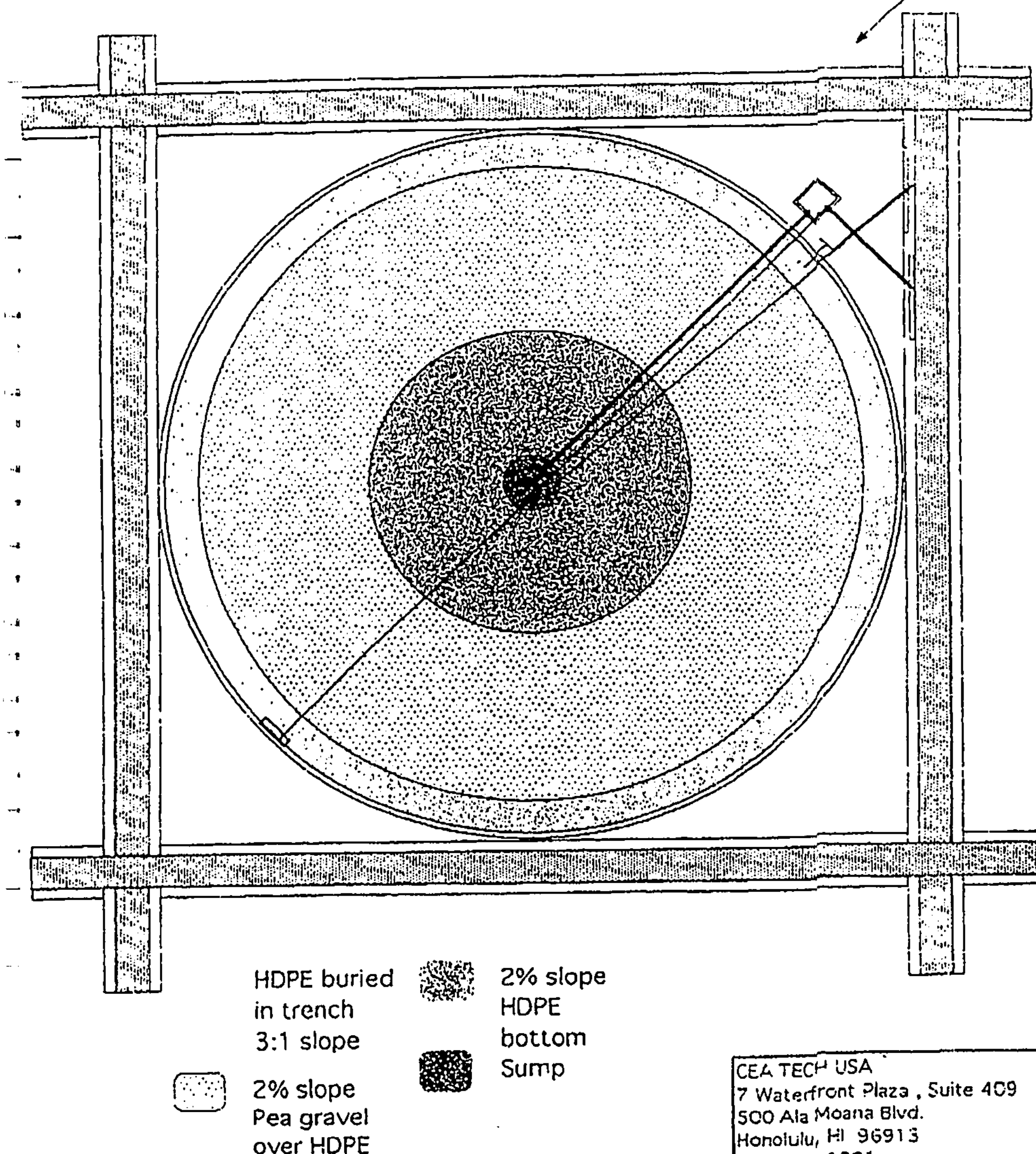

1125'
1050'
AMFAC DRAIN
1975'
316'
CEATECH MAIN DRAIN TO OCEAN
AMFAC DRAIN TO OCEAN
Nursery Ponds

EXHIBIT - H

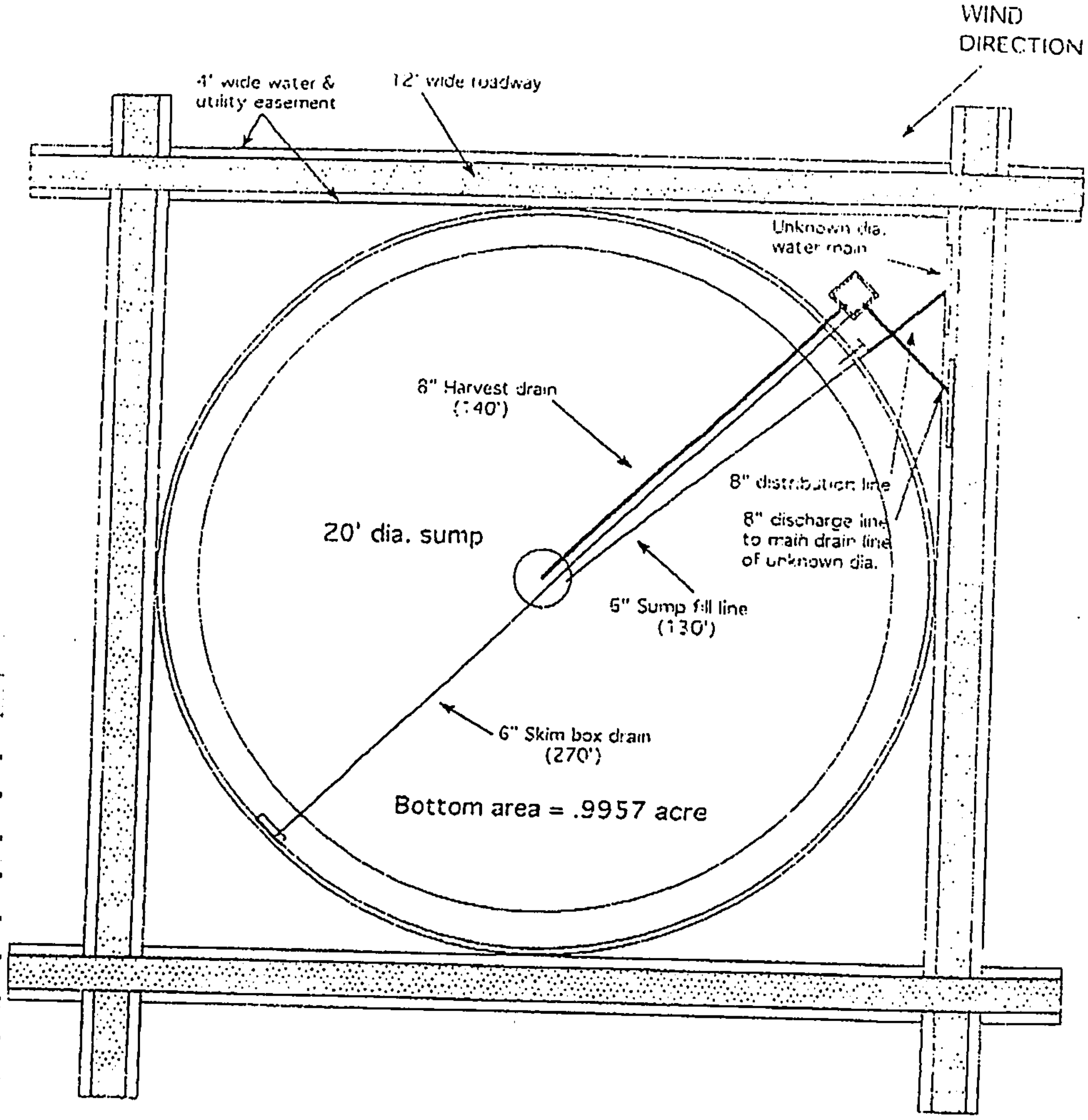
CEA TECH
ONE ACRE GROWOUT SHRIMP POND



CEA TECH USA
7 Waterfront Plaza , Suite 409
500 Ala Moana Blvd.
Honolulu, HI 96913
808 521 1801
808 537 1307 fax

5-10-97 GB

CEA TECH
ONE ACRE GROWOUT SHRIMP POND

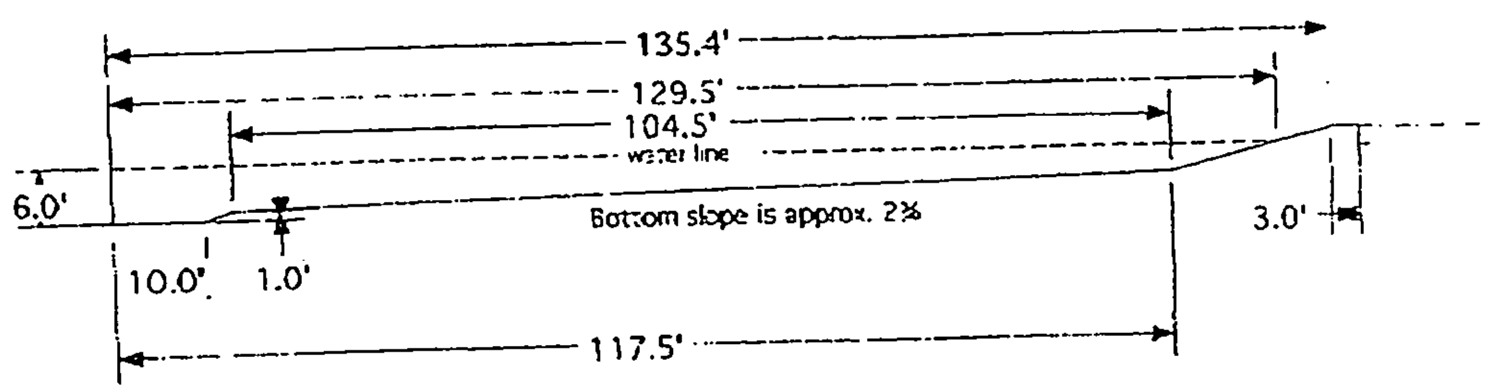


CEA TECH USA
7 Waterfront Plaza , Suite 409
500 Ala Moana Blvd.
Honolulu, HI 96913
808 521 1801
808 537 1307 fax

-97 GB

C.E.A. Tech.

One acre - round pond radial profile



Note: 117.5' of radius will provide .9957 acres of bottom area Total liner area is approx. 68,000 sq. ft. This area includes the 20' dia. sump, bottom profile and anchor trench (2' deep w/ 1' of horizontal liner buried). With a 3:1 slope ponds should be kept 20' apart as measured from the top edge of each pond. The freeboard from waterline to the top edge of the pond is18".

CEA Tech. USA
7 waterfront Plaza, Suite 409
Honolulu, Hawaii 96913

EXHIBIT - I

MARYANNE W. KUSAKA
MAYOR

DEE M. CROWELL
PLANNING DIRECTOR
IAN K. COSTA
DEPUTY PLANNING DIRECTOR
TELEPHONE (808) 241-6677
FAX (808) 241-6699

PLANNING DEPARTMENT

August 18, 1997

Mr. Roland Sagum III
P.O. Box 1724
Lihue, HI 96766

SUBJECT: TMK: 1-2-02: 1 Por. at Kekaha, Kauai

The following is in response to your August 7, 1997 inquiry:

a. The County of Kauai Subdivision Ordinance does not apply for the reassignment of a lease.

b. Under the provisions of the County Subdivision Ordinance, the dividing of land for leasing purposes requires compliance to the Ordinance. Compliance to the Subdivision Ordinance mandates that CZO regulations are also met, which means that CZO lot size requirements must be complied with.

c. Subleasing requires compliance to the Subdivision Ordinance.

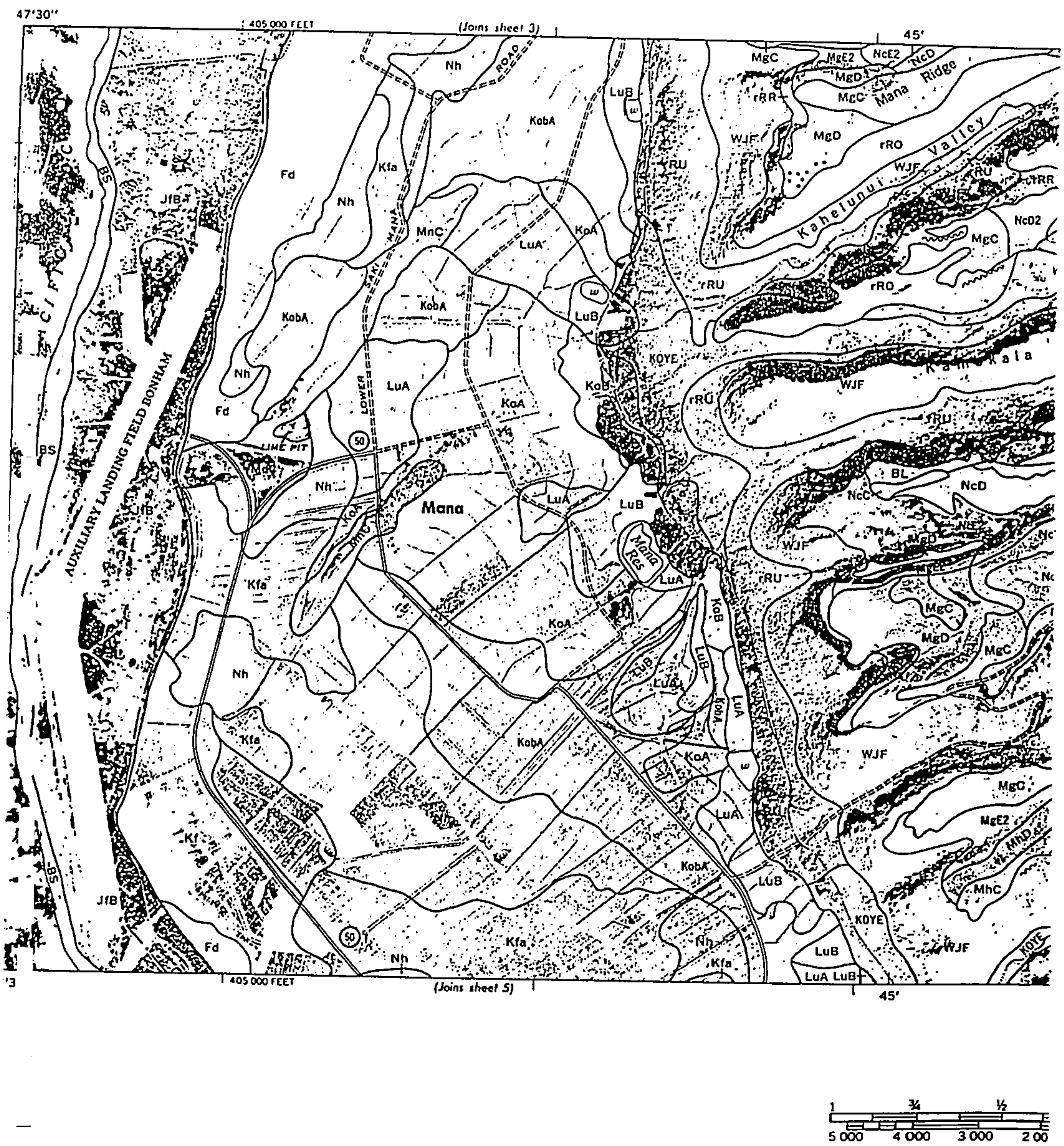
Please note that according to the Subdivision Ordinance, creating entities of land for leasing is considered a form of subdivision. By applying the ordinance, the party leasing the newly created entity is assured that the leased area meets minimum size requirements, and has all of the amenities such as utilities, infrastructure, access, etc. that a subdivided lot has.

Should you have any questions, please feel free to contact Keith Nitta or Dale Cua of my staff at 241-6677.

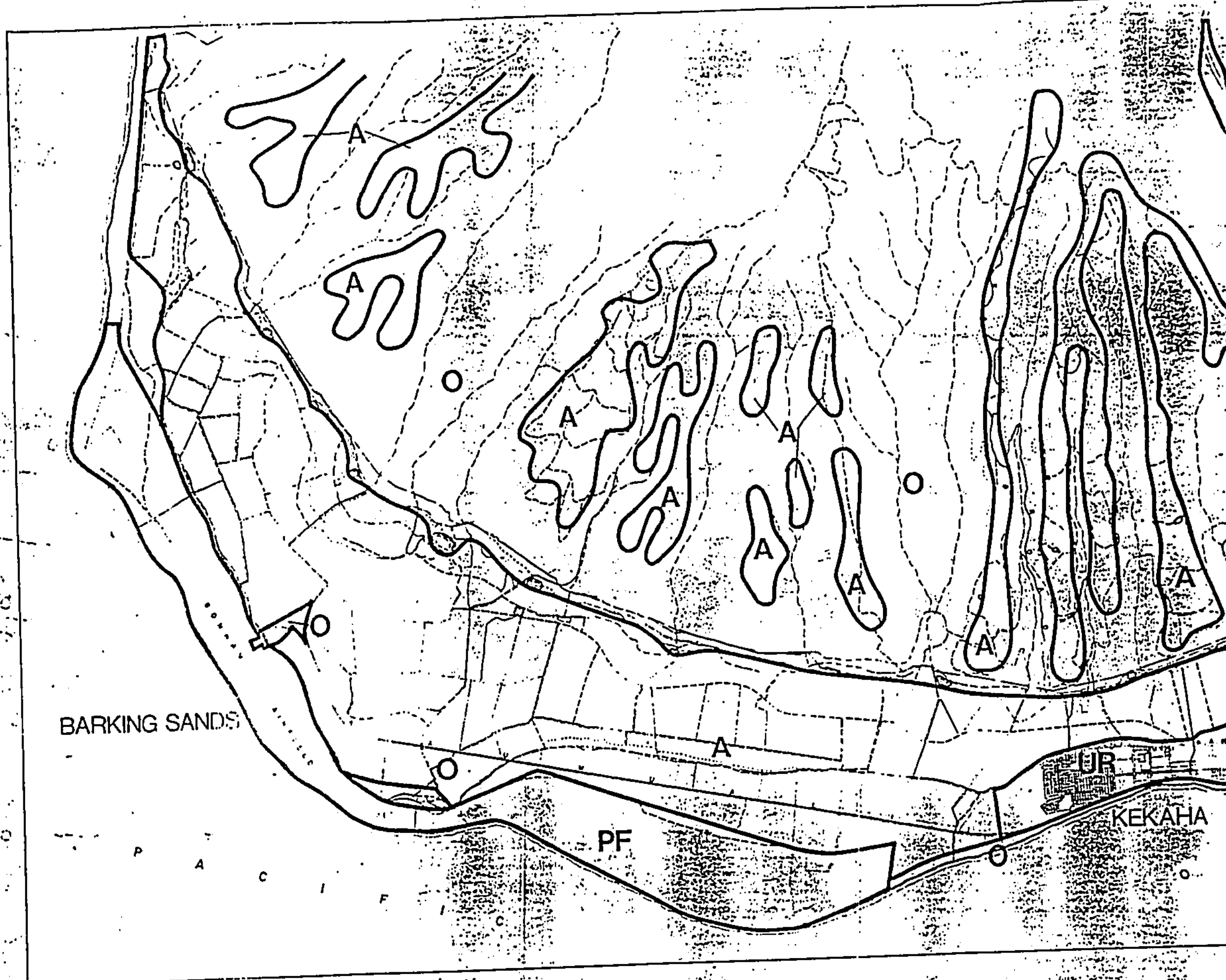
DEE M. CROWELL
Planning Director

CC: Sam Lee, DLNR

EXHIBIT - J
US-DOA-SCS Map
Soils Map



GP – WAIMEA – KEKAHA



KAUAI GENERAL PLAN

LEGEND

- O OPEN
- A AGRICULTURE
- RR RURAL RESIDENTIAL
- UR URBAN RESIDENTIAL
- UMU URBAN MIXED USE
- R RESORT
- PF PUBLIC FACILITIES

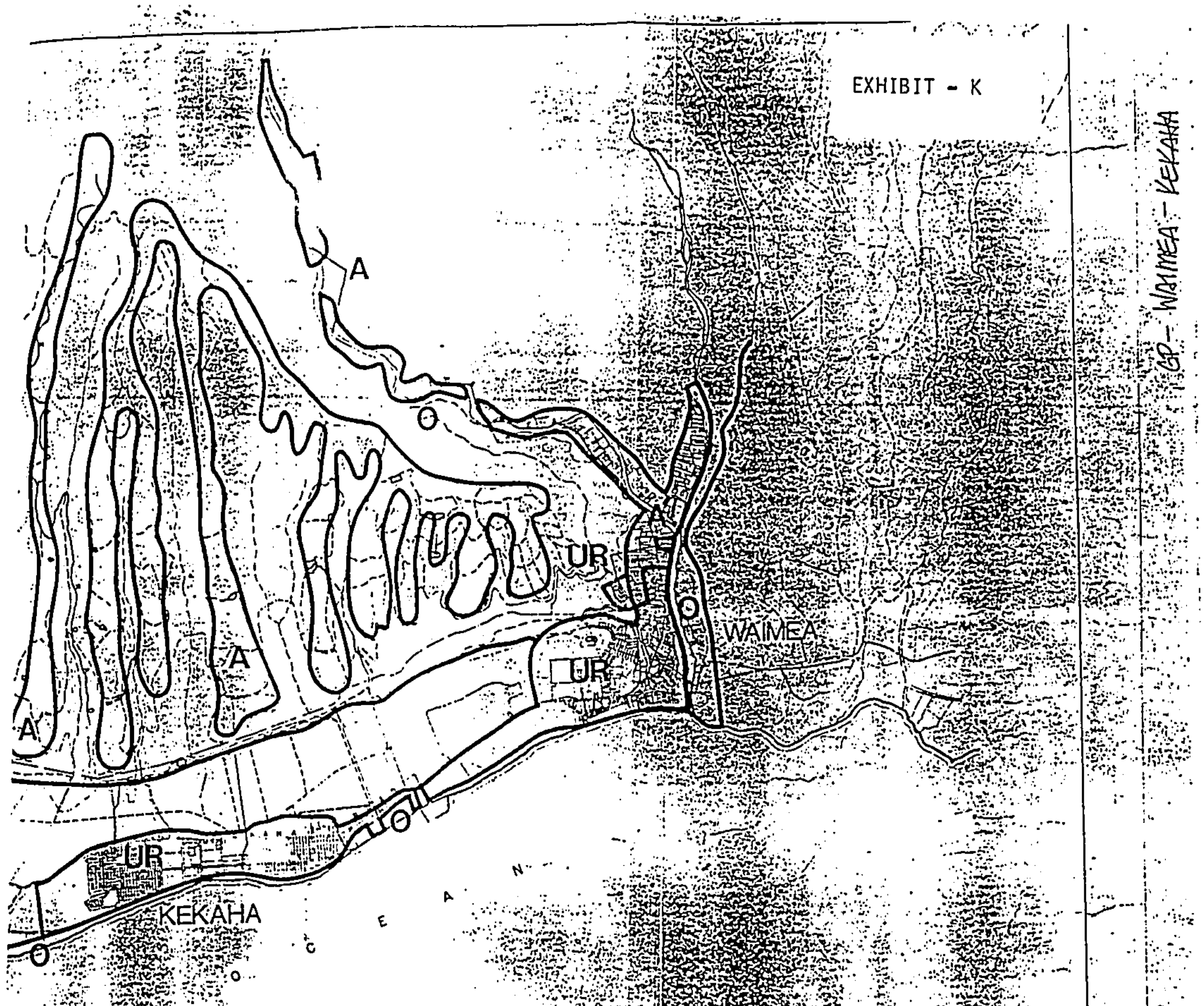


EXHIBIT - K
GP - WAIMEA - KEKAHA
A
O
UR
WAIMEA
KEKAHA
O C E A N
WAIMEA·KEKAHA
ADOPTED BY COUNTY OF KAUAI
Adopted 9-8-82, by PLANNING COMMISSION
Chairman, Planning Commission
EXECUTIVE BRANCH
Mayor
COUNTY COUNCIL
0 2500 10,000 25,000
JUNE 1982

1 WAIMEA KEKAHA

KAUAI COUNTY

HAWAII STATE LAND USE DISTRICTS

CONSERVATION DISTRICT C
AGRICULTURE DISTRICT A
RURAL DISTRICT R
URBAN DISTRICT U

SPECIAL MANAGEMENT AREA

ADOPTED BY COUNTY OF KAUAI

Adopted 11-25-75 by PLANNING COMMISSION

Chairman, Planning Commission

Approved 11-29-75

Mayor

AMENDMENTS

1. To Comply With Amendments to Chapter 205A, H.R.S., in Accordance With Act 200, Session Laws of Hawaii 1979

Chairman, Planning Commission / Date 12-14-79

Mayor / Date 12-17-79

2. ... as Adopted November 1981

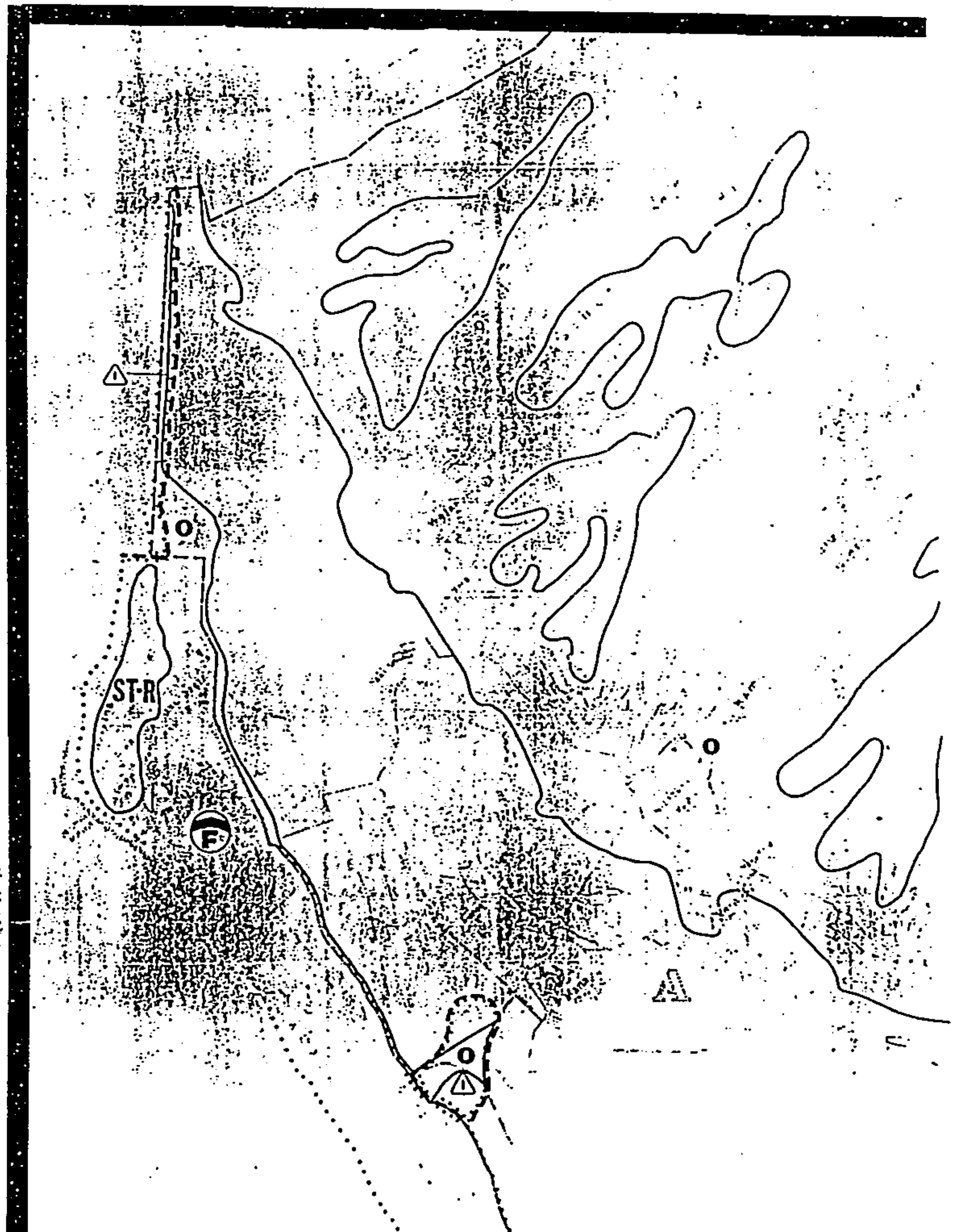
Chairman, Planning Commission / Date 8-31-83

Mayor / Date 10/14/83

THE PREPARATION OF THIS MAP WAS FINANCED IN PART BY THE COASTAL ZONE MANAGEMENT ACT OF 1972, AS AMENDED, ADMINISTERED BY THE OFFICE OF COASTAL ZONE MANAGEMENT, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, UNITED STATES DEPARTMENT OF COMMERCE

LEGEND

--- SMA Boundary is the Seaward Edge of the Line



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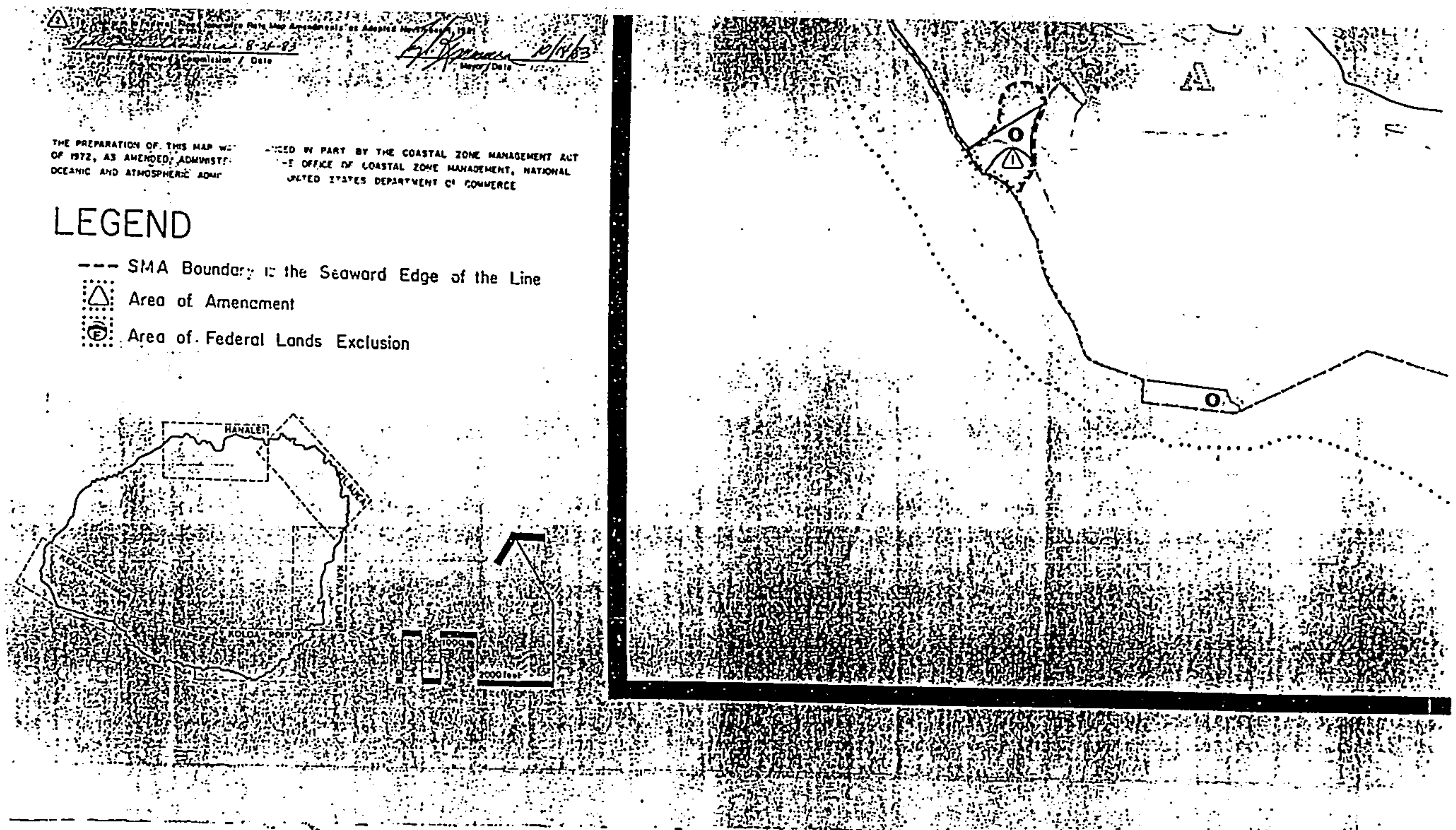
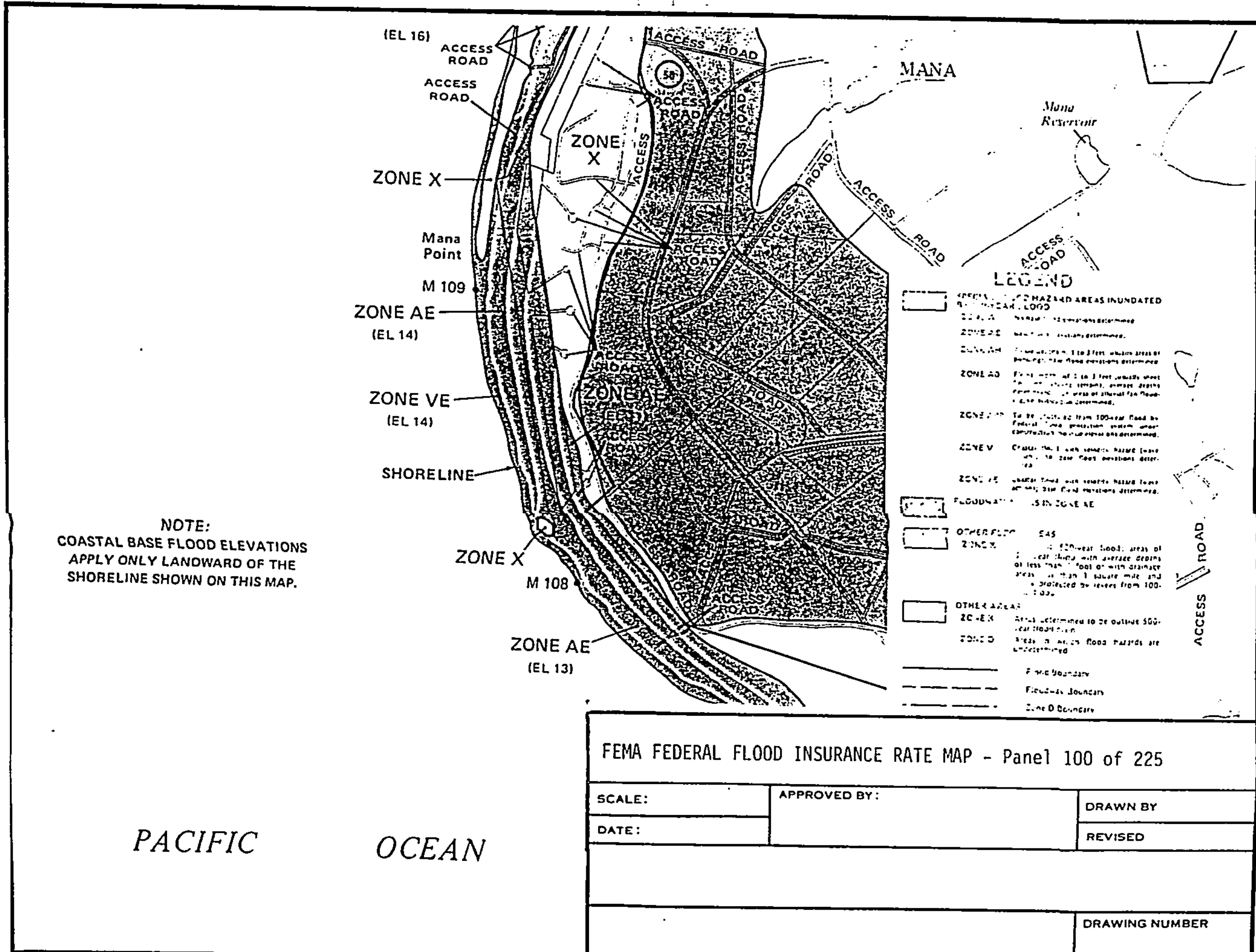


EXHIBIT - L

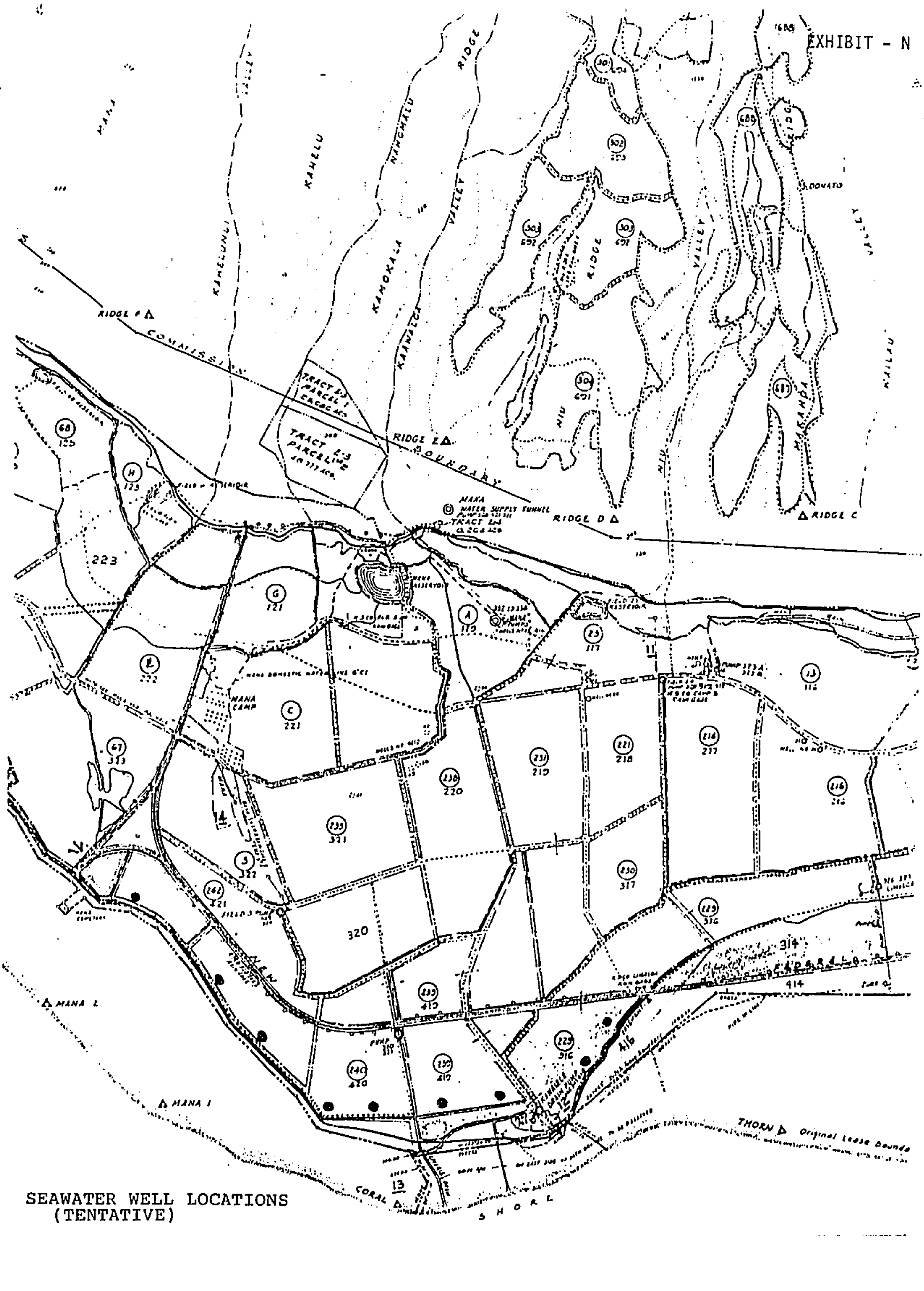


FEMA FEDERAL FLOOD INSURANCE RATE MAP - Panel 100 of 225

SCALE:	APPROVED BY:	DRAWN BY
DATE:		REVISED
		DRAWING NUMBER

EXHIBIT - M

EXHIBIT - N



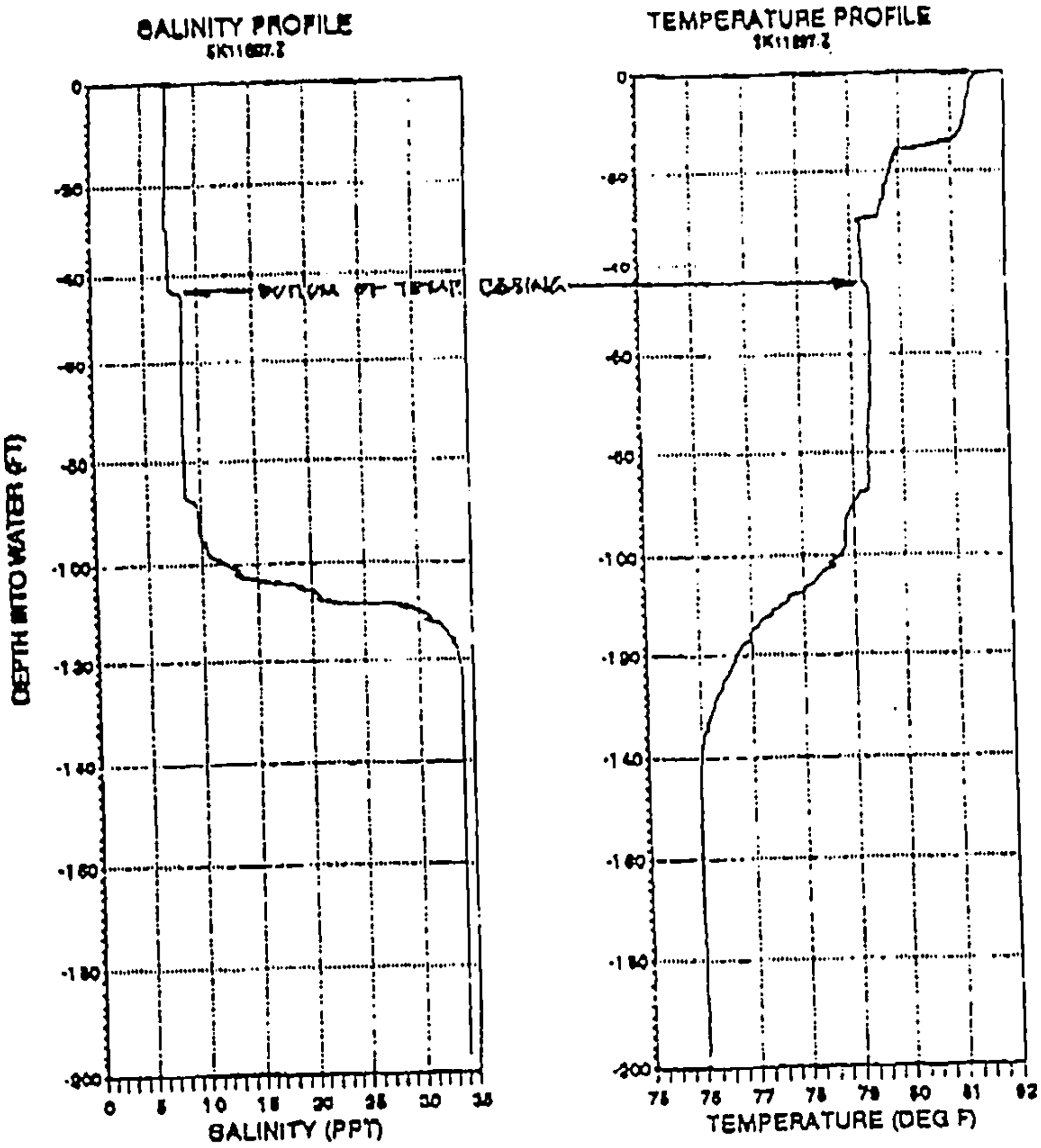
SEAWATER WELL LOCATIONS
(TENTATIVE)

IMPACT WELL DRILLING

WELL LOG

SUNKISS WELL

DEPTH	FORMATION	WATER
0-18	SAND	9'
18-23	CORAL	X
23-55	SAND	X
55-76	SANDY CLAY WITH CORAL	
76-80	BROKEN CORAL	X
80-90	SOFT WHITE CORAL	X
90-94	SOFT SANDY CLAY	
94-110	HARD BROWN CORAL WITH LAYERS OF STICKY CLAY	
110-137	CORAL AND SILTY CLAY	
137-140	FIRM CORAL	
140-148	CORAL WITH POCKETS OF TAN CLAY	
148-152	FIRM CORAL CUTTINGS CLEAN, NO CLAYS	X
152-160	CORAL WITH BROKEN AREAS, STILL CLEAN	X
160-190	CORAL WITH SILTY TAN CLAY	
190-200	CORAL WITH SILTY WHITE CLAY AND LAYERS OF STICKY TAN CLAY	



Sunkiss Shrimp Farm
Well 5844-06
November 6, 1997

Drainage

EXHIBIT - 0

The historical use of the area for agriculture has required the establishment and maintenance of a series of canals and drainage ditches, some of which are shown below. This ditch network, together with various pumps and outfalls, serve to; convey irrigation water throughout land parcels, prevent flooding, and eliminate agriculture wastewater from the property.

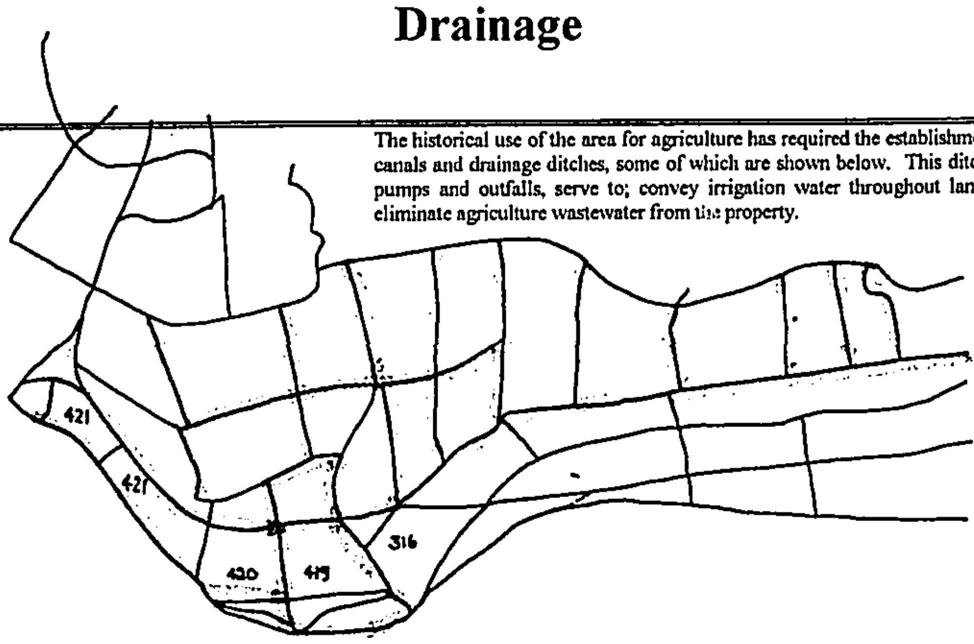


Figure 1 CURRENT AGRICULTURE DISCHARGE/DRAINAGE NETWORK

The land targeted for CEATECH's aquaculture operation consists of field plot numbers 316, 419, 420 and the portion of 421 which is makai (seaward) of the highway. A berm at least five feet above mean sea level in height will be constructed along the property as shown below. This berm will run along the entire makai boundary of the property from the northwestern end of field plot 421 to the southeastern end of 316. Is also will border sides of the canals which separate field plots 420 - 419, and 419 - 316. The mauka boundary of the subject property is bermed by the highway, which is graded to at least eight feet above mean sea level.

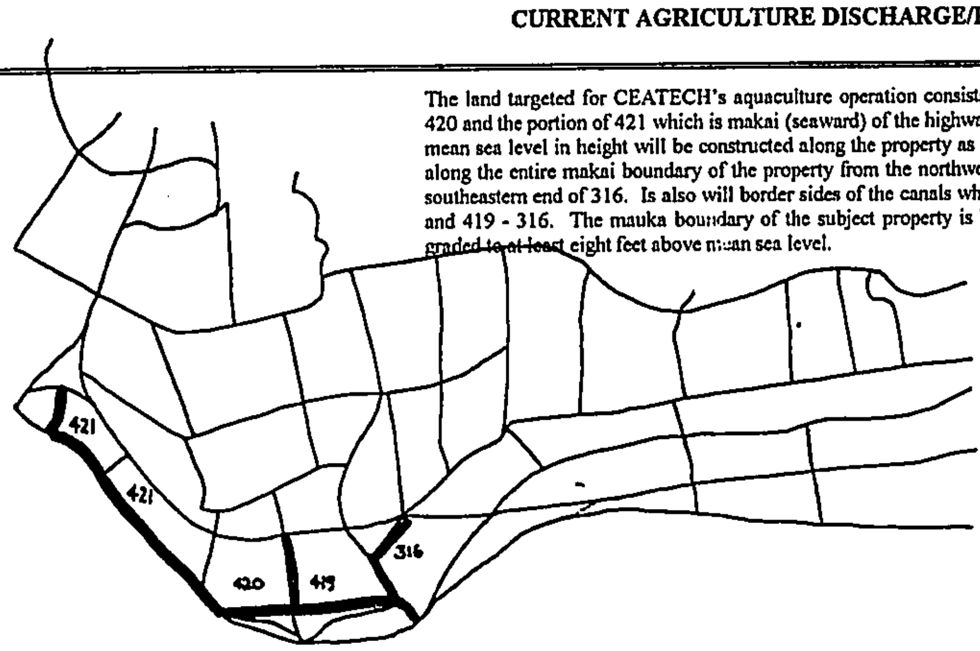


Figure 2 BERM CONSTRUCTION TO AQUACULTURE PARCEL

The aquaculture effluent will be routed along the makai boundary of the property, adjacent the berm. The path of the aquaculture is shown in red. That portion of agriculture effluent (shown in blue) which would now be transported along this path will be rerouted into the existing canal extending along the mauka side of the highway; and will continue to be used only for agriculture discharge. Additionally, the berm, which is now located at a point known as Kinikini and serves to prevent seawater intrusion and provide for emergency drainage during heavy rains will be moved north several hundred yards to permit the independent monitoring of the discharge streams.

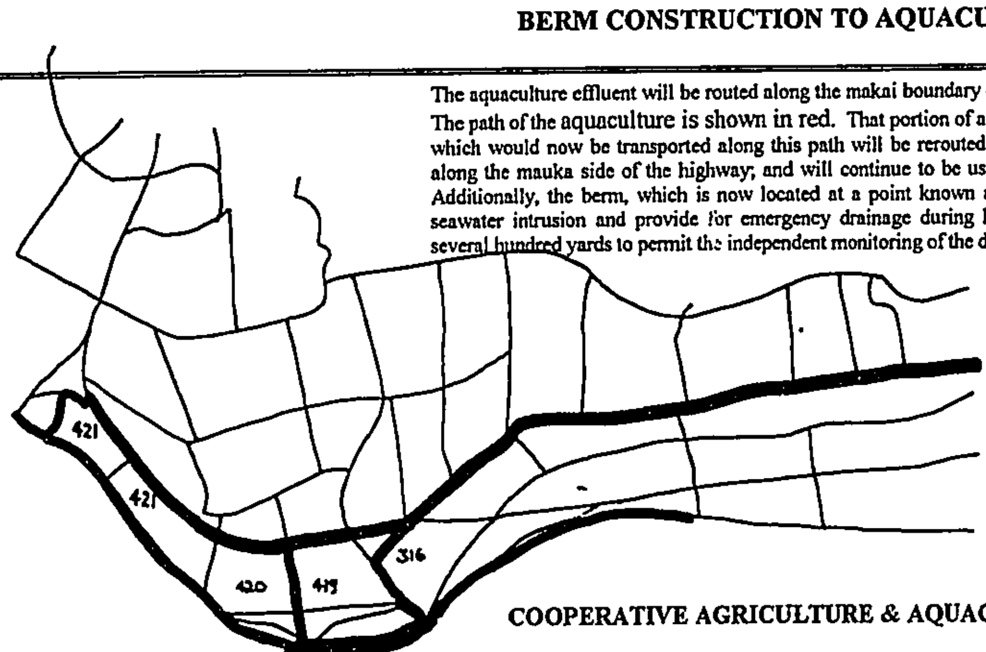


Figure 3

APPENDIX

Appendix 1

CEATECH Personnel

CEATECH PERSONNEL

J.A. Garcia

President, Chief Executive Officer, Chairman of the Board of Directors since July12, 1996. Los Angeles, California.

Since 1988, Mr. Garcia has served as President, Chief Executive Officer and Chairman of the Board of The Rally Group Ltd., Los Angeles, California, a venture capital and financial consulting firm.

Mr. Garcia's exposure to the shrimp industry goes back to the late 1950's when he served on the Board of Directors of Pearl Island Seafood of Panama, helped finance their expansion program and served as exclusive marketing agent for shrimp sales in the United States. Since then he has, for over 30 years, served as officer, director, and principal of several publicly traded companies with a strong demonstrated ability to develop, structure, and organize new businesses and development stage companies.

Mr. Garcia is a graduate of the Georgetown University School of Foreign Service where he received his Bachelor of Science in Foreign Service.

Ronald L. Ilsley

Chief Financial Officer, Treasurer, Member of the Board of Directors since February 1, 1997. Los Angeles, California.

Mr. Ilsley has served as Vice President and Chief Financial Officer of Chemoil Corporation, San Francisco, California, since 1994. Chemoil Corporation is recognized as the largest independent integrated supplier of marine fuels in the United States with annual sales in excess of $400 million.

Prior to his work at Chemoil, Mr. Ilsley served from 1985 as Treasurer and Director of Finance for Santa Fe International Corporation, Los Angeles, California, a major multi-national company publicly traded on the New York Stock Exchange.

Mr. Ilsley has additionally served as Senior Executive and Manager of domestic and international investment banking groups of European American Bank, New York, New York, and Wells Fargo Bank, N.A., San Francisco, California.

Mr. Ilsley received his Bachelor of Arts Degree from California State University Northridge and is a graduate of the Pepperdine University Graduate School of Business and Finance, Los Angeles, California. He has been a faculty member and lecturer in the Graduate School of Banking and International Finance at Golden Gate University, San Francisco, California.

Ernest K. Dias

Senior Vice President, General Manager of Operations, Member of the Board of Directors since February 1, 1997. Honolulu, Hawaii.

Since 1988, Mr. Dias has served as Manager of Facilities Development and Construction for The Oceanic Institute, Honolulu, Hawaii. As Manager, Mr. Dias was responsible for the planning, implementation and construction of The Center for Applied Aquaculture at Makapuu Point, Oahu, and The Oceanic Institute satellites on the islands of Hawaii and Molokai. Mr. Dias directed the design and construction of the World Bank / U.S.A.I.D. financed 6000 acre Maryut Fish Farming Co. hatchery and facilities in Alexandria, Egypt, and represented The Oceanic Institute in all negotiations with U.S.A.I.D., the Egyptian government and private sector participants.

From 1960 to 1983, Mr. Dias held various key supervisory and management positions with several major construction and engineering firms including Peter Kiewit & Sons, Guy F. Atkinson, Gordon Ball, Kassler Corp., and Polich-Benedict.

A civil engineer, Mr. Dias received his Bachelor of Science, Engineering from San Jose State University, San Jose, California. Mr. Dias also attended the Pepperdine University Graduate School of Business, Los Angeles, California.

Paul Bienfang, Ph.D. Senior Vice President, Environmental Compliance and Technology, since February 1, 1997. Honolulu, Hawaii.

Dr. Bienfang has served as Vice President, Senior Scientist, and Co-Chief Executive Officer for The Oceanic Institute where he has worked since 1973. Dr. Bienfang was responsible for all phases of research, development, and operations management.

Dr. Bienfang formerly served on the Executive Committee for the Tropical and Subtropical Aquaculture Regional Center and the Board of Directors, Western Association of Marine Laboratories. He currently is a Member of the Governor's Hawaii Aquaculture Council. He is a recognized authority and reviewer of scientific research for the United States government and technical journals in oceanography, aquaculture, fisheries and marine environment.

Gary S. Joiner Secretary and Member of the Board of Directors since January 19, 1995. Boulder, Colorado.

A partner of Frascona, Joiner & Goodman, P.C., Boulder, Colorado, Mr. Joiner specializes in the areas of business organization, tax, estate, financial planning, and also practices in the area of securities law.

Mr. Joiner received his Bachelor of Science in Economics from Northwestern University, Evanston, Illinois, in 1972 and his Juris Doctor from the University of Denver, College of Law in 1975. Additionally, he received a Masters in Law (taxation) from the University of Denver, College of Law in 1978. Mr. Joiner is a certified financial planner and his professional affiliations include the American Bar Association and the Institute of Certified Financial Planners.

Ronald Morrison

Director of Marketing since February 1, 1997. El Paso, Texas.

Founder and Managing Director of Dos Aguilas International Trade Center, Inc., El Paso, Texas, 1992.

Director of Operations IBM World Trade Corporation Area de Caribe, Mexico City; *responsible for all IBM marketing* and sales operations, all product divisions, in Mexico, Central America, Northern South America and the countries of the Caribbean.

Executive Assistant to the Chairman and C.E.O. of IBM, Thomas J. Watson, Jr.

Marshall Industries, San Marino, California, Vice President of Marketing

Booth Resources International, Inc., Los Angeles, California, Director of Marketing.

Mr. Morrison holds a B.A. degree in Industrial Economics from the University of California, at Berkeley, and an M.B.A. (Honors) in Operations Research and Industrial Management. Following graduation, he was awarded a Fulbright scholarship for study at Cambridge University, England.

James N. Sweeney

Vice President and Director of Shrimp Program, all subsidiaries since February 1, 1997. Honolulu, Hawaii

Shrimp Program Manager, The Oceanic Institute, Honolulu. Since 1983, Mr. Sweeney has managed and participated in all phases of shrimp research, development, breeding and hatchery, maturation and growout.

Mr. Sweeney is a graduate of the Fuginaga Penaeid Shrimp Institute, Aio, Japan.

He is an acknowledged authority in his field and has authored numerous publications and co-authored the Manual of Intensive Shrimp Production Technology.

Ronald M. Bailey

Manager, Systems & Services since January 1, 1997. Honolulu, Hawaii.

Since 1993, Mr. Bailey served as Procurement Manager and Director of Personnel and Compliance at The Oceanic Institute, Honolulu, Hawaii. Prior to joining the Oceanic Institute, Mr. Bailey served in the United States Navy holding the positions of Manager, Budget & Procurement; Pacific Region; Administrative and Personnel Officer, Special Security Officer, Navy Space Technology; Washington, D.C.;

and Master Training Specialist, HQ United States Pacific Fleet, Honolulu, Hawaii.

William K. Richards, Jr. Vice President, Market Research Director, Hawaii High Health Seafood Corporation, since February 1, 1997. Honolulu, Hawaii.

Manager of The Oceanic Institute, Honolulu, Hawaii, Keahulolu facility at Kona, Hawaii. The facility is the Institute's Aquaculture Education and Training Center, as well as the site of its SPF shrimp holding and breeding operations. During his 18-year tenure at the Institute, Mr. Richards managed and participated in various projects in all phases of marine shrimp research and development. He is a registered aquaculture lobbyist in the State of Hawaii. Additionally, from 1982 to 1984, Mr. Richards served as Manager of the State of Hawaii funded marine shrimp research and development program.

Mr. Richards was a participant in the Leeward Community College Marine Technology Program and has authored numerous publications

Robert A. Kanna Vice President and General Manager, Sunkiss Shrimp Co. Ltd., Kekaha, Kauai, Hawaii since March 15, 1997. Hanapepe, Kauai.

From 1984 to 1995, Mr. Kanna was involved in all facets of the shrimp program at The Oceanic Institute, as a research assistant and supervisor of intensive shrimp aquaculture technology. Mr. Kanna has traveled extensively in South America and South East Asia for The Oceanic Institute as an observer, troubleshooter, and personnel trainer for the transfer of shrimp technology.

In 1995 he joined Sunkiss Farms Co. Ltd. where he initiated and successfully operated the shrimp technology developed at The Oceanic Institute as a total commercial venture, achieving growth and survival rates equaling the best results and performances reported from previous research and controlled commercial projects at The Oceanic Institute.

Mr. Kanna has co-authored numerous important publications and presentations.

Mr. Kanna attended Oregon State University from 1978 to 1983 where he received his Bachelor of Science degree in Fisheries.

Landis Ignacio President, Sunkiss Shrimp Co. Ltd., Kekaha, Hawaii. Director of Plantations and Facilities, CEATECH Plantations Inc. since March 15, 1997. Kekaha, Hawaii.

Mr. Ignacio founded Sunkiss Shrimp Co. Ltd. in 1991. In 1979 he became Senior Agriculture Coordinator, Irrigation Superintendent of Kekaha Sugar Co. He served as the Manager of Agricultural Operations of Amfac Sugar Kauai (formerly Kekaha Sugar Co.) from 1983 until January, 1997. Mr. Ignacio was General Manager and Partner of Waimea Aquatics, an Aquaculture Farm.

Professional Societies: Associate Director, West Kauai Soil and Water Conservation. Member, Waimea Professional and Business Association. Member, Hawaii/Kauai Cattleman Association. Member, Hawaii Aquaculture Association.

In 1978, Mr. Landis received a Bachelor of Science in Tropical Crop Production from the University of Hawaii, Hilo, Hawaii, and completed various management courses at San Jose State University, San Jose, California.

Ricky N. Oyama

Manager CEATECH HHGI Breeding Corp. since March 15, 1997. Lawai, Kauai.

From 1985 to February, 1997, Mr. Oyama was involved in all phases of the Shrimp Program at The Oceanic Institute, Honolulu, Hawaii, specializing in the high health, genetically improved breeding program, maturation system design and development, including coordinating all maturation experiments. During 1993 and 1994 he was responsible for the technology transfer, design and setup, receiving and acclimation of broodstock and training of personnel from startup at high health projects in Panay in the Philippines and Salinas, Ecuador.

Mr. Oyama received his B.A. in Aquaculture from the University of Hawaii at Manoa, Honolulu, Hawaii. He has co-authored and published several papers and articles on maturation, breeding, and broodstock of specific, pathogen free, and high health, genetically improved shrimp (Panaeus vannamei).

David M. Godin

Shrimp Growout Manager, CEATECH Plantations Inc. since February 1, 1997. Waimea, Kauai.

From 1988 to January, 1997, Mr. Godin participated in all phases of shrimp growout, serving as manager and research assistant in that area as well as interim quarantine and selective breeding programs of The Oceanic Institute, Honolulu, Hawaii.

Mr. Godin graduated in May, 1987 with a Bachelor of Science Degree, Major in Natural Resource Studies, Minor in Wildlife Biology from the University of Massachusetts.

Mr. Godin has published and co-authored various articles and dissertations on fluorescent elastomer internal tagging, feeding and nursery and growout performance of Pacific White Shrimp (Penaeus vannamei).

David Anthony Leong

Manager, Maturation and Hatchery Operations, CEATECH HHGI Breeding Corp. since April 1, 1997. Kekaha, Hawaii.

December, 1995 to March, 1997, Maturation Department Manager of GMBS, Inc., Summerland Key, Florida.

1989 to December 1995, The Oceanic Institute, Honolulu, Hawaii. Consultant for maturation and breeding projects, training specialist, disease technician, overseas consultant and trainer in hatchery and maturation.

Mr. Leong received his Bachelor of Science Degree in Animal Science from the University of Hawaii, College of Tropical Aquaculture, Honolulu, Hawaii, with additional studies at Fresno State University, Department of Animal Studies, Fresno, California.

BOARD OF TECHNICAL ADVISORS

The Board of Technical Advisors for the Company includes leading experts from a range of disciplines in general aquaculture, shrimp pathology, environmental science, high health shrimp breeding and production systems, aquatic feeds, and environmental policy. Board members are resources to assist in the design and solution of various challenges in shrimp aquaculture, waste disposal and environmental compatibility.

Donald V. Lightner, Ph.D.

Ph.D. Fish Pathology, Colorado State University
M.S. Fish Pathology, Colorado State University
B.S. Fisheries Biology, Colorado State University

- Professor, Dept. of Veterinary Science, University of Arizona
- Internationally recognized authority on penaeid shrimp pathology and aquatic disease diagnosis
- Principal investigator for disease research in the Gulf Coast Marine Shrimp Farming Consortium, and recipient of numerous grants and contracts for pathological research on crustaceans
- Extensive records of consultation to commercial shrimp aquaculture worldwide
- Written or co-authored more than 200 scientific books, book chapters, journal articles, review papers, and professional presentations on the pathobiology of penaeid shrimp

James A. Wyban, Ph.D.

Ph.D. Zoology, University of Hawaii
B.S. Biology, Northwestern University

- Former principal investigator for The Oceanic Institute's research component of the USDA-funded U.S. Marine Shrimp Farming Program, and recipient of various research grants in the area of high health marine shrimp production systems
- President/Founder of the first private company to commercialize high health shrimp breeding technologies
- Board of Directors of Hawaii Aquaculture Association and the World Aquaculture Society
- Consultant to private and government on the design and operation of integrated marine shrimp aquaculture operations

Michael P. Hamnett, Ph.D.

Ph.D., University of Hawaii
M.S., University of Hawaii
B.A., Upsala College

- Director for the Center for Developmental Studies Social Science Research Institute, University of Hawaii
- Senior Policy Analyst for Pacific Basin Development Council, and Coordinator for the Ocean Resources Management Program
- Author of numerous technical reports and governmental studies on environmental management and development in the Pacific region
- Recognized authority on Ocean and Coastal Resource Management, Environmental Policy, Disaster Preparedness and Mitigation, and Private Sector Development in the Pacific Islands.

Harald Rosenthal, Ph.D.

Ph.D. Fishery Science, University of Hamburg
B.S. Zoology, Free University of Berlin

- Professor, Institute for Marine Science, Kiel University, Germany
- Internationally recognized authority of aquaculture relating to issues of recycling, environmental interactions, wastewater treatment, and the development of coastal zone planning and management for sustainable use.
- Recipient of numerous scientific awards, and member of the editorial boards for more than ten scientific journals.
- Author of over 280 scientific publications relating to environmental issues of aquaculture.
- Former President of the European Mariculture Society, and Chairman of the International Council for the Exploration of the Seas' Working Group on Environmental Interactions with Mariculture.

Appendix 2

Archaeological Inventory Survey

APPENDIX - 2

SCS Project Number 117-2

AN INVENTORY SURVEY WITH ORAL HISTORIES OF A PARCEL OF LAND ON THE PLAIN OF MĀNĀ, WEST OF KEKAHA IN THE *AHUPUA`A* OF WAIMEA, DISTRICT OF KONA, ISLAND OF KAUA`I (TMK 1-2-02).

By:
Leann McGerty, B.A.
and
Robert L. Spear, Ph.D.
September 1997

Prepared for:
Controlled Environment Aquaculture Technology, Inc.
(CEATECH USA, Inc.)

SCIENTIFIC CONSULTANT SERVICES Inc.
711 Kapiolani Blvd. Suite 777 Honolulu, Hawai`i 96813

EXECUTIVE SUMMARY

An archaeological inventory survey and oral history documentation was conducted on a parcel of land to be developed in anticipation of a change in use. The project area is west of the locality of Kekaha in the *ahupua'a* of Waimea, District of Kona, Island of Kaua'i, and lies in what was the extensive wetlands of Wai'eli and Mānā. The Scope of Work (SOW) included archival and background research, a field reconnaissance, and, a limited number of oral interviews with long-time residents of the area.

The archival background and research indicated that few, if any, significant archaeological sites would be present within the project area. The field reconnaissance confirmed this. Written records indicated that the project area, indeed a very large portion of the plain, was a swamp or marsh and had been such in traditional times, as well. The shift in modern times from that of a marsh and ponds to agricultural land impacted the project area dramatically. The plowing and tilling of the cane land for the past 70 years has disrupted any natural stratigraphy for at least a meter under the surface.

Based on the documented post-Contact record, it is clear that because the dunes had been excavated to fill the march and because of the impact of sugar cane agricultural practices, few, if any, intact sites are to be expected to remain in the project area. Because the dunes are known as potential burial locations, future impacts to existing dunes should be monitored by a professional archaeologist. If any remains are encountered, all work in that specific area must stop and the State Historic Preservation Division be immediately notified.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

At the request of Controlled Environment Aquaculture Technology, Inc. (CEATECH USA, Inc.), Scientific Consultant Services conducted an archaeological inventory survey and oral history documentation on a parcel of land to be developed. The project area is west of the locality of Kekaha in the *ahupua'a* of Waimea, District of Kona, Island of Kaua'i (TMK 1-2-02).

Based on discussions with the State Historic Preservation Division, a Scope-of-Work (SOW) was designed to include archival and background research, a field reconnaissance, and, a limited number of oral interviews with older residents of the area.

ARCHIVAL RESEARCH

Archival research included a study of references to the project area in previously published accounts, a analysis of land records, and a review of the archaeological studies that had been conducted in the past.

The project area lies in what was the extensive marsh lands of Wai'eli, and Mānā. Above the marshy plain, forests grew on the slopes and there are traditions of trees being harvested for canoes in pre-Contact times (Handy and Handy 1972:411, Figure 1).

TRADITIONAL LAND USE

Traditional *mo'olelo* (story, legend, etc.) reveal much information, such as place names, and past activities held in different regions. *He Mo'olelo no Mākalei* (A Legend of Mākalei), written by J.W.H.I Kihe, was published in the Hawaiian language newspaper *Ka Hōkū o Hawai'i* between January 31 and August 21, 1928 (Maly 1993:A-6). This legend concerns a famous water cave on Hawai'i Island, but includes information concerning Kaua'i. At one point in the story, Mākālei expresses a wish to visit Kaua'i:

> [Kaua'i] the land famed for the firebrands of Kāmaile, and where the fire darts are thrown as fluttering tribute from Makuaiki. [The land] of the cliff trail of Nu'alol where the ocean moves about the cliffs. Where the pandanus trees of Naue grow by the sea, nodding gently in the water fetching wind of *Lehua*. [The land] of the waters which are red like the sandalwood leaf shoots at Waimea, and [to see] the glittering-mirage forming waters on the plain of Mānā, and [to see] the houses not built by men's hands, but [built] by the deity Limaloa, there at Linaloa amongst the salt beds. [That land of] the ringing (resonant) sands of Nohili which merrily sing when moved forward and backwards in the bosom. [To see] the *pahapaha* seaweed of Polihale. . . (4/17/1928)

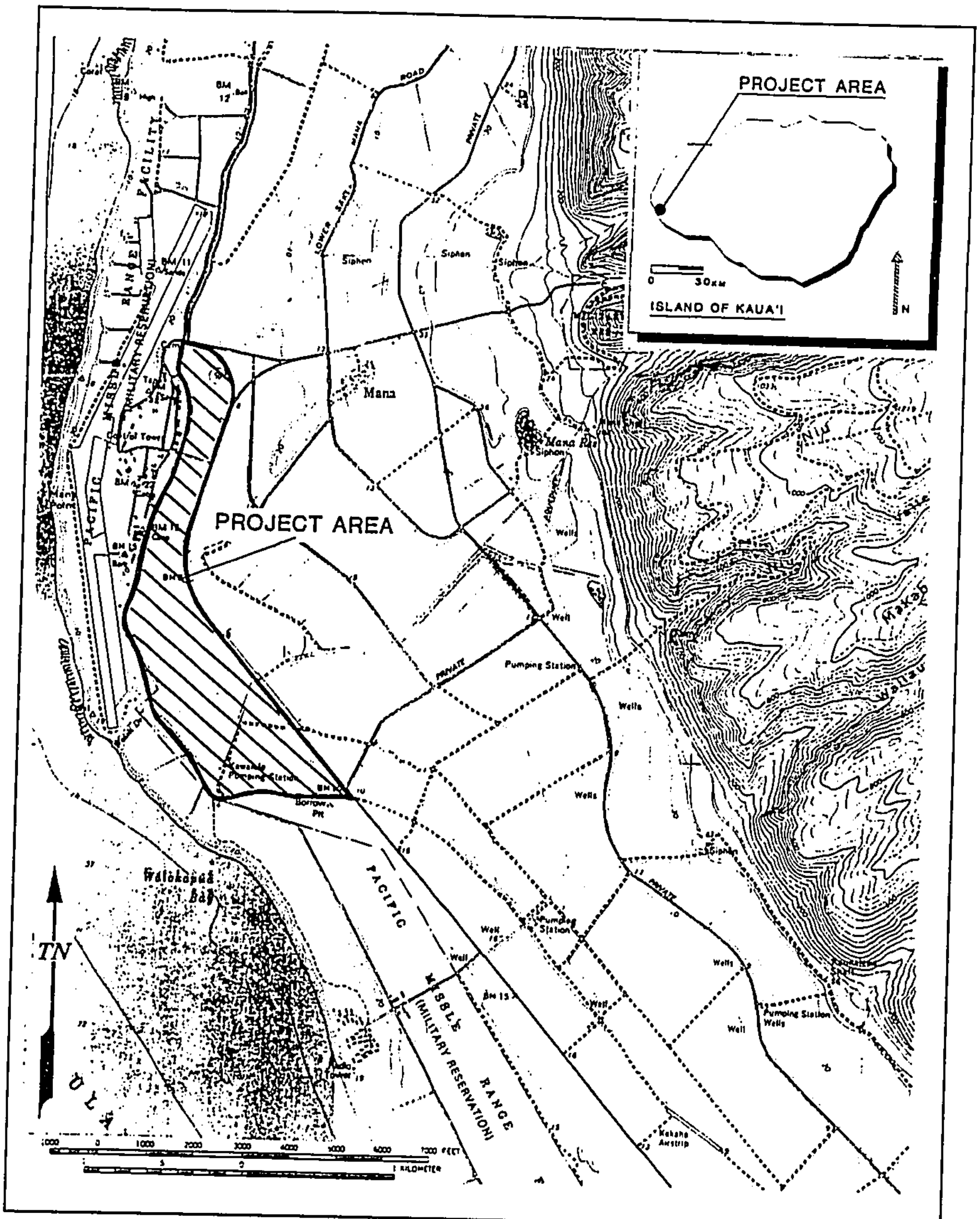


Figure 1: USGS Makaha Point and Kekaha Quadrangles Showing Project Area.

Later in the story, he is pulled by a supernatural swordfish (A`ulele) from Lāna`i to Kaua`i where the fish is killed and Mākālei and his companion Palawai arrive at Kekaha (the arid shores of Mānā.

> Now this place where their canoe landed was filled with many native people who greeted them kindly. Mākālei divided the fish among the people, and it was here that Mākālei and his companion made their home. Mākālei took up farming to help in the tasks of the native residents, and because of his great skills, he came to marry Ka-wai-li`ula-o-Mānā...
>
> During the fishing season of "*ke kaha o Mānā*" (The shore-place of Mānā), all the people of this place went *lawai`a hī aku* (bonito lure fishing). Mākālei and Kawai remained at their cultivated fields, and Kawai told Mākālei of her desire to eat *aku*. . . .Maluaka arrived at their home and told them of the events occurring on the shore and about the great catch of Mākālei's in-laws Wai`awa and Pōki`i (6/5/1928).

The story recounts the return of the fishing fleet and of the success they had in fishing. Mākālei requests the assistance of three *Kāohi* (paddlers who hold the canoe in place while *aku* fishing.)

> Mākālei and his companions paddled to the deep sea *ko`a* of `Awini, and he then took out the lure Kolo-mikimiki, and attached the line. Mākālei then chanted to his ancestress Hina-I-ka-malama-o-Kā`elo who caused the *aku* to rise to the surface. More than 400 *aku* were caught that day and Mākālei divided the fish among his fishing compainions, his wife, all the people and it was said that "all Mānā was filled with the scent of *aku*"(6/12/1928).

Again, the next day, Mākālei and his companions returned to the *ko`a* of `Awini and prayed to his grandmother, the goddess Hina, who caused the *aku* to rise once more, and again, they filled the boat with enough *aku* for themselves and all the villages. This continued until the end of the *aku* fishing season at which time Mākālei offered half the catch to the fishing deities.

> From then on they fished for *ahi, kāhala, uku, `ōpakapaka, `ula`ula, kalekale, hāpu`u, nukumomi, weke `ula, ōpelu paka*, and the *kawakawa* (6/19/28).

In the following years, Mākālei had a son, Kalei, and it was because of their fishing and farming skills that a famous saying concerning this region arose:

Ola I ka `aiuahi`ole ke kini o Mānā!
The multitudes of Mānā live upon food which is cooked without smoke!

This story names the seaweed best known to the area, identifies an underwater religious feature *(ko`a)*, informs us that many people lived there, discusses the successful agriculture caused by the abundant water in the region, plus gives a list of the many kinds of fishes that were plentiful and easily obtained from the sea.

Other *mo`olelo,* such as one following Hi`iaka's journey to bring Lohiau from Kaua`i to Hawai`i Island, reveal alternate place names, overland trail documentation, and refer to the beliefs and myths concerning different places (Emerson 1915, Maly 1993:A-12). Mānā is referred to as the land of ghosts and when Hi`iaka, traveling overland, looks down from the cliffs above the plains she saw the 40,000 ghost gods that dwelt in the region. There were men and women, great people and insignificant people dwelling there and from the cliffs she chants describing the plain below (Emerson 1915:159, Maly 1993:A-13). Events take place which forces Hi`iaka to vanquish the ghosts with her lightning skirt and it was said that the sounds from the sand dunes (Barking Sands) was the wailing of the ghosts that Hi`iaka destroyed, "the sound is that of the wailing ghosts of Mānā who cry out at all times when the sun is unbearably hot, and the sands are dry" (Maly 1993:A-14).

Mary Kawena Puku`i has recorded sayings concerning Mānā which gives insight as to how people lived there (Puku`i 1983). Often, the most apparent physical attributes of the region are poetically used to portray human qualities. These saying with their hidden meanings offer much information concerning, not only traditional values, but traditional activities.

Mānā was known for its heat and marshes. There are 13 sayings in Puku`i's collection that mention this region and seven of them refer to the mirages caused by the physical conditions of this coastal area:

> 1908 The sun sets up mirages at Mānā
> (Said of a boastful person who exaggerates.)

Not only are the unique planting methods mentioned (see below), but activities occurring between villages is described:

> 2480 Ola I ka ʻai uwahi ʻole o ke kini o Mānā
> (The inhabitants of Mānā live on food cooked without smoking).

Said of the people of Mānā, Kauaʻi, who in ancient days did very little *poi*-making, except in a place like Kolo, where taro was grown. The majority of the inhabitants were fishermen and gourd cultivators whose products were traded with other inhabitants of the island, even as far as Kalalau. Because all the taro cooking and *poi*-making was done elsewhere, the people of Mānā were said to live on "smokeless food."

> 2910 Waikāhi o Mānā.
> (The single water of Mānā.)

Pukuʻi then explains the meaning of this by saying:

When schools of *ʻōpelu* and *kawakawa* appeared at Mānā, Kauaʻi, news soon reached other places like Makaweli, Waimea, Kekaha, and Pokiʻi. The up landers hurried to the canoe landing at Keanapuka with loads of *poi* and other upland products to exchange for fish. After the trading was finished the fishermen placed their unmixed *poi* in a large container and poured in enough water to mix a whole batch at once. It didn't matter if the mass was somewhat lumpy, for the delicious taste of fresh fish and the hunger of the men made the *poi* vanish. This single pouring of water for the mixing of *poi* led to the expression, "*Waikāhi o Mānā.*"

Springs lay along the base of the cliffs feeding the Hawaiian's *kalo* lands in Kekaha (Kekaha's spring was called Kauhika), Pokiʻi, and Limaloa and Handy and Handy (1972) suggest that there was more water flowing from the valleys in times of old. They recorded 22 "dry streams" from beyond Mānā to Miloliʻi, and interprets the existence of these place names as indicating dwelling or planting sites at some former times when water was more readily abundant (ibid.:412, Knudsen 1991:98).

To the north of Kekaha, the fresh water marshes of Waiʻele and Mānā were surrounded by more swampy land. Some of the areas in the wetlands were modified for use as inland fishponds containing *ʻanae, awa, ʻoʻio, ʻoʻopu, moi, weke*, and others. Four of the ponds were named: Kawaiʻeli, Kolo, Nohili, and Limaloa. The fishponds were managed by *konohiki* with the help of a *kiaʻi loko* (pondkeeper), for the *aliʻi* Yent (1992).

Although these have all been drained and filled for sugar cane, it was reported that wet *kalo* was grown in the swampy ground at the northern end of the Mānā marsh and a method of agriculture using soil "rafts" were used within the marsh itself, thus, the traditional reference which said: "Mānā, where the mounded taro moves in the water". Puku'i records there were five patches of *kalo* at Kolo (Handy and Handy 1972:410, 411, 419; Puku'i 1983:232, 233)..

Before the introduction of cattle by Vancouver in 1792, the uplands had more forest. There are traditional references made to *iliahi* (*Santalum* spp.), *koa* (*Acacia koa*) and *kauila* (*Alphitonia pondersosa*) growing in the valleys and on the bluffs (Maly 1993:A-4, Lydgate 1991:94). Traditions were known in this century of the harvesting of *koa* for canoes (Handy and Handy 1972:411). Wai'awa gulch had a stream that fed a small pond or swamp. The cattle, left to their own devises, damaged the forest region and probably altered the water supply, which was intermittent at best, issuing from the valleys. It wasn't until the mid-1800's that settlers, such as Valdemar Knudsen, procured large tracts of land for ranching and the eradication of the wild cattle became a serious venture. By that time, the damage to the uplands had already been done, and, although some recovery occurred, erosion prevented the re-establishment of the pre-western forest.

HISTORICAL PERIOD LAND USE

Portlock and Dixon had explored the western sea plain in hopes of discovering a sheltered harbor in 1789. Dixon describes the country through which he traveled as "very dry" and said it was mostly covered in grass. Although disappointed in there search for a safe anchorage, Dixon does mention swampy ground along the shore and the well-established settlement of Kekaha, which he places in the same vicinity as the current town of Kekaha. He states the village of Kekaha was known for its "manufacture of cloth".

> A Tappa is a pretty large village, situated behind a long row of cocoa-nut trees, which afford the inhabitants a most excellent shelter from the scorching heat of the noon-day sun. Amongst these cocoa-nut trees is a good deal of wet swampy ground, which is well laid out in plantations of taro and sugar-cane (Dixon 1789:125).

Handy and Handy suggest that there must have been close contact between settlements in Waimea and Kekaha, as they are only three miles apart, and suggests sweet potatoes, gourds and coconuts were sent from the dry regions of Kekaha and exchanged for bananas, sugar cane and taro from the wetter valley of Waimea. As to the production of *kapa* (cloth plant), *wauke* must have been grown or *mamaki* available in the gulches (1972:410).

During the Māhele in 1848, the *ahupua'a* of Waimea was awarded as Crown Lands to Kauikeaouli (Kamehameha III). However, no L.C.A. claims were awarded in the project area and only three claims were made in the vicinity of Kekaha. A house lot, six *lo'i* and some *kula* land were claimed at the base of the cliffs at Pōki'i (Native Register 1848: Vol. 9:397). A *lo'i*, a house lot, an *aliapa'akai* (a salt bed) and a *muliwai* by the name of Kapenu was awarded in Kekaha (Ibid:146). A woman named Elia Lihau claimed all of the land in the valley of Wai'awa and included a fishery off the coast (Native testimony, Vol 11:155). However, this was not awarded.

By 1854, Valdemar Knudsen, who was originally from Norway, was living in Wai'awa, ranching and beginning to cultivate a large tract of land leased from the government that had been previously used for a tobacco venture that had failed (Lydgate 1991:93). Knudsen eventually became the *konohiki* of a vast area from Nu'alolo to Waimea, except for the *kuleana* lands. His son Eric was born at Wai'awa and at the age of 23 had never been further west than Mānā and never beyond Līhu'e (Kaua'i Historical Society 1991:viii).

Sometime before 1850, William E. Rowell, as a baby, moved to the Waimea region with his missionary family. His early memories included descriptions of the area. He remembers his father going up into the valley where he had a garden with the name of Kakalae. Here, he grew loquats, oranges, bananas, peaches and the first mango tree in Waimea. Summers were spent in the cool uplands where several families had cottages. Rowell remembered hearing the rhythm of the tapa-beaters from the valley and said they got the *wauke* from up in the mountains or "Perhaps they raised it makai" (Lydgate 1991:93).

In the 1860s, a Chinese immigrant by the name of Leong Pah On, bought and restored an abandoned rice mill at Waimea. He grew rice on government leased swamp land in Mānā, as well as, Kekaha and Waimea. Figure 2 depicts a map that illustrates land use in 1920.

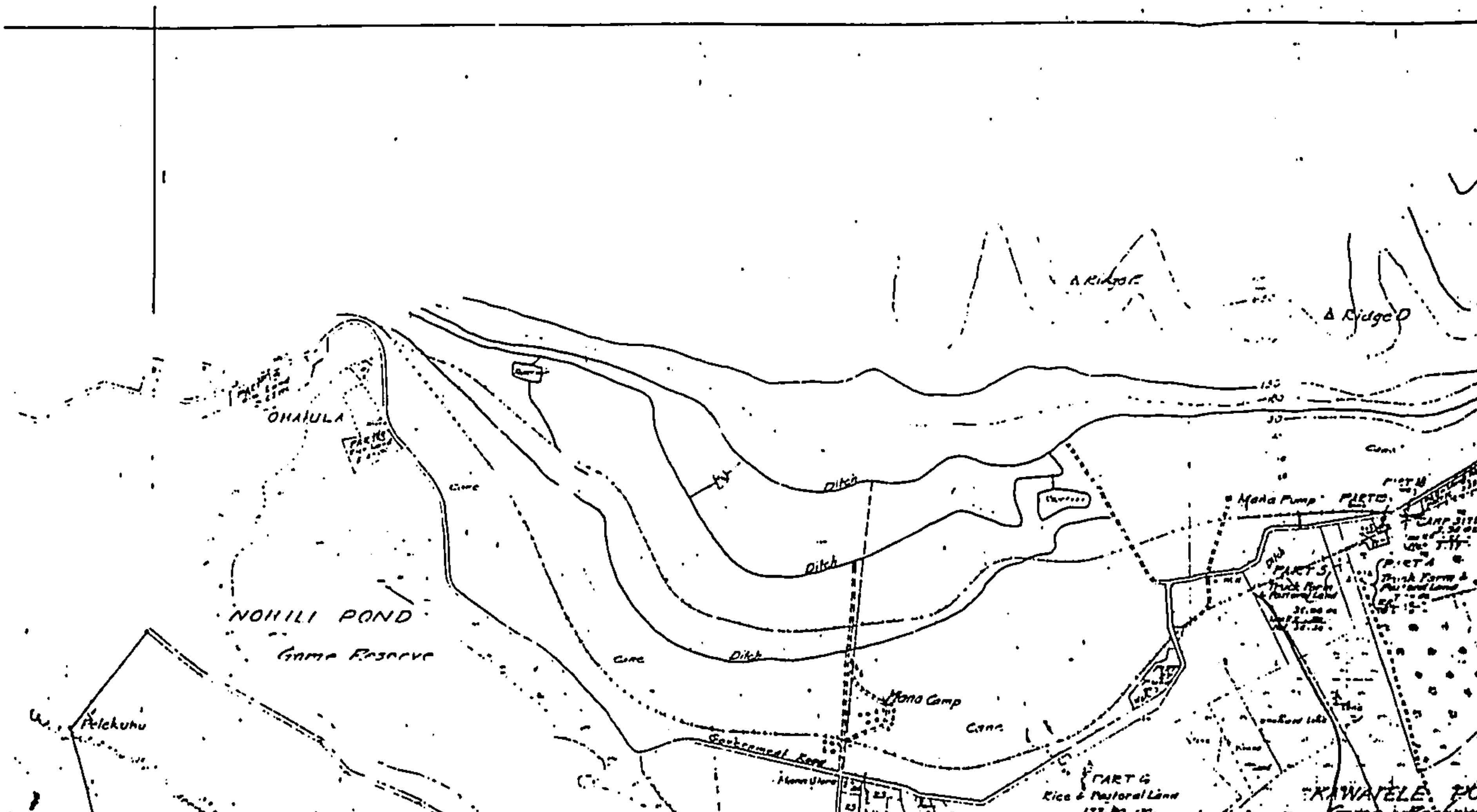


Figure 2: Circa 1920s Land Use Map Showing Project Area.

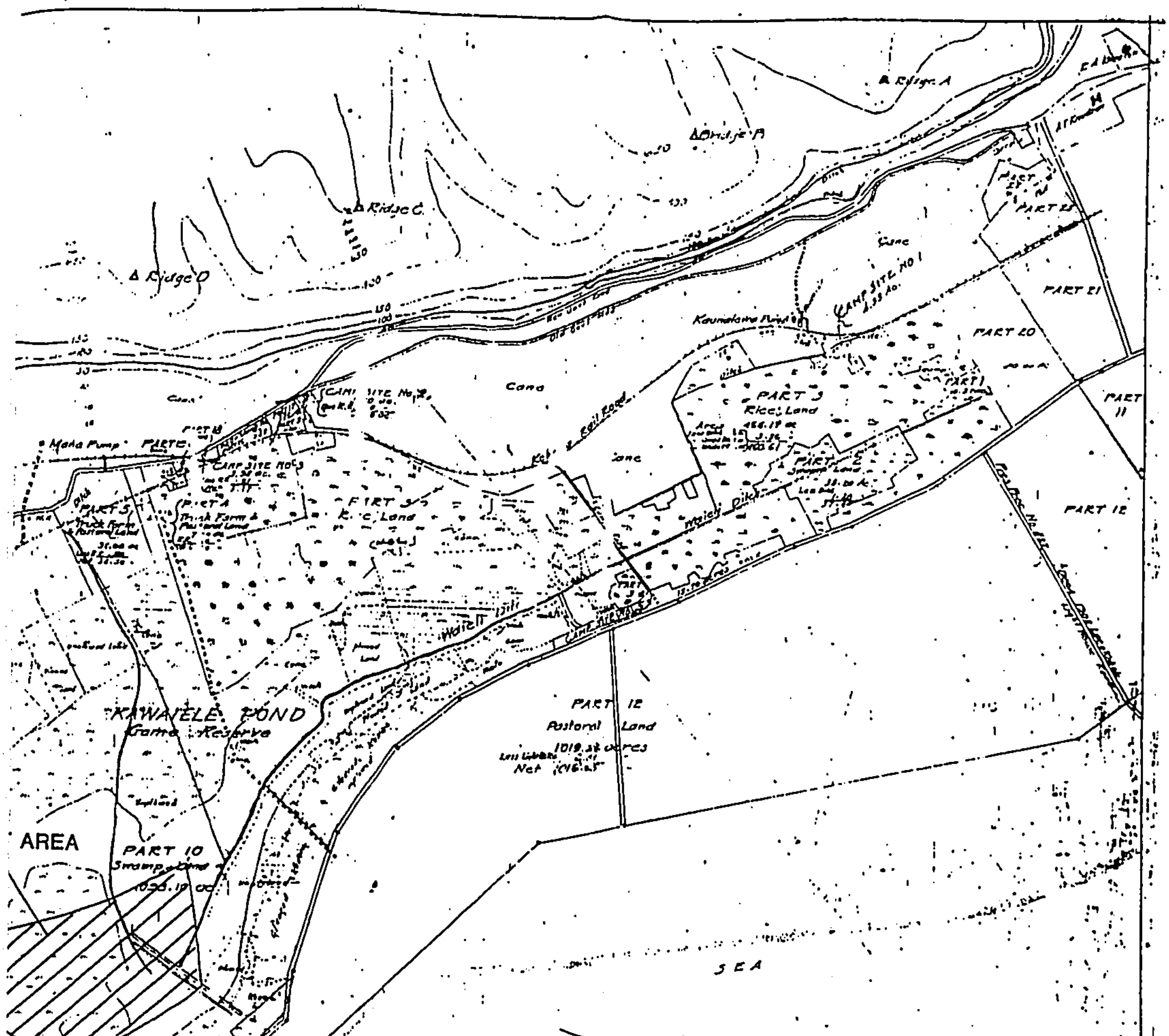


Figure A-2.

HAWAII TERRITORY SURVEY
Walter E. Wall, Surveyor.
MANA CANE, RICE AND PASTURE LANDS
WAIMEA, KONA, KAUAI
Scale 1 In. = 1000 ft.

The land was being used by both rice and sugar. Pah On's rice fields were in and amongst land already leased by Kekaha Sugar and growing cane. In 1922, Pah On's leases were about to expire and the manager of Kekaha Sugar (H.P. Faye) convinced him to allow the sugar company to buy up all the leases and rent back to him the rice fields. Unfortunately, Pah On agreed. When Kekaha Sugar had control of all the leases, its Board of Directors would not honor the agreement and Pah On lost his business and the rice land was converted into cane.

Valdemar Knudsen, Christian L'Orange, and Hane P. Faye began Kekaha Sugar Company in 1878. Sugar was first planted near Kekaha at Pōki'i and it was Faye who dug the first artesian wells in Hawai'i at Kekaha (Joesting 1984:216). With the steady financial backing of Paul Isenberg and George Wilcox, the sugar company dug wells, filled in previous swamp lands, plowed new fields, developed immense irrigation systems, and, finally built a railroad to carry the cane to their sugar mill in Kekaha. An interesting anecdote states that in early times the Hawaiians had attempted to drain the marsh at Wai'ele by constructing a ditch that was abandoned when they struck sandstone. Later, Knudsen widened and deepened the old Hawaiian ditch and eventually drained the marsh for cane (Wilcox 1996:92).

Eric Knudsen, who was the son of Valdemar and born in Wai'awa in 1872, also recounted his earliest memories (1991:97-104). According to him, the original road followed along the base of the cliffs to Kekaha. From Waimea to Mānā was all open country as there were no trees, fences or even cane, early on. There were *kalo* patches at Kekaha and Pōki'i and coconuts were also grown near the *kalo*. At Pōki'i, above the road, Hawaiians lived in thatched houses and grew tobacco. Wai'awa contained some coconut trees, a few *kalo* patches, and several wells. One in particular, called the King's well, was regarded as sacred and no commoner was allowed to drink from it. About one mile from Wai'awa, along the old road, was Kaunalewa which contained a famous grove of coconut trees and a village (Puku'i et al. 1974:95 place names) . Continuing on, was Limaloa on the edge of the swamp. Limaloa also had a spring, seven coconut trees, according to Knudsen, and a small patch of *kalo*.

> Beyond for miles and miles, all the way to Mana the country lay open and bare with a great swamp full of Nekes or bulrushes lying between the fertile soil and the sand lands. This swamp extended all the way from Kekaha to Mana, and when we had heavy winter rains the Hawaiians would paddle their canoes from Mana to Waimea on the inland sea and tie their canoes to the cocoanut trees in the Waiawa garden (Ibid.:99)

According to Knudsen, the majority of the population was strung along this road at the bottom of the cliffs:

> A row of grass houses extended all the way along the foothills from Waimea to Mana. Every house site had a name. To find a man you had to find his house name. The natives seemed to know every name and would keep sending you along until you finally came to the spot you were looking for " (1991:100)

He continues by describing the unusual communication methods between the settlements:

> At certain hours all the women sat in their houses and beat tapa cloth and as they beat they talked to one another in a tapa beaters' code. They could send a message with great speed from Waimea to Mana. When the men returned from the mountains with fire wood or canoes, the woman that saw them at once tapped out the news and it flew from house to house with the result that every man, when he came home, found his house in order and no surprised visitors hanging around. The men tried to learn this secret code but never did, though an old man at Mana told my father that the men had tried for years to learn the secrets of the tapa code but were never able to do so (Ibid.)

In spite of the heat and isolation, no one went without, according to Knudsen:

> Taro and sweet potatoes, rice and milk, yams and watermelons were plentiful. The Mana natives raised wonderful melons . . . Every now and then Mana fisherman would come past with huge packs of dried squid and give some to father. . . Eggs and chickens were plentiful. Turkey wandered about in large flocks . . . we had figs, papias (sic), mangos and fresh hau cocoanuts . . .(Ibid.:100-101)

Apparently there was no market for beef cattle, but goat skins could fetch a good price. Twice a year all the men went goat hunting in the valleys, eventually driving thousands of them to the top of Hō`ea Valley. The rest of the villagers would make two long lines on the sides of the Valley and the men would send the goats down the middle to the sea for slaughter (Ibid.:101,102).

In Knudsen's time there was no road to Mānā, only a trail. When they traveled to Barking Sands, they went down to the lower edge of the swamp and followed along the edge "almost all the way" (Ibid.:103). Native birds were supported by the swampy waters and the travelers saw hundreds of ā*e`o* (*Himantopus mexicanus knudseni*, stilts), *koloa* (*Anas wyvilliana*, Hawaiian ducks), and *`ale`ula* (*Gallinula chloropus sandvicensis*, mudhens).

Knudsen recounts an interesting story told to his father concerning the arrangement of the houses belonging to the Hawaiians. They all consisted of one big room with two doors opposite one another and two gable ends which were always built facing the east and west. When Knudsen's father asked why the doors were always facing the ocean and the hills he was told:

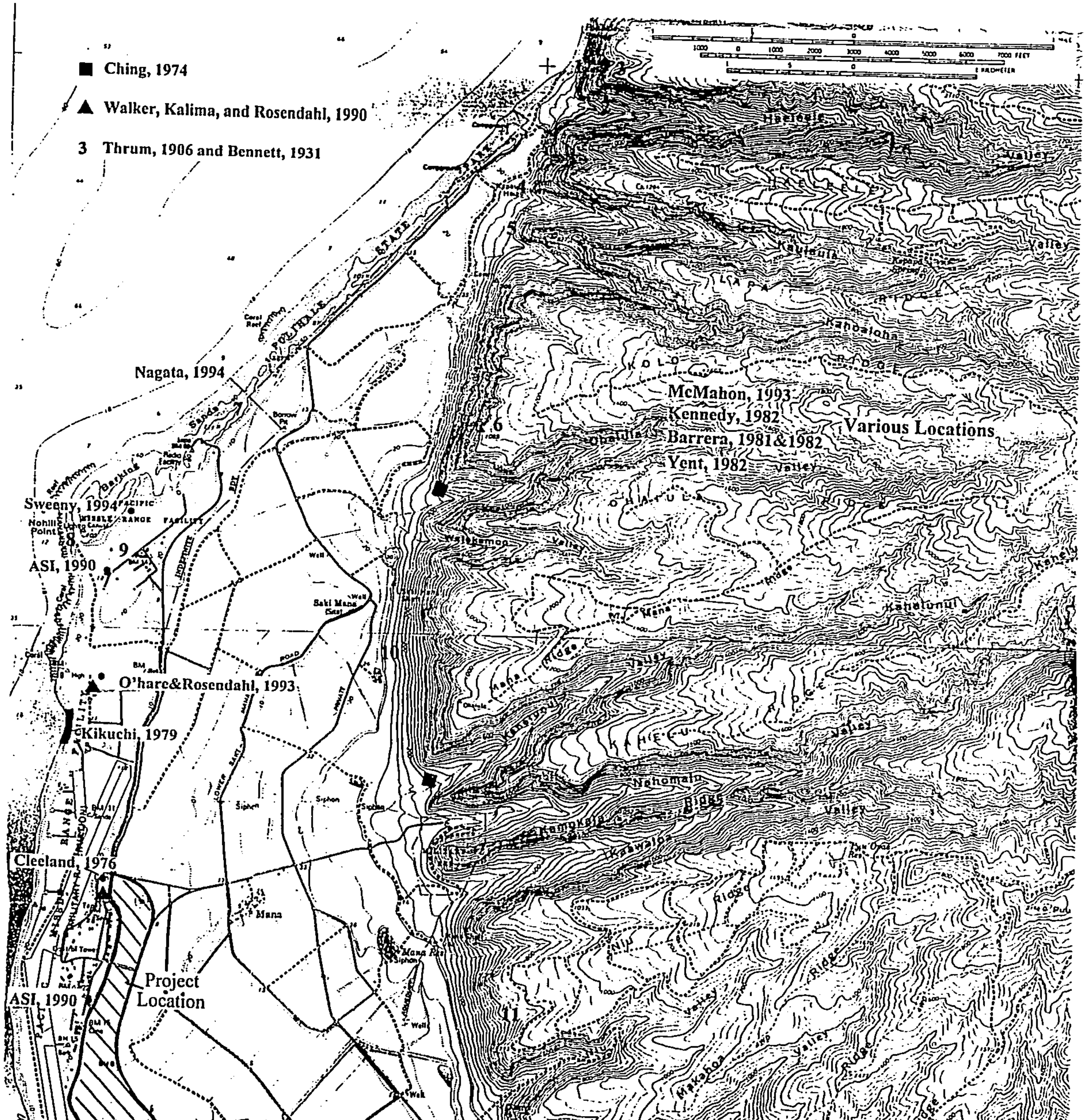
> Why, you know that Po, the abode of the dead, lies under the ocean just outside Polihale, where the cliffs and the ocean meet, and the spirits of the dead must go there. As the spirits wander along on their way to Po, they will go around the gable-end of a house but if the house stood facing the other way, the spirits would walk straight through and it would be very disagreeable to have a spirit walk past you as you were eating your meal. In fact, . . we can always tell when a battle has been fought by the number of spirits passing at the same time (Ibid).

PREVIOUS ARCHAEOLOGY

Thrum compiled a study of *heiau* in the early 20th century in which he recorded information concerning these religious features throughout Hawai`i (1906). Several *heiau* are associated with the west end of Kaua`i in the general area of the project In addition, an archaeological survey of sites was compiled in the 1930s by William Bennett. Most of the sites recorded by Bennett were located at the base of the cliffs, in the valleys, and on the bluffs in between the gulches (1931). Figure 3 shows the majority of the archaeological studies completed in the past twenty years, or so.

Sites 1 through 16 are not directly associated with the project area but illustrate settlement patterns and activities that included the vicinity of the project area.

Site 1. Polihale heiau, a four-terraced structure on the seashore at the base of Polihale cliff (Bennett 1931:99). Thrum said that during his examination of the structure, two mounds on the forth terrace gave "evidence of comparative recent observances" (1906:39). In 1853, a native of Kaunalewa told Thrum he had been present at a sacrifice at Polihale of 12 warriors from Hawai`i that had been captured during a battle at Koloa (Mahaulepu) and that the *heiau* was dedicated to Kū (Ibid.:62).


Ching, 1974
Walker, Kalima, and Rosendahl, 1990
3 Thrum, 1906 and Bennett, 1931
Nagata, 1994
McMahon, 1993
Kennedy, 1982
Barrera, 1981&1982
Yent, 1982
Various Locations
Sweeny, 1994
ASI, 1990
O'hare&Rosendahl, 1993
Kikuchi, 1979
Cleeland, 1976
Project Location
ASI, 1990
Haeleele
Valley
Kauhao
Kahoaloha
Ridge
Valley
Mana
Nahomalu
Valley
Makaha
Ridge
Siphon
Mana
Nohili Point
Saki Mana
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11

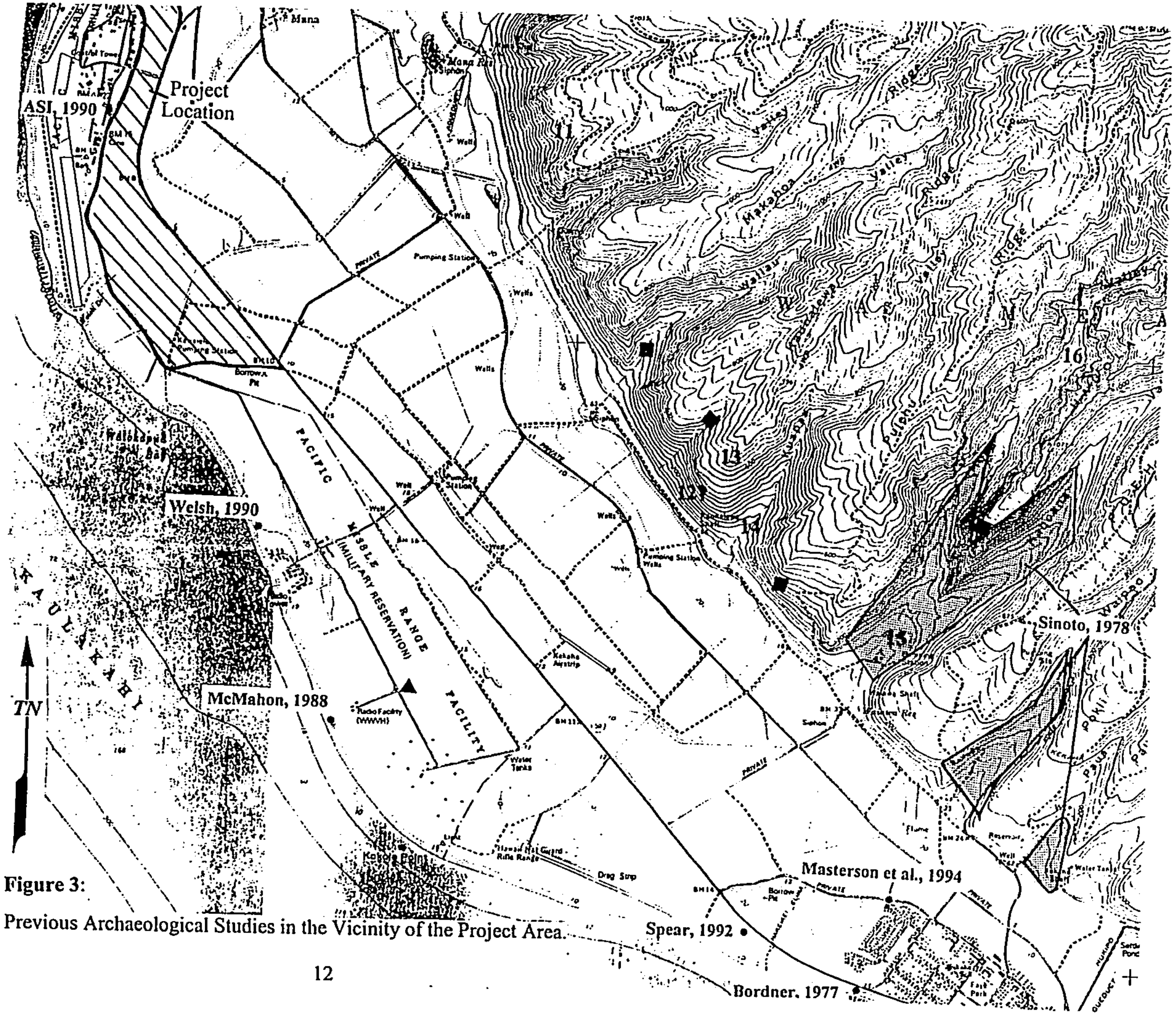

Figure 3:
Previous Archaeological Studies in the Vicinity of the Project Area.

Site 2. House sites, in Haeleele valley not far from Polihale heiau (Bennett 1931:99). Bennett said this was a series of stone platformed house sites on a ridge between two branches of an intermittent stream.

Site 3. House site, in a niche in the cliff back of Polihale heiau. Bennett said a variety of midden and other artifacts were identified at this site (1931:100).

Site 4. Kapaula heiau, on the north side of Kaulaula valley, about 100 feet above the base of the talus slope on Haeleele ridge (Ibid).

Site 5. House sites, at the base of Lapa ridge and continuing up the valleys on both sides of this ridge (Ibid:101).

Site 6. Kapaula Heiau, at Kolo near Mana (Ibid.) Thrum said this temple was of unknown class, stood four feet high, and was located against the hill (1906:39).

Site 7. Dune burials and camp sites, between Polihale and Barking Sands.

Site 8. Elekuna heiau, near the Barking Sands at Mana, in a cove on the inland side of the dunes. Thrum said no structure was found, "simply a mound of outcropping sandstone at the base of which were placed the offerings of the devotees" (1906:39). He continues by saying his guide, Kalapi'i, told him the *heiau* (located at Nohili) was an *in situ* ledge of sandstone with no modification. Kalākaua brought sacrifices here several times and people in the area said they could often hear unexplained hula drums and music there at night (Ibid.:62).

Site 9. House sites along the inland side of the dunes from the Barking Sands northward (Bennett 1931:102). Apparently these sites were at the edge of one of the swamps which has since been drained, filled, and planted with sugar cane.

Site 10. Kahelu heiau, at Kahelu near Mana . . .(Ibid.) Thrum said it was a platform that was located at the base of the hill and stood about 6 feet high in front (1906:39)

Site 11. Makahoe heiau and village site on Niu ridge, Kaunalewa. Thrum calls it a village shrine and said it was named "Makahoa". Thrum continues by saying it was located at an elevation of 1200 feet, included taro land and dry crops (1931:64). There were a few *kalo* terraces located in small valleys with water and petroglyphs were reported for this area.

Site 12. Hooneenuu heiau, along the ditch line inland from the government road near the center of Kaunalewa ridge (Ibid.:102. Thrum called this a *heiau* for circumcision. He located it on the south side of Kaunalewa gulch 250 feet *mauka* of the government road (1931:41).

Site 13. Burial caves of Kaunalewa ridge. Bennett described traditional artifacts found with the burials (1931:102).

Site 14. Two small heiaus, near Waiawa . . .Thrum said that one was a village shrine at Kuapa, near Wai`awa and one (called Wai`awa) was situated about 200 feet up the pali, on a ledge (1906:62).

Site 15. House sites and taro terraces, in Waiawa Valley (Bennett 1931:103) . Bennett said there was terracing in the lower Wai`awa valley and "many house sites".

Site 16. Hauola heiau, in Hoea valley at the base of Hauola ridge (Ibid.). Thrum said it had a "opened platform character". He identifies it as *po`okanaka* or *`awa`awa* class and said was dedicated to Kane and Kanaloa. Valdemar Knudsen told Thrum it was built to commemorate the recognition of Ola as a prince of the Royal House. On the sandy plain was a sacred hill called Kanaloa where many would stand to observe the rites. Thrum says this was a "temporary place of refuge and is approached with reverence by the natives to this day" (1931:64). Above this *heiau*, on the steep hill of Hauola, was a *pu`u kaua* (fortification) that was last used during the intended invasion of Kamehameha I in 1804 (Ibid.).

Recent archaeological studies, occurring over the past twenty years, have added little to the record. These projects included a description of the historic Japanese cemetery at the north west boundary of the project area (Cleeland 1975). A reconnaissance survey conducted in the area around Nohili Ditch, which identified a sand-ash strata, and two horizontal features in the ditches wall (Kikuchi 1979), and the identification of three aqacultural pondfields within the Mānā plain at Kolo, Nohili, and Kawai`eli (Kikuchi 1987).

In 1978, a reconnaissance survey was conducted involving portions of eight valleys in the Waimea District, east of the project area. Sites identified by Bennett were relocated and five previously unrecorded sites were identified in Waiaka, Paua, Waipao, Wai'awa, Kahoana, Hō'ea. Features included rock mounds, stone cairn, stone walls, enclosures, terracing, platform, modified cave shelters, and traditional *'auwai* (Sinoto 1978).

Sinoto (1987) and Jones (1992) both state that the most archaeologically sensitive areas are located at the interface of the cliffs and the plains. Sinoto suggests the possibility that prehistoric settlement was concentrated closer to the valleys and ridges on higher, dry ground away from the swampy plain (Sinoto 1987:7). Jones suggests that at least within the Barking Sands region, the major use of the coastal area was for burials.

Two archaeological surface and subsurface testing projects conducted within the Kauai Test Facility (KTF) and Pacific Missile Range Facility at Barking Sands (PMRF) resulted in the identification of one possible buried soil horizon, charcoal, *nerita picea*, and sea urchin (Welch 1990a, 1990b).

Additional archaeological work conducted on the coastal plain includes two field inspections (McMahon 1988a and 1988b) on the boundary of the PMRF, and a reconnaissance survey of Kekaha Beach (Bordner 1977). The valleys and ridges to the east of the project area include surveys by Kennedy and Jenks (1982), Barrerra (1981, 1982), Yent (1982), and McMahon (1993). In 1974 a re-survey of many of Bennetts sites was conducted (Ching 1974)

An inventory survey was conducted in 1990 at specific areas within the PMRF and within the Koke'e Geophysical Observatory in the uplands (Walker, Kalima, Rosendahl 1990). Only one feature, a historic retaining wall, was identified. An archaeological subsurface inventory survey was conducted on the PMRF at Barking Sands which resulted in no prehistoric subsurface cultural deposits being identified (O'Hare and Rosendahl 1993).

Monitoring was conducted by SCS, Inc., on a parcel of land to be developed by the Sunkiss Shrimp Co. with no cultural deposits being identified (Spear 1992). An archaeological inventory survey was conducted in conjunction with the Kekaha Housing Project (Masterson et al. 1994a). Although three sub-surface strata were recorded during testing, none were identified as cultural. Also in 1994, an archaeological inventory survey was conducted on the PMR, in the area of Major's Bay (Sweeney 1994). Ten backhoe trenches and several auger core samples resulted in the identification of one site (50-30-05-4016), a charcoal lens deposit, located at 85 centimeters below surface. This feature produced in the earliest dated evidence so far of human activity on the southwest coast of Kaua'i (770+-60 years B.P.). A memo from Ralston Nagata (1994) discusses an eroding cultural deposit (Site 50-30-01-6027) at Nohili Dune on the PMRF lands.

Two burials were encountered east of the Kekaha Agricultural Park Pumping Station (Masterson, Folk, and Hammett 1994b). In addition to the uncovering of isolated burials, the northern portion of the PRMF, from Nohili Ditch to Polihale State Park, contains what is referred to as a major burial ground and midden deposits and *imu* have been identified in the eroding edges of the sand dunes (Gonzalez 1990, Dolittle and McMahon In: ASI 1990). To the south, a recent archaeological inventory survey at the Hawai'i Army National Guard Firing Range at Kekaha did not identify any cultural deposits (Folk and Hammett 1994).

SETTLEMENT PATTERN

Based on previous archaeological studies, ethnographic information and archival research, it would be expected that permanent habitation features would be located along the bottom of the cliffs and in the valleys. The springs issuing from the escarpments provided fresh water for small *kalo* patches and for domestic use. Cultivation in the gulches depended on rainfall and intermittent streams which probably contained more water than is presently evident.

The natural fishponds and wetlands on the plains were modified for agriculture and the marshy terrain attracted waterfowl which was a alternative food source to the rich fishing grounds off shore (Malo 1951:39, Handy and Handy 1972). The beach area in front of the swamps undoubtedly supported temporary fishing camps and portions of the dunes were used for burials.

Verbal traditions suggest close contact and the exchange of fish, gourds, and other dryland crops for *kalo* from the Kekaha and Waimea region. This exchange system likely extended to the Napali coast valleys.

Post-Contact activities brought changes to the life-styles and, more immediately, to the environment. Cattle and goats altered the landscape on the hills and gulches, natural ponds and swamps were drained and filled for agricultural pursuits, dispersing the native fauna, and some of the beach areas were developed for military use.

Archaeology previously conducted identified no sites in the project area. The project area was traditionally referred to as a marshy region and was filled for sugar cane cultivation sometime after the 1820s. The intense agricultural activity in the project area would preclude the survival of any surface archaeological features.

FIELD RESULTS

Field reconnaissance was conducted by Leann McGerty (Project Director) on August 20, 1997 under the overall direction of Robert L. Spear, Ph.D. A general pedestrian walk-through along the embankments of several canals bisecting the project area in a north/south, as well as, an east/west arrangement (Figures 4 and 5). Nothing cultural was identified in the walls of the ditch cuts. The tilling equipment could not easily maneuver the corners where canals from both directions met. A few basalt boulders and grayish sand was noted at those points (Figures 6 and 7). This particular field, however, was at least partially filled with material from the *makai* dunes. It is likely these boulders represent a secondary deposit. The exposed grayish sand deposits were examined and found to contain nothing culture.

ORAL INTERVIEWS

Although limited in scope and number, oral interviews were obtained to provide a glimpse into the history of the project area and its vicinity from the viewpoint of primarily long-time residents. The main focus of the interviews was to obtain land use history and information on the changes that had taken place over time. We were fortunate to have at least an hour with each person. The focus of this report is not to provide a verbatim transcript but to include instead, pertinent comments and observations. The assistance given us by these individuals was greatly appreciated, as they each expressed their own unique viewpoints.

Figure 4: One of Several Canals in the Project Area. View to East.

Figure 5: One of Several Canals in the Project Area. View to South.

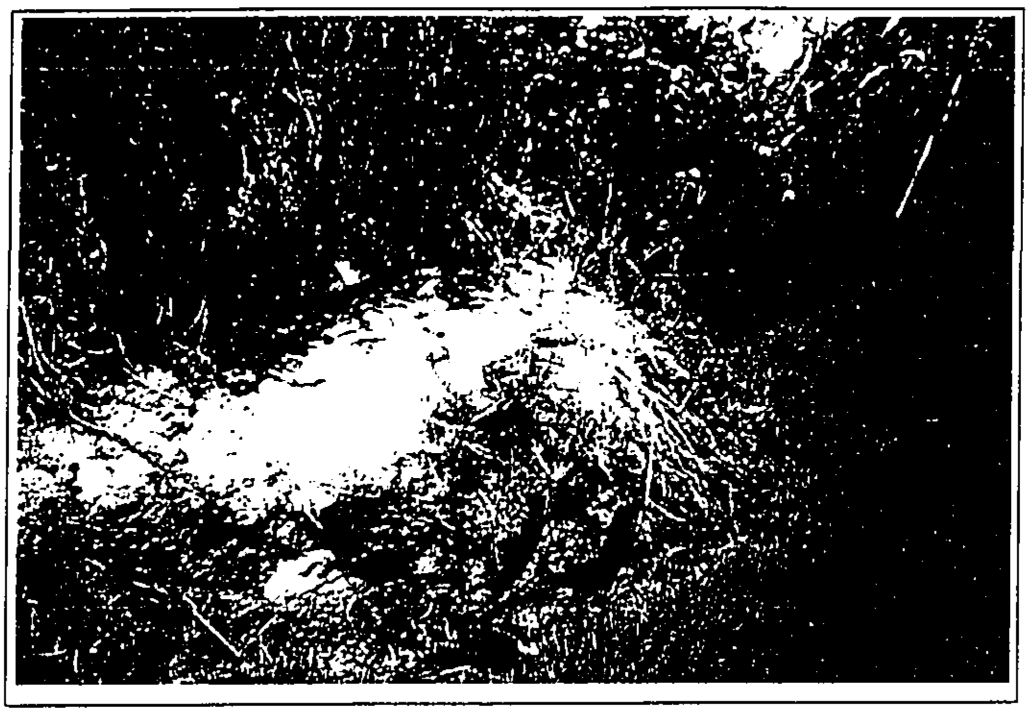

Figure 6: Sandy Soil Matrix and Basalt Boulder at Edge of Canal.

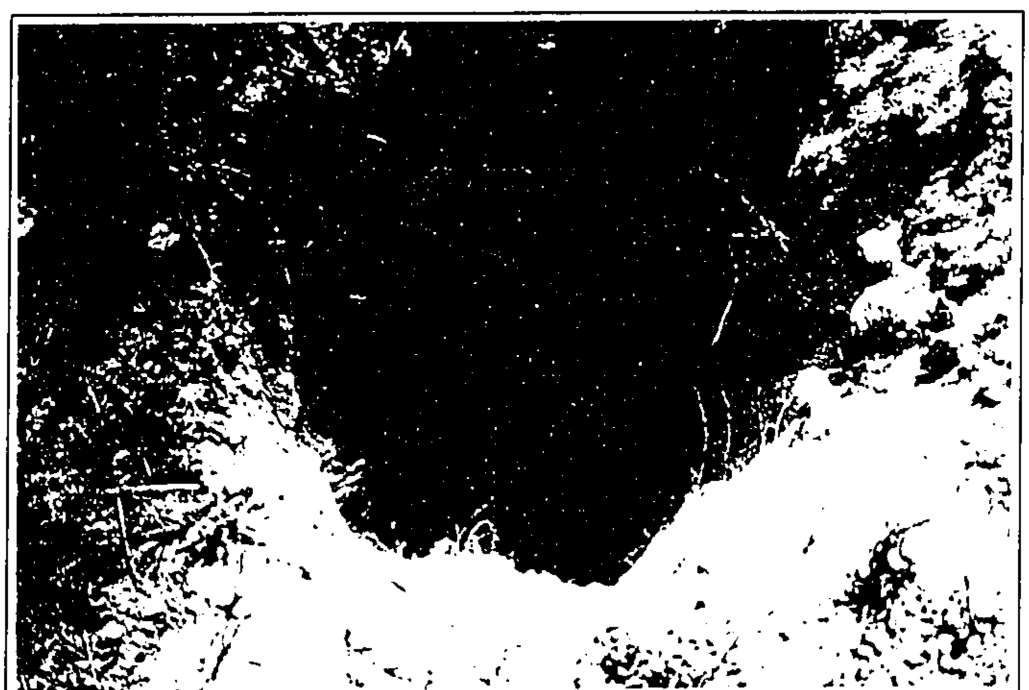

Figure 7: Soil Stratigraphy Showing Mixed Dune Deposit.

Six individuals were interviewed concerning plantation life, traditions they might be familiar with, and changes long-term residents have seen within the community over time. Mr. Calvin Shirai was the Director for Kaua'i's Main Street Project (Figure 8), Mr. Moriyoshi Ganeko (Mori) began working for Kekaha Sugar over 30 years ago, retiring as Manager of the Irrigation Dept.; Antonio Wong (Tony) began working for Kekaha Sugar in 1943, Lindsay Faye, Jr. (Tony) had been the Manager of Kekaha Sugar from 1973 until his retirement in 1992, Aletha Kaohi was born and raised in Kekaha, and Kalani Flores was a resident of Waimea.

Figure 8: Kaua'i Main Street Project Director, Mr. Calvin Shirai.

Calvin's concern for the future of Kekaha and its people is evident. He sees lack of business and economic opportunities and a migration of the young people out of the area for jobs other places now that Kekaha Sugar is down-sizing (they used to employ about 1,000 people, now only 150 people have jobs there). Kids he went to school with thought they could always work for Plantation so there was no need for higher education. Now there is nothing for them here and they must go elsewhere.

Calvin's grandparents lived in Kekaha sugar camp. Originally from Japan, his grandfather came first and then the woman who would be his grandmother. They had seven or eight children. Calvin's grandmother used to cut hair for everyone in Kekaha. In those day, almost every house in Kekaha Camp had a Japanese *furo*. Calvin still remembers his grandmother stoking the fire for their *furo* when he was a boy (in the 1960s). His parents lived in the old sugar camp while his father worked for Kekaha Sugar Company.

Thirty-five years ago the community had lots of businesses: a movie theater, variety stores, and several markets. Kekaha Road was lined with different shops. In his father's time (1940s and 50s) it was difficult to travel, only a few people had cars, so Kekaha was self-contained, as were most of the sugar towns along the coast. In the past, Kekaha Sugar supported the schools and there was a warm relationship between plantation and community. Activities when he was a child were not very different from before, except children had bicycles and would travel from camp to camp, to the beach, to the swimming pool at Mānā Camp and go to the movies. In spite of the economic changes, the community is still close knit, looking out for each other.

As Manager of the Irrigation Department for Kekaha Sugar Company, Mori knew the land and its yearly flooding cycles well and was familiar with stories of the Hawaiians paddling from Kolo swamp to Waimea when water from the winter rains filled the swamp land (Figure 9). He was also aware of the burial ground at Polihale. After participating in WWII in Europe, he returned to Hawai`i and attended the University of Hawai`i. He and his wife then returned to Kekaha to raise their son. Living in a plantation house near Mānā Camp (or village), they participated in the its community life. There was a school, swimming pool, plantation store, a park with beautiful trees, a tennis court, and a club house. For the young there were such activities as fishing, swimming, diving hunting goats, and movies. Adults had them same options, as well as, volleyball, softball, and baseball, organized and sponsored by the plantation who was very involved with community life. Different camps competed in these games.

Antonio's father was a carpenter who stowed away from Canton, China to escape the political situation at home (Figure 10). He worked for over 40 years at McBride Sugar where he met Antonio's mother, who was Spanish. Antonio quit school and went to work for Kekaha Sugar cutting cane at 16 years old. He did quite a variety of things on the plantation including, driving a tractor, construction on the plantation, training horses and mules for 10 years, bulldozer operator, and machinery repairing. It was a time when ability counted

Figure 9: Mr. Moriyoshi Ganeko

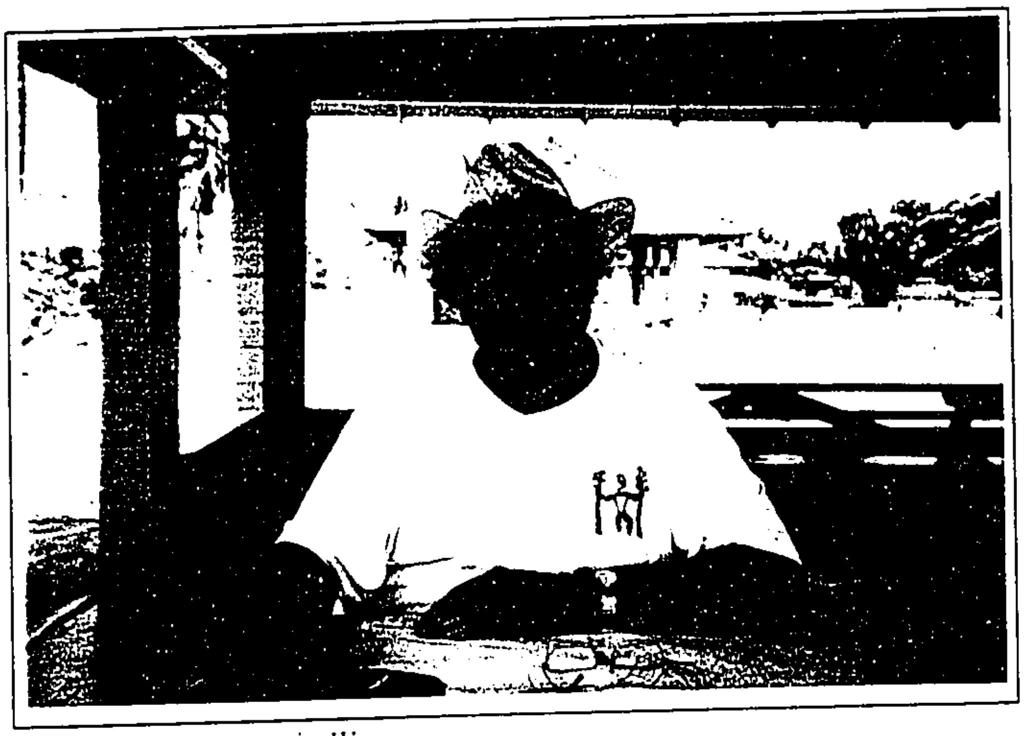

Figure 10: Mr Antonio Wong.

more than certificates. Antonio's wife was from a Hawaiian family who had lived in Kekaha for generations. Every weekend for 27 years, he would hunt goats and pig to help support his family of ten children. During these excursions into the valleys, he noticed structural remnants of Hawaiian occupation in the past. He was also aware that at least one valley contained a *heiau*.

Kekaha Sugar had camps at Mānā, Saki Mānā, Kolo, Limaloa, Polihali, Nohili, Kanalewa, and several up on the bluffs so there would be easy access to these fields. There were houses where the Tracking Station is now and all along the rocks where the power plant is located. Although 70 years old (last May), Antonio still trains horses and makes saddles.

Lindsay Faye is the grandson of the first manager of Kekaha Sugar. The Fayes' lived in Poki'i and Waimea, and the Kndusen were in Wai'awa. In the mid to late 1800s, his grandfather and four others were planting cane in the higher lands because of the approximately 2,000 acres of swamp and marsh on the plains. Early on, rice was planted in some of the swampy areas by the Chinese.

He remembers going with his father, who was also a Plantation Manager, early in the morning to watch the burning cane. The men would wait with their dogs on the edge of the fields to catch rats as they ran from the fire as there a bounty for tails. When machinery arrived and automation occurred, there were less and less jobs for people. The old road along the bluff referred to by Knudsen was still in use when he was a child. Lindsay mentioned the plantation camps on the bluffs and said that one in particular, Hukipō located between Waimea and Kekaha, was used to guide fishermen home at night. He also remembered talk about the "Great Train Robbery" when the plantation railroad, delivering the payroll to Mānā, was held up.

In the early days, people had to make their own fun. Lindsay remembered a party held by his mother and father at Polihale Beach in which all the guests were transported to and from the beach by train. A platform was constructed to assist in the embarkation and debarkation of some of the heavier guests. In the heat of the summer, the wives and children would go to cabins at Koke'e. Before 1930s, the land was clearer and it was easy to take horses on the trails. A nice settlement of people would gather up at Koke'e during the summer.

Travel was difficult before the war and Lihu'e was to far away to visit very often. Sometimes families, or wives and children, would take the steamer to O'ahu for shopping. When people visited one another, they often stayed for sometime, or after a party, people would spend the weekend, which meant there was a need for larger houses or guest houses.

Kalani Flores presently lives in Waimea and Aletha Kaohi was raised in Waimea (Figure 11). Her family has lived in the area for generations. Aletha's father was Bennett's guide in the 1930s. Bennett puts the *heiau* he calls Makahoe on Niu ridge, in Kaunalewa. According to Aletha and Kalani, this is not correct. Aletha's father described Makahoa Heiau as having been located at the base of Makahoa ridge (not Niu ridge) and as having been a tower structure similar to an *anu'u* (tower found on platform temples constructed of wood and *kapa*), not of basalt. It was associated with prophecy and because it was made of wood and *kapa*, nothing was left to show its exact location. There was a *heiau* at Kaunalewa, but it was not called Makahoe or Makahoa.

Figure 11: Ms. Althea Kaohi, Mr. Landis Ignacio, and Mr. Kalani Flores.

Aletha and Kalani said that plantation moved all the Hawaiian families out as it acquired and planted the lands for cane. She said that some families still maintain burials near where their houses had been.

There were stories of Niu Valley having a watercourse that was used to float down *koa* logs for canoes. Although a lot of the cutting was completed up in the mountains, the finishing work would be done on the flats. Perhaps the logs were floated in the swamp to other work stations. She also thought the name of Kahoana valley, one of the two valleys that opens into Wai`awa, suggests it was associated with adze production (*hoana* means to rub or grind, a whetstone or a grindstone). The seaweed from Polihale called *pahapaha* was used for *lei,* a custom unique to this area.

DISCUSSION

The Scope of Work (SOW) included archival research, a field reconnaissance, and oral interviews. Written records indicated that the project area, indeed a very large portion of the plain, was a swamp or marsh and had been such in traditional times, as well. Areas had been modified for some *kalo* cultivation, especially near springs, and portions of the marsh were used for the containment of brackish-water fish. Habitation occurred mainly along the bottom of the bluffs, with some scattered within the valley openings, and a few on the bluffs. Temporary habitation, such as fishing camps, were suggested for the beach, based on the excellent marine resources. The easily dug sand dunes were convenient for burials and beliefs concerning the souls of the departed from this spot encouraged internment here.

The shift in modern times from that of marsh and ponds to agricultural land impacted the project area dramatically. The dunes were cut back and the sand was taken to fill in the wetlands. Natural drainages were expanded and new canals dug to reduce the flooding. The plowing and tilling of the cane land for the past 70 years has disrupted any natural stratigraphy for at least a meter under the surface.

The results of the archival and background research indicate that temporary habitations, burials, and agricultural features might have been present in or near the project area. Based on the documented post-contact record, it is clear that because the dunes had been excavated to fill the marsh and because of the impact of sugar cane agricultural practices, few, if any, intact sites are to be expected to remain in the project area. This expectation was confirmed by the field reconnaissance. The reconnaissance did not identify any significant surface archaeological features. Examination of exposed cut-faces along roads and ditches, also, failed to identify significant sub-surface deposits.

The purpose of the interviews was to obtain a glimpse into the life style of the residents of the area, obtain specific information concerning the project area, and obtain information concerning traditional Hawaiian culture. Thin work was successfully completed with insights into plantation camp life and information which supported previously recorded information by confirming the traditional areas for habitation and activities that were know to have been present in this region. No extensive new information related to traditional Hawaiian life ways was obtained. It should be again noted that all of the informants were quite helpful and that the information presented here is only a portion of what they so kindly offered.

CONCLUSION

The archival and background research indicated that few if any significant archaeological sites would be present within the project area. The field reconnaissance confirmed this. Because the dunes are known as potential burial locations, future impacts to existing dunes should be monitored by a professional archaeologist. Because dune material was used as fill for the marsh, it is also possible that secondarily deposited human remains may be encountered when developing the project area. If any such remains are encountered, all work in that specific area must stop and the State Historic Preservation Division be immediately notified.

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Appendix 3

Animal Health Management System

APPENDIX - 3

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Animal Health Management System

CEATECH's Animal Health Management System

The biosecurity measures and protocols used by CEATECH USA, Inc. are applied at any facilities which may be involved, and are equivalent to those developed and used by the U. S. Marine Shrimp Farming Program, supported by the United States Department of Agriculture. Several individuals who were responsible for the original design and development of those biosecurity protocols under support from the federal government are now members of the CEATECH staff. The biosecurity measures used by CEATECH address: (a) the **shrimp stocks**, (b) the **design of facilities**, and (c) **operational protocols**.

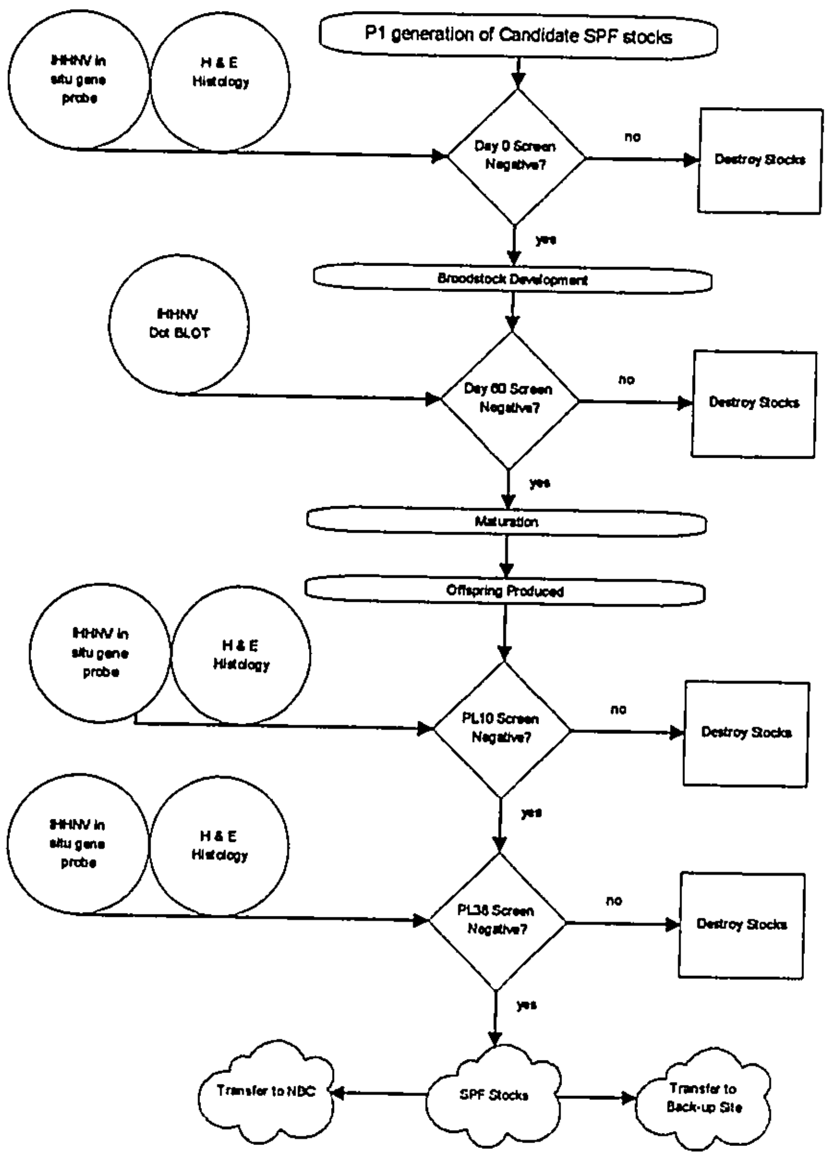
All of the **shrimp stocks** used by CEATECH are derived from Specific Pathogen Free (SPF) populations originating from the USDA Marine Shrimp Farming Program, coordinated by The Oceanic Institute. These stocks, maintained in captivity for at least six generations over a period in excess of nine years, have repeatedly been shown to be free of the specific pathogens summarized below.

Specific pathogens excluded via the screening program.

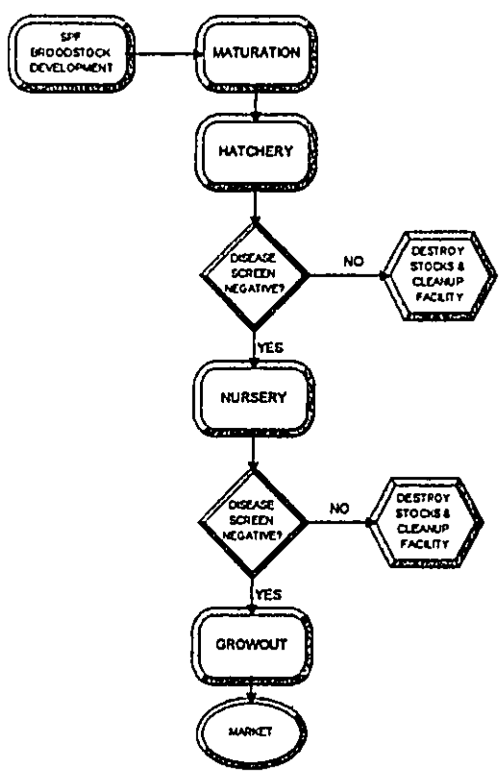
Pathogen	Type	Classification	
White Spot Syndrome Virus (WSSV)	virus	baculovirus	
Yellowhead Virus (YHV)	virus	baculovirus	
Taura Syndrome Virus (TSV)	virus	picornavirus	
Infectious Hypodermal Hematopoietic Necrosis Virus (IHHNV)	virus	parvovirus	
Baculorivus penaei (BP)	virus	baculovirus	
Hepatopancreatic Parvolike Virus (HPV)	virus	parvovirus	
Microsporidians	protozoan	microsporidian	
Haplosporidians	protozoan	haplosporidian	
Gregarines	protozoan	gregarine	
Nematodes	metazoan	Nematode	
Cestodes	metazoan	cestode	

These SPF shrimp stocks are screened on a regular basis by dot blot IHHNV gene probes, *in situ* IHHNV gene probes, and routine histology methodologies. The protocols under which these stocks have been routinely subjected to pathogen screenings are summarized below.

DISEASE SCREENING PROTOCOLS
USED BY THE
U. S. MARINE SHRIMP FARMING PROGRAM



After considering the flow pattern of animals, CEATECH designed a disease monitoring surveillance program which is both biologically and economically feasible. These protocols follow those developed by the U.S. Marine Shrimp Farming Consortium, and are adapted from published procedures. CEATECH's animal health management program is shown schematically below.



This prudent sampling strategy for disease monitoring takes into account two considerations: (1) that the goal of sampling postlarvae (Pl) is to evaluate the virus status of the broodstock, and (2) that the goal of sampling broodstock animals is to monitor their environment. Sampling the offspring of broodstock has been shown to enhance traditional histologic methods for diagnosing viral infections of adult shrimp[1].

[1] Lightner, D.V. 1988. Diseases of Penaeid Shrimp. pp. 8-133, in: C.J. Sindermann and D.V. Lightner (editors), Disease Diagnosis and Control in North American Marine Aquaculture. Second Edition. Elsevier Scientific Publishing Co., Amsterdam.

Since microsporidians and gregarines are environmental parasites with intermediate hosts[2], the pond environment should be the primary focus of monitoring for these pathogens. These parasites are unlikely to become a problem at the CEATECH/SUNKISS sites due to the good culture environment and the absence of the necessary intermediate hosts. The information below summaries the sampling methods for the various life stages embraced within CEATECH's health management surveillance program.

Summary of Sample Sizes and Techniques

Post Hatchery Phase Disease Screen

a) Sample of at least 100 to 200 postlarvae (PL5 to PL10) per spawn
b) Samples are fixed with Davidson's fixative using standard protocols
c) Routine hematoxylin & eosin histology performed
b) In-situ IHHNV gene probe performed

Post Nursery Phase Disease Screen

a) Screen conducted on an as needed basis
b) Routine hematoxylin & eosin histology performed
c) In-situ IHHNV gene probe performed

Post Broodstock Growout Disease Screen

a) Sample 15-30 animals for fixation with Davidson's solution
b) Sample15-30 animals by non-lethal hemolymph, or pleopod biopsy
c) Routine hematoxylin & eosin histology on 15 to 30 animals
d) Dot blot gene probe on hemolymph samples or in-situ gene probe on pleopod samples

To monitor the most economically significant viruses, the optimum time to sample is when animals are at the Pl10 stage in the hatchery. We sample every batch of animals that comes out of the hatchery. Each sample consists at least 200 Pls. A sample of this size should yield at least 50 good specimens each for histology and for gene probe analyses. Using the generally accepted assumption that a prevalence of 10% or greater virus infection is the limit of detection, a 95% level of confidence is achieved with a sample size of 30 animals[3].

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[2] Brock, James A. and Brad LeaMaster. " A Look at the Principal Bacterial, Fungal, and Parasitic Diseases of Farmed Shrimp". pp. 219-220. In Proceedings of the Special Session on Shrimp Farming. Editor James Wyban. World Aquaculture Society May 22-25, 1992.

[3] Department of Fisheries and Oceans. 1984. Fish Health Protection Regulations: Manual of Compliance. Fish. Mar. Serv. Misc. Spec. Publ. 31 (Revised):pg. 12.

The sensitivity of this Pl sampling protocol increases over time, since the effective sample size really becomes the product of 30 times the number of hatchery tanks evaluated within the system. Thus, by examining greater than 160 Pls, the sensitivity of detection goes to a limit of infection prevalence of 2%. Research has shown that this sampling protocol provides the highest possible sensitivity for a given sample size; unless they were infected at an early age, older animals may not show classical viral inclusions on histological examination.

Monitoring the most significant protozoan parasites - microsporidians and gregarines - requires the sampling of 30 sub-adults (10 to 15 grams) per pond per year. The primary intent of this protocol is to compile a "normal" prevalence for proliferative lymphoid organ viruses at any given site. This information is used to determine both the impact of these agents at a given site, and to allow recognition of potential problems at the earliest possible stage. This sampling involves routine histological examination of two slides per animal. An option is to use wet-mount microscopy to screen for gregarines; the advantage of this is that wet-mounts of the anterior mid-gut intestine can be more a sensitive test than histopathology. This procedure would examine 30 shrimp (5 to 10 grams in size) per year per pond. After collection, test animals are held overnight to purge some of their intestinal matter prior to examination. An option for monitoring the presence of the specifically listed pathogens and/or to screen broodstock animals for shipment, is to perform nonlethal pleopod biopsies in conjunction with the IHHNV in-situ hybridization. Since the Western Blot shows excessive background noise in samples with low levels of IHHNV infection[4], the method of choice is to use histological preparations of the leg biopsies for in-situ hybridization. Thus, three pleopod biopsies would be examined per slide for a total of 10 slides per 30 animal sample set. The number of sample sets varies with the expected number of broodstock groups being handled. This procedure ensures that each group of broodstock is free of specifically listed pathogens. Additional sampling may be performed on an as needed basis. The information below summarizes the pathogens of interest and the representative diagnostic methods used for the various shrimp life stages.

[4] Personal communication with Bonnie Poulos, Univ. of Arizona, on March 18, 1993.

STAGE-SPECIFIC PATHOGEN/METHOD SUMMARY

Life Stage	Pathogens of Interest	Diagnostic Methods
pl10	IHHNV, BPV, HPV, WSSV, YHV	Histology, Gene Probe
Sub-adult	TSV, WSSV, Gregarines YHV, Microsporidians	Histology, Wet Mount
Broodstock	TSV, WSSV, Microsporidians, IHHNV, YHV, Gregarines	Histology, Gene Probe

The above summarizes the various options for the disease monitoring program used by CEATECH.. Of these options, we prefer: (1) Sampling all batches of Pl10 animals for histology and in-situ hybridization, (2) Sampling sub-adults from ponds to assess lymphoid organ virus status, (3) Performing wet-mount microscopy evaluation for gregarines, and (4) Performing non-lethal biopsies of broodstock for in-situ hybridization. It is generally accepted position of pathological experts in the field that these methods provide the most cost effective and biologically sound means to assess the health status of shrimp stocks on a routine basis

The **design of CEATECH's hatchery and production facilities** is to prevent the transmission of shrimp pathogens in either direction and the environment. The hatchery structure is fully enclosed, located on a concrete foundation, and identical in design to the secondary quarantine facility which was operated successfully for years by the U. S. Marine Shrimp Farming Program. A security fence surrounds the entire facility; this serves to restrict access by unauthorized personnel, who may represent a contamination risk. Staff pedestrian access to the facility is exclusively through a single gate, which is kept locked at all times. Vehicular access, is restricted to a limited number of staff vehicles, all of which are caused to pass through a disinfection reservoir. Entering personnel are made to change footwear, and disinfect hands with an alcohol spray prior to entering the hatchery. All influent water is pumped from a subterranean well, passed through several in-line filters, and subsequently passed through a UV sterilizer which is rated at 200% of the nominal flow rate.

All effluent water from the hatchery is passed through another UV sterilizer, also rated at 200% nominal flow, and subsequently transferred to a covered settling pond prior to final discharge.

The CEATECH production units also contain numerous features designed to prevent any transmission of shrimp pathogens to or from the environment. The units themselves are located in areas which are as isolated as possible from incompatible activities in adjacent watershed or coastal areas. Access and egress from the production system is restricted to authorized personnel, and is exclusively through discrete gates where disease prophylaxis protocols can be implemented. The production units are covered with bird netting to restrict physical contact with native avian populations which might otherwise come to feed in the ponds. The units themselves are lined to prevent physical exchange between the pond environment and the surrounding ground and/or water table. Incoming seawater is derived exclusively from wells to prevent introduction of surface contaminants, and to provide for the natural filtering of suspended particulate material, including living organisms. The effluents from the individual production units and the total system are screened at several stages to prevent the escape of animals.

The **operational procedures** for confirming health maintenance within the production system is based on a regimen of regular screenings for a variety of health indices. Performance based parameters include conformance with expected growth, survival, and coefficient of variation on the population size distribution. Other monitoring includes observations of animal quality, vigor, and appetite. Examination of physical appearance addresses molting patterns, and checks for the presence of abrasions, melanized exoskeletons, or gill fouling. There is also a system of random gill examinations under the microscope to evaluate the presence of fouling, microsporidians, or melanization of tissues.

Appendix 4

Corporate Strategy for Environmental Compatibility

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Corporate Strategy for Environmental Compatibility

CEATECH's Corporate Strategy for Environmental Compatibility

Executive Summary

By prudent use of site selection, farm design, best management practices, and best available technologies, the effluent from CEATECH's aquaculture operations will not have a deleterious impact to the ocean environment. There will be no persistent signature from this aquaculture effluent outside of a zone of mixing affronting the discharge point. The quality of effluent discharged will improve over its current condition. Any environmental effects will be the minimum possible given current, practical technology, which the company will strive also to improve. The Company will continuously monitor both the farm system and the adjacent environment to conform fully with permit requirements, and to verify those assumptions germane to efficient production and conservation of the environment.

Background.

CEATECH USA, Inc. was a development stage company until late 1996 when an aggressive commitment was made to commercialize state of the art technologies for the production of marine shrimp. The company attracted recognized and proven management and technical personnel, and established offices in Honolulu, Hawaii. The management intends to concentrate on two aspects of business: (a) the development of a large scale shrimp farming agri-business on the Mana plain on Kauai, and (b) the breeding and production of high health, genetically improved shrimp seed for its own farming operations, and for sale to independent shrimp growers elsewhere.

The production unit for this enterprise consists of one-acre production ponds, together with appurtenant support infrastructure. Each pond will produce 40,000 pounds of shrimp per year from three fourteen week growout cycles. The marketing plan anticipates the production and sale of 80% of these shrimp to the U. S. mainland as a high-value product of unsurpassed appearance and taste. The CEATECH enterprise is being viewed a phased growth project. It is expected that this new farming business will have positive and sustaining effects to the employment and economic perspectives of Kauai.

The venture takes advantage of extensive government investment in research and development which was designed to promote profitable and sustainable shrimp farming in the United States. Many of CEATECH's technical personnel played important roles in that applied research, done largely in Hawaii. The company's officers and staff include capabilities in finance, management of public companies, shrimp aquaculture, marketing, engineering, and environmental science. The shrimp production technologies developed by this USDA-supported research is fundamentally different from shrimp farming practiced elsewhere. CEATECH's farming system is centered around the responsibility to preserve and sustain the surrounding environment.

Environmentally Sound Site Selection

The insistence on proper site selection is a cornerstone of CEATECH's environmentally responsible approach to aquaculture. CEATECH will not propose aquaculture in an area which would require destruction of either mangrove or wetland habitats. CEATECH prioritizes the suitability of environments for aquaculture based on the self-cleaning potential of the receiving waters, and their historical use patterns.

The capacity of the receiving waters to assimilate and dissipate wastewater is one of the most significant factors in determining the environmental effect, or lack thereof. The potential effects of aquacultural discharges are dependent in large part on characteristics of the receiving environment. The **receiving capacity** of a particular environment refers to the capability to accept some quantity of discharge without a measurable change in the biological community structure beyond an area where the effluent enters and mixes with the surrounding waters. Receiving capacity is dependent on the physical and biological characteristics of the area and the effluent character. Nutrient and particulate concentrations in aquaculture effluents are generally higher than in coastal waters in Hawaii. When these materials enter the marine environment, a small portion may be assimilated by the local biological community, but the vast majority need to be diluted and dispersed by the advective forces of nearshore currents, winds and waves.

An analysis of the coastal environments surrounding all of the major islands, conducted in 1990, assessed the relative potential for impacts from aquaculture discharges for all shoreline areas. The key parameters used in this analysis included: the dominant biological community type, the nearshore physiography, the prevailing wind direction, and the location of the wave breakpoint. More detailed analyses considered the near-shore current patterns to ascertain the natural capability of the environment to flush the area, and the historical use of the area which reflects the degree of pristine character at the time that effluent effects are being evaluated. This work described the coastal environment affronting the Mana plain, Kauai as having a **low sensitivity** to aquaculture discharges. This finding, which indicated a low probability for negative ecological effect from aquaculture discharge for the area, was important in CEATECH's selection of this site for its aquaculture operation. The naturally high advective forces, and open coastal character of this environment give it a high self-cleaning potential.

The **previous use history** of receiving waters was another feature of appropriate site selection. Previous use reflects the degree of pristine character represented by a given site and thus the potential for environmental compromise. It also brings to the site selection process the community's historical valuation of land-based activities in their area, and the appropriateness of specific restrictions designed primarily to preserve wilderness conditions. A feature contributing to the appropriateness of the Mana environment for aquaculture is that the adjacent coastal environment has been receiving agricultural effluents for over a hundred years. These receiving waters have been subjected to sediment and nutrient loads for years under approved permits. Restrictions, generically intended to prevent the degradation of wilderness-type receiving waters, consider any deviation from the historical condition to be degradation. The history of agricultural discharges to Mana coastline minimizes any danger of wilderness loss.

Under the current regulatory framework, there have been several **zones of mixing** established within the area. These zones, having radii of 6,000 feet, affront permitted discharges into the ocean at several points along the coast. The agriculture discharge consists of irrigation water pumped from sugarcane fields, mixed with seawater. These zones have been subjected to regular environmental evaluations. In compliance with provisions of the Clean Water Act and Administrative Rules of the Department of Health, an NPDES permit was granted to allow discharges into the ocean. The permit also required that regular monitoring be done to ensure maintenance of water quality and indigenous populations of marine organisms. The most recent of these analyses concluded that there is no evidence of any negative impact to the water quality or the aquatic flora and fauna in the receiving waters of the agricultural discharges. This finding reflects the high cleaning capacity and low sensitivity to discharges of the Mana coastal environment. The aquaculture effluent is expected to have as good or better water quality characteristics than the agriculture effluent. This indicates the low probability for the addition of aquaculture effluent to the present discharge stream causing a deterioration of the condition in the receiving waters.

A hydraulic analysis of the zone of mixing was done to be able to compare the relative contribution of an additional aquaculture discharge to the natural advection and self-cleaning characteristics of the coastal environment. The estimated amounts of seawater that naturally flushes the zone of mixing and the aquaculture effluent daily volume conservatively indicate that the discharge will contribute less than four one hundredths of one percent of the flow naturally passing through the zone due solely to tidal currents.

Environmentally Responsible Design and Operation

Environmental responsibility is a company value that figures prominently in the design and operation of CEATECH's aquaculture production strategy. Many features of the production system are designed to sustain the quality of the surrounding environment, and make it a model for aquaculture husbandry that is compatible with responsible environmental stewardship.

The use of lined ponds prevents seawater seepage into groundwater supplies. Lined ponds also eliminate any addition of terrigenous sediments to the discharge stream, due to resuspension by animal or current movements. It also avoids sediment pulses to the environment during harvest and draining events. The aeration component of the farming design prevents any anoxia, or noxious odors in the discharge stream. Daily water quality monitoring within all ponds optimizes the water quality not only for the aquatic animals being farmed, but also for those exposed to the subsequent discharge. Lined ponds and netting over the ponds mitigates use conflicts with avian populations that may be either resident or migratory in the area.

The intensive production protocols to be used by CEATECH result in a greater efficiency of feed, land, and water use that the style of shrimp farming operations applied in other countries. This production technology has been shown to have substantially better feed conversion ratios than those in other farming systems. By measuring the proportion of added feed that actually ends up being incorporated into animals, the feed conversion ratio also reflects the amount of uneaten feed that is potentially contributed to the waste pool. An optimum feed conversion ratio therefore reflects also a minimum waste addition ratio. The land and water use in intensive production systems is intrinsically conservative of these resources. Comparisons indicate that a pound of shrimp produced in the CEATECH system will require only about 10-20% of the land and/or water which would be needed by semi-intensive shrimp farming operations as practiced in other countries.

By relying exclusively on a controlled hatchery system to provide seed animals for its *shrimp farming operations, CEATECH's production design avoids any large scale* harvesting of native shrimp populations to stock ponds. The feeding protocols avoid any use of highly polluting feeds such as trash fish, or macerated marine animals. The farming style uses no bioactive compounds such as pesticides, antibiotics, fertilizers, or growth hormones in its production operations. Pond design includes surface skimmers on each pond to both collect and remove any buoyant plant material prior to it's addition to the discharge stream. Design of the piping and discharge infrastructure, also includes screens at multiple locations, designed to prevent any escape of animals into the natural environment. At the Mana location in particular, the effluent also will have to pass through a ditch system which is populated with carnivorous fish; this further reduces any probability that farmed animals would survive to reach the ocean. CEATECH's corporate approach for reducing the risk of an accidental release of aquaculture organisms and/or associated pathogens into the environment follows the Code of Practice developed by the International Council for the Exploration of the Seas (ICES). This protocol, which relies on rigorous quarantine procedures utilizing first generation progeny, is one of the three widely adopted approaches for avoiding harmful introductions in use around the world.

The exclusive use of high-health animals reduces risk of any contamination to the surrounding environment. All of the shrimp stocks to be used by CEATECH are derived from specific pathogen free populations originating from the U. S. Marine Shrimp Farming Program, supported by the United States Department of Agriculture. These stocks, maintained in captivity for over six generations, have repeatedly been screened by a variety of diagnostic techniques and shown to be free of specific shrimp pathogens of interest. The company's animal health management system includes a disease monitoring surveillance program, as well as biosecurity measures and protocols. CEATECH has also engaged the nation's foremost authority on shrimp pathology to implement and oversee the appropriate application of diagnostic protocols. The design of both the hatchery and production facilities includes numerous features to prevent any transmission of shrimp pathogens between the farm and the environment in either direction.

Aquaculture Waste Management

CEATECH's farming strategy is to apply the best degree of aquaculture waste treatment that is both technically reliable and economically feasible. The waste management philosophy is based on reduction, recovery, reuse, and refinement.

In addition to the aforementioned design and operation features, a key piece of the waste treatment design is the operation of settling basins. The purpose of the settling basins is to collect particulate waste materials, and provide increased residence time for the assimilation of some dissolved nutrients. Collection and treatment of as much of the biosolids as practical is the most prudent and functional facet of an environmentally responsible aquaculture waste management strategy. The use of intensive production in round ponds having center drains will augment the efficiency with which biosolids material can be collected.

There are three types of solids involved. During production, the periodic purging of settled material from pond bottoms via the center drain will contain pulses of particulates with relatively high settling rates and concentrations of suspended solids. Because of the use of lined ponds, this material will have no terrigenous material; it will have shrimp feces, molts, and bacterial flocs. The second type is the particulate material generated during harvesting and draining of the ponds at the conclusion of a production run. This material will have shrimp feces, molts, and bacterial flocs, but little mortalities or uneaten feed, because of the high survival and feed conversion efficiencies characteristic of the system. The third type is the suspended particulate material contained in the turnover water that is continuously discharged from the pond as a part of normal water exchange. This is composed largely of living phytoplankton and bacterial flocks, and has low suspended solids concentrations and low settling rates. Only a portion of this type material is amenable to collection. The intent is to do the best job of removal that is practical, given the state of the current technology, knowledge, and experience that exists at the time.

The waste management strategy also calls for the recovery and reuse of the collected biosolid. The amount of land available for biosolids collection/treatment, and the adjacent agriculture present opportunity for alternate uses as a soil enhancement which will be pursued. The tentative reuse plans are to desalt, and recover the organic biosolid waste material by means similar to those used to handle sludge in conventional waste treatment systems. The proximity of agriculture in the vicinity, makes the transport and positive use of this material a possibility that will be evaluated.

Untreated aquaculture effluents are in most cases of better quality than the acceptable effluents from sanitary waste treatment facilities. Nonetheless, there is no conventional wastewater treatment technology that would allow give a final quality sufficient to allow aquaculture discharge into anything other than a zone of mixing. The pursuit and evaluation of additional treatment strategies is addressed the Improvements section below.

Water Quality Monitoring

The company will establish and maintain a program of regular water quality monitoring throughout all facets of its aquaculture system to assure optimization of the production, waste treatment and environmental compliance components.

The production protocols to be used by CEATECH require daily monitoring of the water quality within each of the individual ponds. This is to insure the persistence of ambient conditions that are optimal for the growth and survival of the shrimp being aquacultured. It also provides useful information concerning the efficiencies of feed utilization, and pond management. Such regular monitoring is designed to eliminate wide variability in the water quality that could lead to an unstable environment within the production units. Among other things, this monitoring prevents the development of anoxic conditions that would subsequently effect the quality of the discharge stream from the farm. Within this style of farm, the prevailing water quality is one that is designed and managed for the specific purpose of promoting the well being of aquatic organisms; this condition is similarly a characteristic attribute of the discharge water leaving the farm.

Regular monitoring is also planned for the water being discharged into any waste treatment subcomponents (e.g., settling ponds or other discharge mitigation units), and subsequently from the farm. The data from these monitoring efforts is to be used as baseline information for constituents of the waste stream, and to satisfy the permit requirements, designed to conserve and protect the environment. The parameters to be monitored may change over time, but will include those needed to determine nutrient and particulate loadings being discharged. The applications of these data are: to insure conformance with all permit requirements, to confirm assumptions concerning operations and treatments, and to evaluate the efficacy of various treatment strategies and discharge mitigation efforts being examined.

The company will also perform regular monitoring within the Zone of Mixing, and adjacent ocean waters representing the receiving environments of the farm effluent. This monitoring will include evaluation of those parameters monitored in the discharge stream, as well as those descriptive of the biological communities in the area. This monitoring of the outside environment is provide the record needed to confirm the conservation of the adjacent environment, and to satisfy permit requirements. Such information will be essential to evaluate forecasts regarding the dispersion of the effluent following discharge. Understanding the value of a long-term database to evaluate various assumptions concerning operations, treatments and discharges, and environmental effects, the company intends to begin development of these records immediately after starting operations.

Continuous Improvement

The Company will develop and maintain an ongoing program to evaluate novel opportunities to continuously improve the water quality of the aquaculture discharge stream.

Various academic studies over the last decade have shown that there are currently no known practical, reliable and economical treatment technologies for aquaculture (or agriculture) discharges which would satisfy Hawaii Water Quality Standards, except under the authority of an NPDES discharge permit. An NPDES permit, used historically by both agriculture and aquaculture operations in Hawaii, will be acquired and fulfilled by CEATECH.

Additionally, CEATECH recognizes that the best aquaculture waste treatment system that is available now is not necessarily the best system which is possible. Both the unique characteristics of discharge from this type of marine shrimp farm, and the site specific qualities of the Kekaha environment suggest that there is opportunity further improve the effluent quality in the future. In addition to maintaining compliance with current permitting requirements, the company is committed to the evaluation of novel strategies to further reduce constituent levels within its aquaculture discharge waters.

CEATECH has conceptually evaluated multiple treatment alternatives, which although experimental, appear to show promise for the continuous improvement of the quality of the discharge waters. The mechanisms include a wide variety of strategies, such as augmentation of indigenous microbial populations, acceleration of metabolic rates of the digesting microflora, incorporation of marine nitrification components, and addition of photosynthetic components to reduce inorganic nutrient levels. Such potentials are unverified for commercial scale aquaculture, but recognizing that their evaluation will take time on-line, CEATECH hopes to continuously improve performance of the farm's waste management component.

Appendix 5

Antidegradation Analysis

Antidegradation Analysis

for

CEATECH USA Inc.

Shrimp Aquaculture Project

Kekaha, Kauai

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Antidegradation Analysis
CEATECH USA, Inc. Aquaculture Discharge

I. Introduction

CEATECH USA, Inc. (CEATECH) is seeking authorization to discharge under the National Pollutant Discharge Elimination System (NPDES) permit. CEATECH is applying for a permit to begin discharging seawater effluent from its new aquaculture farm which is to be located on the Mana Plain, near Kekaha on the island of Kauai. The vast majority of this area has historically and currently been in agriculture (sugarcane) use (Figure 1). The area now has permitted agriculture discharge, consisting of irrigation water pumped from sugarcane fields, mixed with seawater, into an established Zone of Mixing (Figure 2). The independent and separately monitorable agriculture and aquaculture effluents would meet just prior to discharge at the shoreline outfall (#002), located at 22° 01′01″ N latitude and 159° 47′20″ W longitude. Because the aquaculture use would be accompanied with different water quality, an antidegradation analysis was prepared.

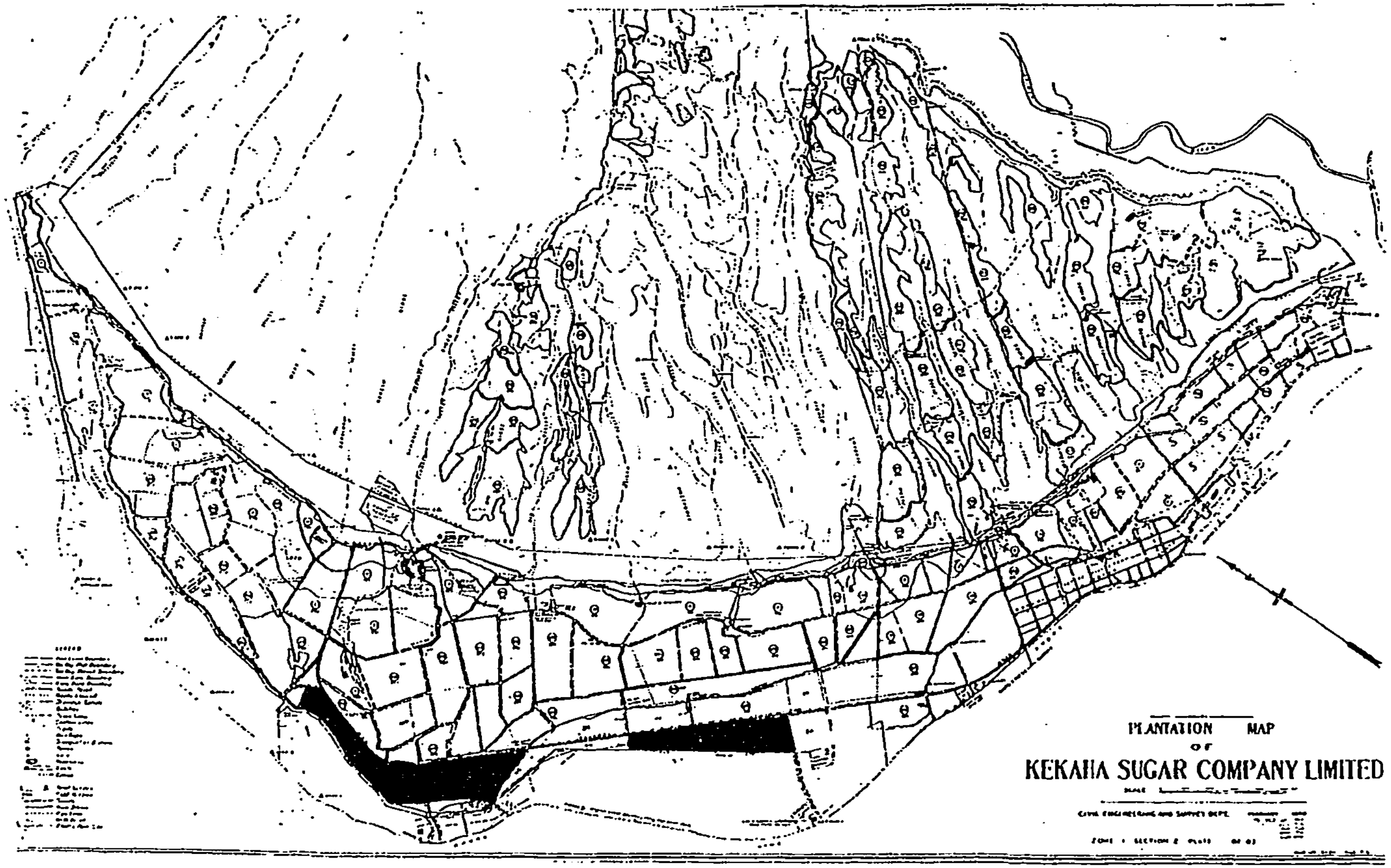
This document follows the format of previous Antidegradation Analyses, and guidance provided in discussions with State of Hawaii Department of Health staff. The content includes descriptions of:

a) the aquaculture operation and its novel waste management system;
b) the volume, constituent concentrations, and daily loading rates anticipated for the discharge stream;
c) the receiving environment's use history and present ambient water quality;
d) model results forecasting the discharge plume's dispersion and dilution, and future water quality in the area;
e) a forecast of biological effects and protection for the designated uses;
f) the social and economic benefits of the project, their necessity to the community, and explanation for why the compromised water quality cannot be mitigated by reasonable means.

II. Description of Discharge

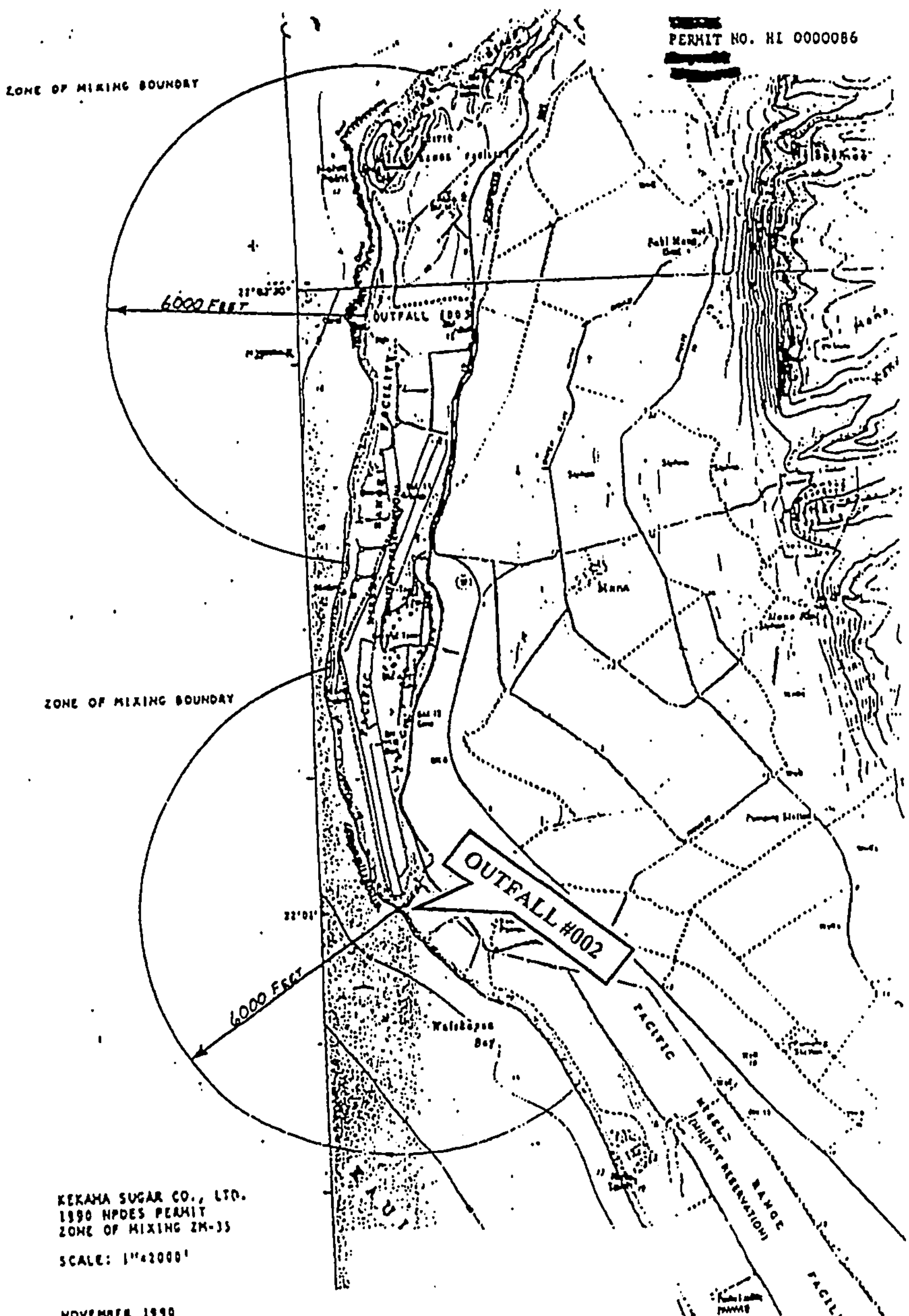
1. Overview of the Aquaculture Operation

The development plan calls for a two-phased shrimp farming operation, each consisting of 52 one-acre round ponds, and producing two million pounds of shrimp per year. Each pond will have a volume of 1.3 million gallons, and a turnover rate of 25-40% per day, amounting to a continuous flow rate of 230-360 gpm per pond. The cumulative discharge rate from all 104 ponds is projected to be ≤ 55 mgd. The adjacent receiving waters for the operation's discharge is an open, extremely well-flushed, coastal system that is currently the site for an existing Zone of Mixing for agriculture discharge.



MAP showing land use on the Mana Plain, Kauai. The shaded portion indicates area for the proposed aquaculture; the remaining (unshaded) portion shows land which is predominatly in agriculture use.

Figure 1



Location of the Zone of Mixing (ZM-35) affronting the agriculture discharge (#002) of Kekaha Sugar Company (NPDES Permit HI 0000086)

Figure 2

This aquaculture project will provide substantial economic development and much needed employment to the community where unemployment is high. This diversified agriculture will compliment and augment current farming in the area, and will provide additional economic stimulus through a primary industry that is based on existing resources. The project takes advantage of extensive federally-funded research aimed at mitigating the U. S. trade deficit in seafood through domestic farming. This diversified use of agriculture lands, addresses Hawaii's need to pursue alternate means of responding to the progressive changes in the sugar market. Initiation of the project is expected to substantially improve the island's export capability, and its socio-economic health.

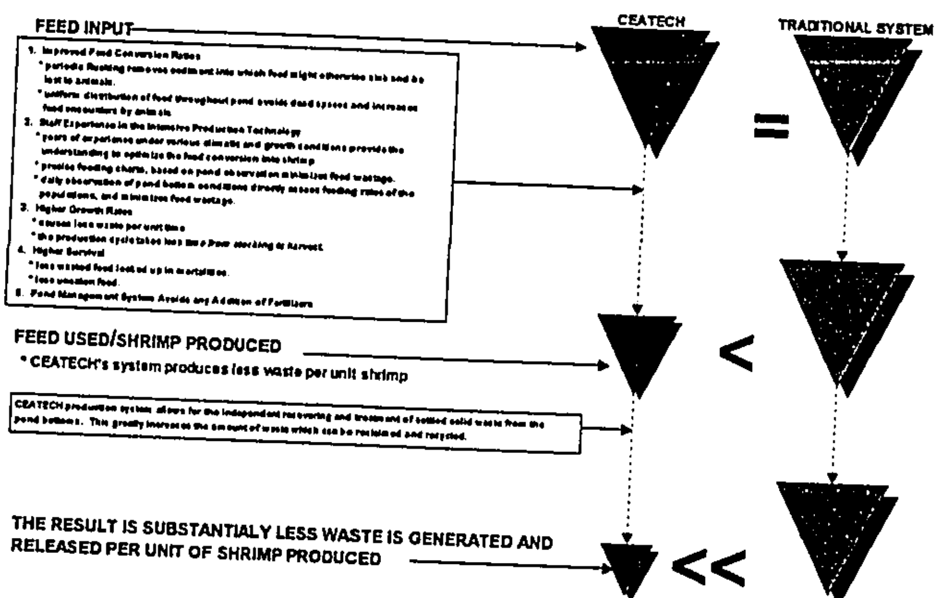
2. Overview of CEATECH's Waste Management Strategy

This controlled-environment aquafarming system includes numerous features to minimize discharges and aid preservation of the surrounding environment. Several of these waste mitigation features are unprecedented in commercial aquaculture. CEATECH's Corporate Strategy for Environmental Compatibility is attached as Appendix 1. It includes: a) criteria for proper site selection, b) features to minimize waste generation, c) features to maximize waste recovery and reuse, d) a program of continuous monitoring, and on-line evaluation for improved waste reduction methods.

The first step in the best management practice for aquaculture is proper site selection. CEATECH's site criteria are summarized in Table 1 below. The capacity of receiving waters to dissipate wastewater is one of the most significant factors in determining the environmental effect, or lack thereof. The Kekaha site is ideally suited for aquaculture because of the self-cleaning potential of the coastal system and its historical use pattern. The naturally high current/wave patterns, and open coastal character of this environment give it a high self-cleaning potential and low probability for negative ecological effect from aquaculture discharge. The historical use of the area contributes to the appropriateness, and minimizes danger of wilderness loss. This coast has been receiving agricultural effluents for decades without negative impacts being apparent.

Table 1. CEATECH's Criteria for Aquaculture Site Selection

1. Avoidance of Mangrove or Wetland Environments
2. Consistency with Previous Use History
3. Consistency with Land Zoning and Long Range Planning Policies
4. Compatibility with Adjoining Land Uses
5. Avoidance of Conflicts with endangered/threatened Species
6. Avoidance of Conflicts with archeological/historical Resources
7. Receiving Water Characteristics
   a. open, well-flushed character
   b. absence of unique biological characteristics
   c. low sensitivity to aquaculture discharges
   d. high self-cleaning properties
   e. compatible past and present use histories
   f. established regulatory/permitting history



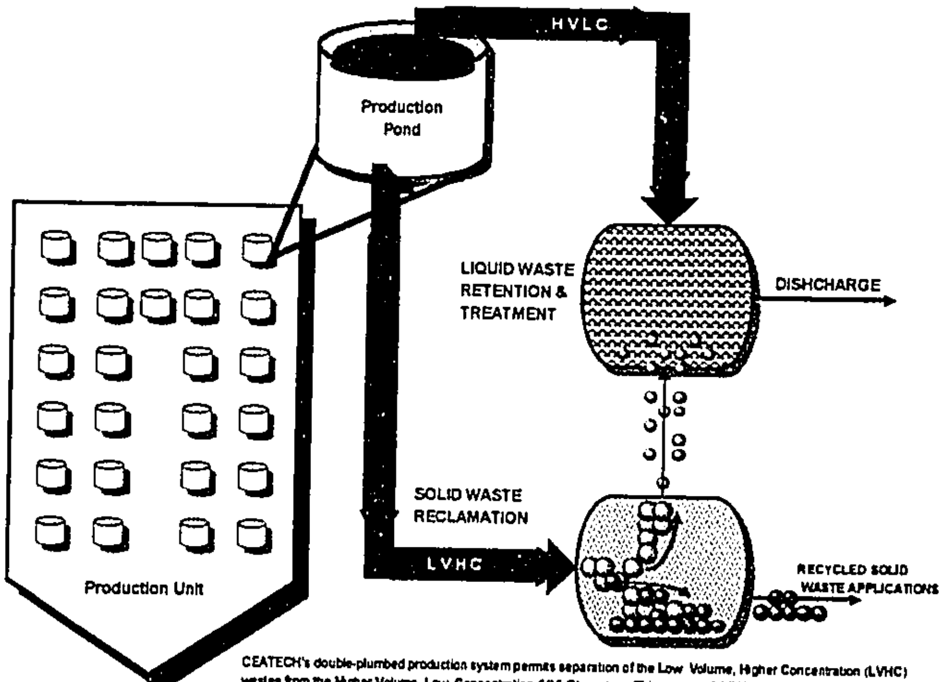
Comparison of CEATECH vs Traditional Aquaculture. Reducing the Amount of Waste Initially Produced is an important component of CEATECH's *BAT* for Aquaculture Waste Management.

Figure 3

The second step of the waste management strategy is to minimize the amount of waste produced in the first place (see Figure 3). Several design and operation features, some of which are unique in commercial aquaculture, contribute to this objective.

1. The use of liners covering the bottoms of all the ponds avoids the addition of terrigenous sediment to the discharge.
2. Aeration of the ponds during evenings prevents anoxia, and/or noxious odors in the discharge stream.
3. The intensive production methods to be used yield about 50% better feed conversion efficiencies than conventional shrimp farms. Such improved feed conversion ratios also reflect the reduction of material being contributed to the waste pool (Figure 3).
4. Intensive production systems are intrinsically conservative of land and water use; comparisons show that each pound of shrimp produced in this system will require only 10-20% of the land and water needed by conventional farming operations.
5. The farming system uses no bioactive compounds such as pesticides, antibiotics, growth hormones, or fertilizers.

The third step is to maximize the recovery and reuse of wastes. The round pond production unit allows for a skimmer system to remove any floating macro-particulate material, the continuous voiding of dissolved and suspended microparticulate wastes, and the periodic removal of material that has settled to the bottom. Analyses indicate that the discharge of settled particulates that accumulate on pond bottoms is probably the most prominent waste problem for traditional shrimp farms. Dealing with this material is the prime focus of our waste treatment strategy (see Figure 4). Paddlewheels will circulate water and concentrate sediments near a central drain. The circular shape optimizes water circulation and subsequent sediment removal via the center drain. All of the production ponds will be double plumbed to permit the separate handling of this particulate fraction from the high volume aqueous fraction. This waste recovery strategy is currently without precedent in commercial aquaculture.



CEATECH's double-plumbed production system permits separation of the Low Volume, Higher Concentration (LVHC) wastes from the Higher Volume, Low Concentration (HVLC) wastes. This aspect of CEATECH's *BAT* greatly improves the recovery efficiency of this marine solid waste, and provides for the reuse/recycling of this material.

Figure 4

The final facet of the strategy is a program of regular water quality monitoring within all production ponds, waste treatment components, discharge streams, and adjacent receiving waters within and outside of the Zone of Mixing. The objectives are: a) to optimize the water quality for both the aquatic animals being farmed, and those subsequently exposed to the discharged waters, b) to confirm the appropriateness of various operating assumptions, c) to maintain complete conformance with all permit requirements, and d) to evaluate the efficacy of alternatives for improved waste reduction.

There are no Federal effluent guidelines promulgated for aquaculture operations, and no Standard Industrial Classification that is applicable to aquaculture facilities. Information from other aquaculture operations may not accurately predict the effluent quality from this type of shrimp farm due to major differences in the design and operation. Collectively, we believe this system constitutes the Best Management Practices in commercial shrimp aquaculture for minimizing the amount of waste discharged, and the mitigating the environmental effect from that discharge. CEATECH will also pursue a program of continuous evaluation to further improve this seawater waste management system.

3. Overview of the Aquaculture Waste Treatment

A key piece of the waste treatment design is the operation of settling basins. The purpose of the settling basin is to collect particulate waste materials, and provide increased residence time for the assimilation of some dissolved nutrients. Collection and treatment of the aquatic biosolids is the most functional facet of a responsible BAT. There are two types of solid wastes involved (Figure 5). The first is material that accumulates on pond bottoms; this material is removed periodically during the production period and at harvest time via the center drain. These particulates have relatively large size, high settling rates, and concentrations. The waste management strategy calls for the recovery and reuse of the organic biosolid as a soil enhancement for agriculture activities in the immediate vicinity. The second type is the suspended particulates contained in the turnover water that is continuously discharged from the pond as part of normal water exchange. This material is composed mostly of living phytoplankton and bacteria, has low TSS concentrations, small size, and low settling rates. Only a portion of this material is amenable to collection, given the state of the current knowledge. The intent is to do the best job of removal that is practical today, and to continually evaluate on-line means for improvement.

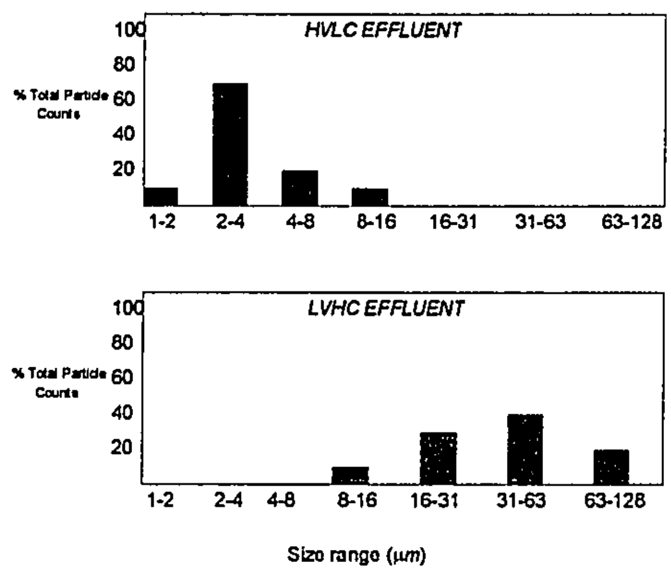


Figure 5. Particle size analysis of laser scatterometry data for the two effluent streams shows the marked difference which drives the waste treatment design.

The discharge of settled particulates that accumulate on the pond bottoms has been a waste problem for traditional shrimp farms. Dealing with this material is the most functional facet of a prudent aquaculture waste management strategy, and is the prime focus of our waste treatment design. Analyses indicate that this settled biosolid component comprises the majority of the total particulate waste generated on a daily basis.

A key feature of the round pond design is the opportunity for the collection and removal of these settled biosolids via the centrally located drains (Figure 4). The recovery and treatment of this particulate fraction, becomes feasible because the water currents generated by the paddlewheels cause the settled material to migrate to the center of the pond around the drains. An important consequence is the capability for the separate handling of the low-volume, high-concentration (LVHC) fraction from the overlying suspended fraction, having high-volume, low concentration (HVLC) characteristics. This waste treatment feature, which is unprecedented in commercial aquaculture, greatly increases effectiveness of the settling basins, which are the centerpiece of the waste treatment system.

Periodically during the production cycle, the settled material that has accumulated near the center drain is purged from the pond via dedicated plumbing that leads to a separate settling basin. Each flush constitutes a volume of ~ 15,000 gallons, and contains particulate material with high settling rates, and high TSS concentrations. This material is comprised primarily of aquatic detritus, marine algae, shrimp feces, molts, and bacterial biomass. There will be few mortalities or little uneaten feed because of the high survival and high feed conversion efficiencies typical of the system.

Each pond may be flushed 10-15 times during each production cycle. Collectively this purged material represents ~ 60% of the total weight of feed applied to the pond during that period. This material is routed to a collection sump, resedimented, and pumped into troughs for desalting, settling, desiccation and recovery. The subsequent processing methods to be applied to this settled particulate fraction are similar to those used to handle sludge in conventional waste treatment systems. The waste management strategy calls for the recovery and reuse of these biosolids as a soil enhancement for agriculture. The proximity of other agriculture operations makes the economical transport and use of this material as a soil enrichment economically feasible, and CEATECH has expressions of interest from commercial agriculture operations.

The growout pond design includes a skimmer system preceding the overflow drain to remove any suspended macro-particulate material, e.g., molts, animals, or wind-blown debris from the effluent being discharged. This material, normally of negligible amount, is collected and processed as the solid waste fraction described above.

The turnover water is the high volume, low concentration (HVLC) component shown in Figure 4. This fraction contains both dissolved constituents and suspended micro-particulate material. This material, composed largely of living phytoplankton and bacterial flocks, has low TSS levels, and low settling rates. The technical and economic limitations of processing the dissolved and suspended microparticulate wastes from aquaculture operations are addressed in section IV.

Numerous studies have shown that there are currently no practical, reliable and economic treatment technologies for removing the dissolved and suspended microparticulate wastes from aquaculture discharges. The concentrations of these wastes in aquaculture discharge streams are generally lower than concentrations found in waste effluents after having received the best available treatment. For this reason effluent released into a Zone of Mixing under the authority of an NPDES permit has been required by both agriculture and aquaculture operations. Nonetheless, the Company intends to evaluate several strategies to reduce constituent levels within the discharged waters. The seeding and propagation of salt-tolerant, vascular plants along the sides of the drainage canals leading to the ocean targets removal of some of the dissolved inorganic nutrients. Another option is to force the discharge to pass through caged aggregations of marine macroalgal biomass to assimilate a portion of dissolved inorganic nutrients. The conceptual evaluation of several novel treatment alternatives shows promise for improvement of the discharge quality, but will require on-line verification at commercial scale. These mechanisms include augmentation of indigenous microbial populations, enzymatic-acceleration of the metabolic rates of the digesting microflora, and incorporation of nitrification components.

The HVLC aquaculture effluent fraction will be routed into the drainage canal leading to the ocean. This canal system further acts as a elongated settling basin to remove additional materials, via sedimentation or assimilation, during the residence time prior to discharge. The discharge is to occur at an existing NPDES outfall (#002) at the shoreline, located at 22° 01′ 01″ N latitude and 159° 47′ 20″ W longitude.

4. Expected Quality of the Aquaculture Effluent

a. Projected Water Quality

Table 2 summarizes the expected water quality conditions in the aquaculture effluent. These water quality values are from analyses of data collected from experimental round ponds operated on Oahu, and the prototype production units operated at the Sunkiss Shrimp Farm in Kekaha, Kauai.

Table 2. Expected Aquaculture Effluent Water Quality

Parameter	Concentration	Daily Loading
Flow	360 gpm [1]	55 mgd [2]
Temperature	26 - 29°C	
Salinity	33 - 35 ppt	
Dissolved Oxygen [3]	6 - 8 mg/L	
BOD [4,5]	10 mg/L	4489 ppd
pH	7.5 - 8.5	
TSS [5]	40 mg/L	18000 ppd
Chlorophyll a	54.3 ug/L	24.4 ppd
Turbidity [5]	9.9 NTU	
Total Phosphorous [5]	0.3 mg/L	135 ppd
Total Nitrogen [5]	1.15 mg/L	517 ppd
Ammonium-Nitrogen [5]	.015 mg/L	6.7 ppd
Nitrate + Nitrite [5]	.042 mg/L	18.9 ppd

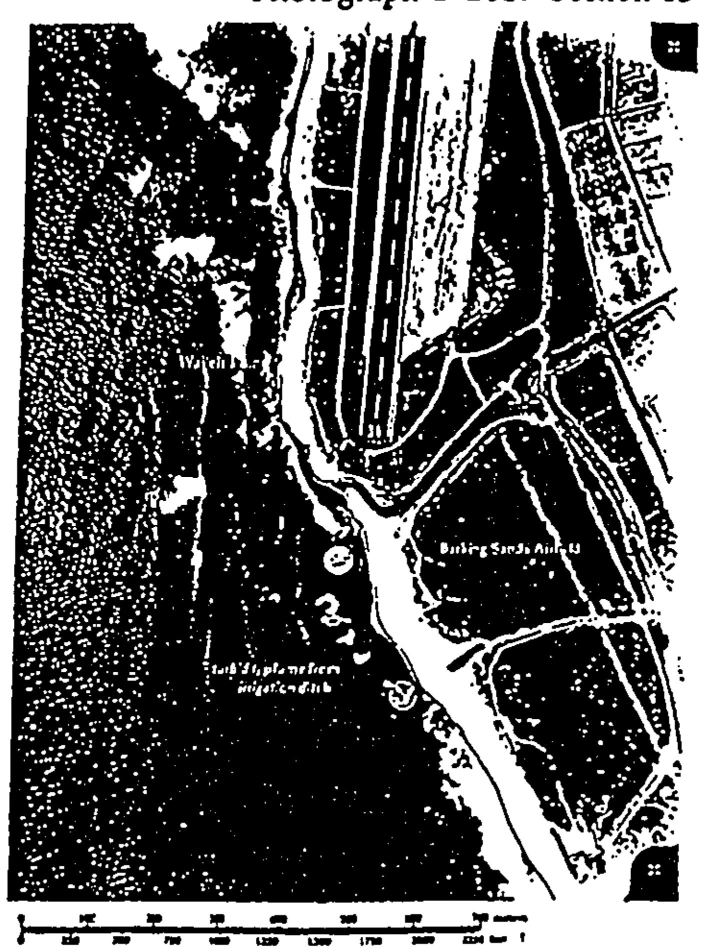
[1] This flow rate assumes the maximum case of a turnover rate of 40% per day per pond
[2] Assumes the maximum case of all 104 ponds, operating at turnover rates of 40% per day
[3] At or near saturation for the prevailing temperature and salinity conditions
[4] This consists mostly of living phytoplankton and bacterioplankton
[5] Data are from water quality analyses from Sunkiss Shrimp Farm (Kekaha, Kauai), and intensive shrimp technology development research USDA-CTSA Tech. Rpt 212pp. (Ziemann et al., 1991)

III. Description of the Receiving Environment

1. General Description

Sandy beach comprises most of the shoreline for several miles on either side of the Kawaiele Outfall (#002). Coastal Resource Inventory Map 1-241 for Kauai (Figure 6) shows this outfall is located just south of the Barking Sands Airfield near Waiele Point. Seaward of the beach the shoreline is predominantly a limestone bench one to three meters in height and extending to 75 feet offshore. Seaward of this bench, the bottom slopes gradually downward with increasing distance offshore. The underwater landscape is characterized by a consolidated limestone platform that is predominantly flat with little vertical relief other than depressions and channels which are filled with coarse white sand. Farther offshore the bottom is mostly sand with occasional rocky features, and/or rock bottom with a veneer of sand. The predominant biota on the reef platform is low algal turf of various species of benthic algae. Living corals are sparsely distributed and when present, occur predominantly as flat encrustations on the flat bottom.

Photograph 1-241: Section 13



Coastal Resource Inventory Map
Showing Outfall Location

Figure 6

2. **Historical Use**

Groundwater and irrigation water are continually pumped from the low elevation Mana Plain, which is mostly in sugarcane agriculture. Despite decades of agricultural discharge through Outfall #002 located at 22°01'01" N and 159°47'20" W (Figure 2 and 6) recent monitoring concluded that there is little indication of any terrigenous sediment deposition or impact to the aquatic flora or fauna along this coast. The long use history of the coastal environment as receiving waters for land-based discharges minimizes the potential for compromise of a pristine resource or wilderness loss. There are several Zones of Mixing in place at areas affronting three such agriculture discharges that occur along the ten miles of coastline between Nohili Point and Oomano Point. The coastal environment has received agriculture effluents for nearly a hundred years.

The area is currently fully permitted (NPDES Permit No. HI 0000086, ZM-35) for discharge of these agriculture effluents to the nearshore ocean. Water quality monitoring of the agriculture discharge exiting Outfall #002 is reported on a monthly basis. Actual discharge levels are normally well below the limitations for all parameters set by the permit (Figure 7).

The projected concentration and loading values for various parameters in the aquaculture effluents are compared with those in the existing agriculture effluent in Figures 8 and 9, and Table 3. In general, the projected water quality from the aquaculture farming is as good or better than that from the agriculture farming. The anticipated aquaculture discharge volume at full scale is approximately half of the currently permitted agriculture flow for outfall #002. The parameter concentrations and loadings projected for the aquaculture discharge are generally lower than those in the agriculture effluent. The exception is higher projected levels for total nitrogen and phosphorous for the aquaculture effluent.

Parameter	Present Agriculture	Projected Aquaculture
Flow	100 mgd[1]	55 mgd
Total Suspended Solids	20,000 ppd[1]	18,000 ppd
	50,000 ppd[1]	18,000 ppd
	48 mg/l[2]	40 mg/l[4,5]
Ammonia	0.009 mg/1[4]	0.015 mg/l[4]
	2.7 ppd[4]	6.7 ppd[4,5]
Nitrate + Nitrite	0.007 mg/l[4]	0.042 mg/l[4,5]
	2.1 ppd[4]	18.85 ppd[4,5]
TN	1.940 mg/l[4]	1.15 mg/l[5]
	571.5 ppd[4]	517 ppd[4,5]
TP	0.381 mg/l[4]	.30 mg/l[5]
	112.2 ppd[4]	135 ppd[4,5]
Turbidity	63 NTU[4]	9.9 NTU[4,5]
BOD	4.4 mg/l[2]	10 mg/l[5]
	1,309 ppd[2]	4,489 ppd
Floating Debris	None[3]	None
Oil	None[3]	None
Scum & Foam	None[3]	None
Odor	None[3]	None
Color	Yes[3]	None

[1] NPDES Permit #0000086

[2] NPDES Permit Application for #0000086

[3] Kekaha Sugar Co. Zone of Mixing Application

[4] Water Quality Analyses of discharge waters sampled 5/30/97

[5] Intensive Shrimp Technology Research; CTSA Y3 Final Report, Ziemann, 1991

Table 3. Numerical Comparison of Concentration and Loading data for the current Agriculture and prospective Aquaculture discharge streams shows that the aquaculture water quality will be as good or better than the present condition.

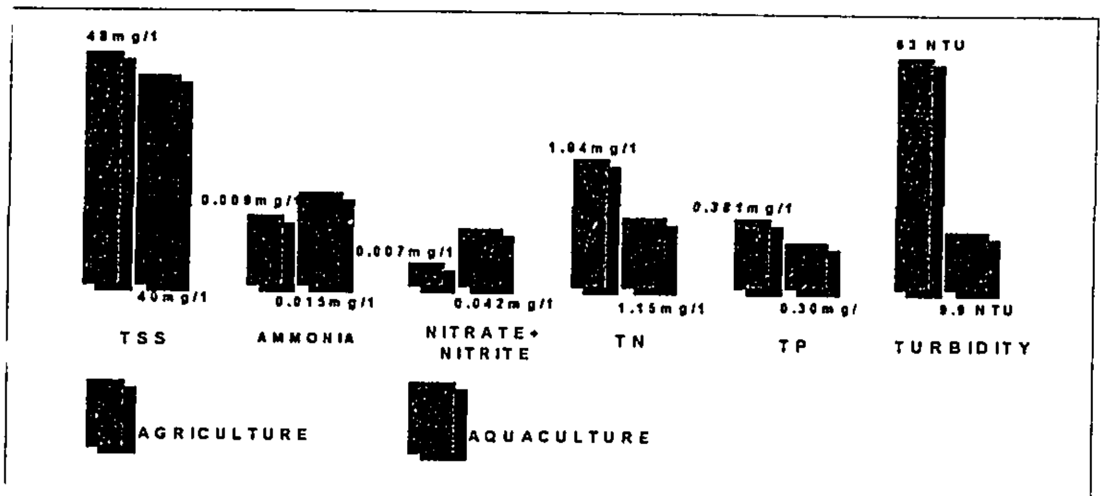


FIGURE 8: Comparison of Discharge Water Quality for the Current Agriculture and the Projected Aquaculture Operations

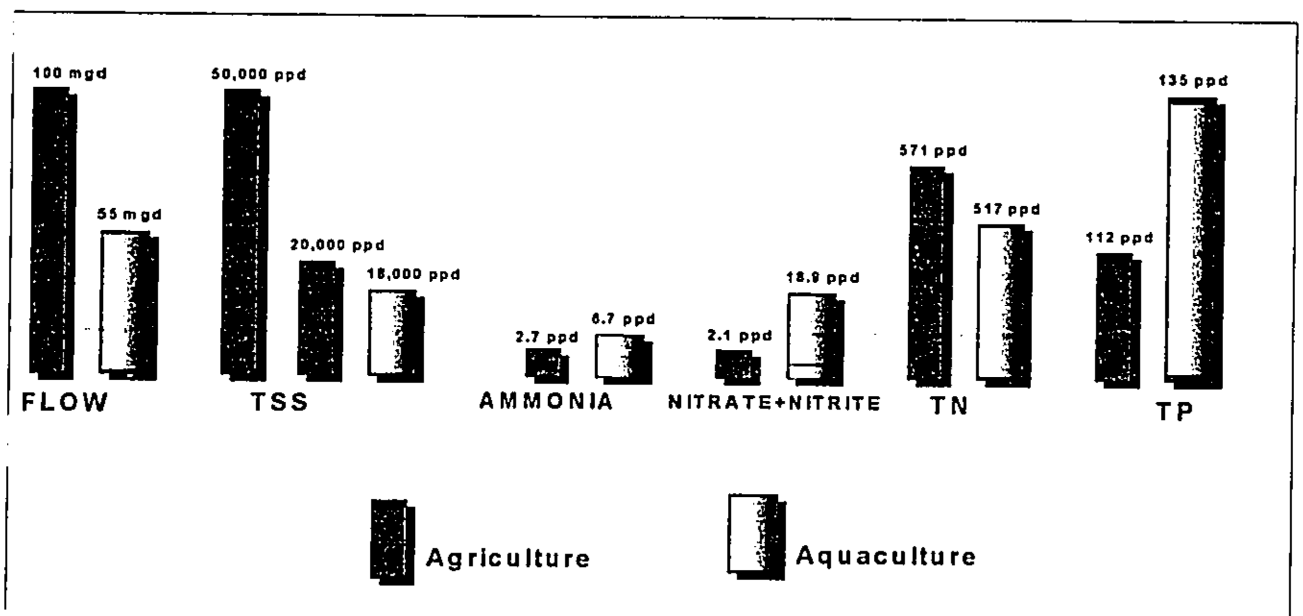


FIGURE 9: Comparison of Loading Rates for the Current Agriculture and Proposed Aquaculture

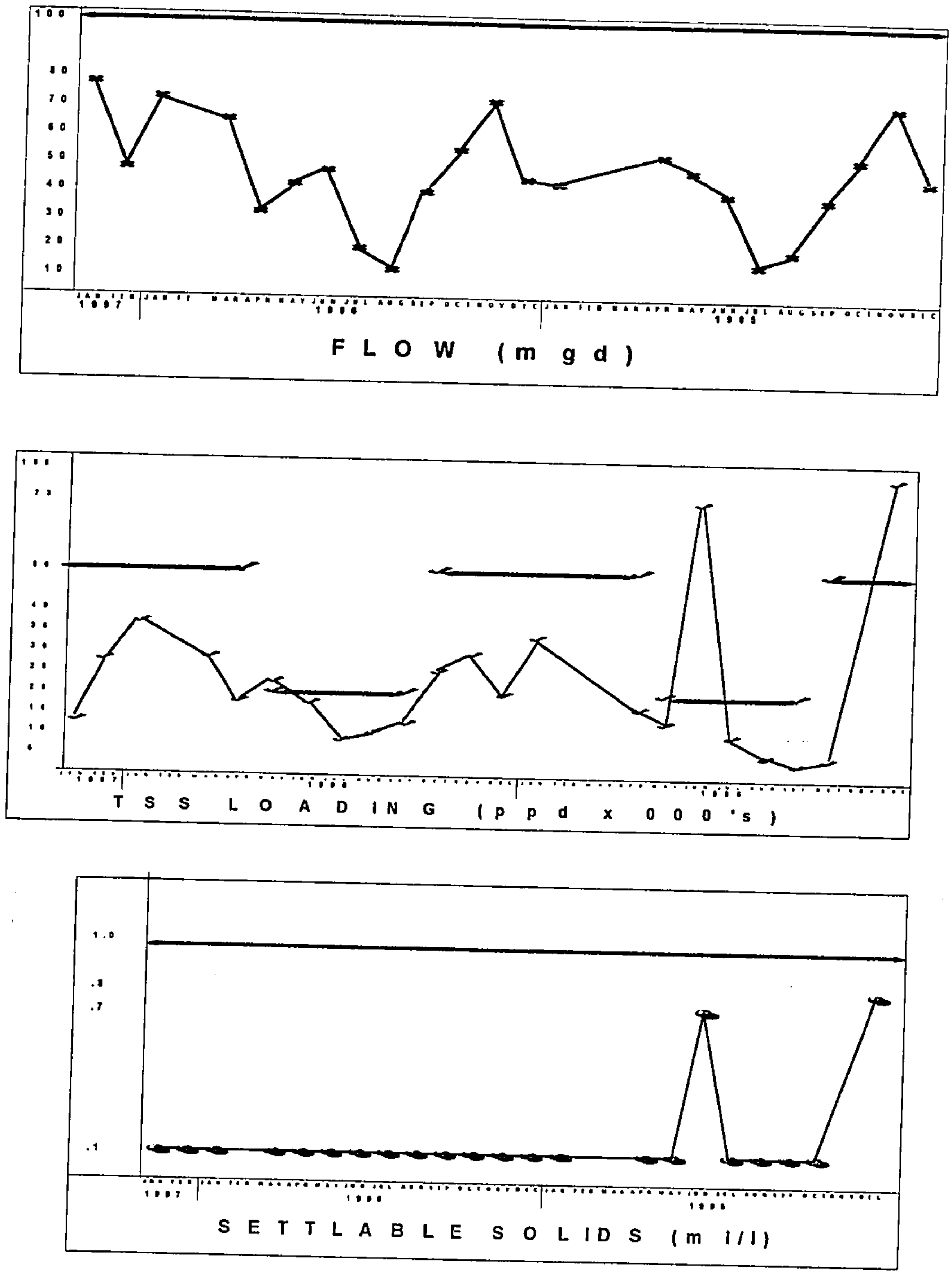


Figure 7. Temporal summary of water quality monitoring data for discharge via outfall #002 shows that the agriculture discharge has normally been well within the permitted levels, shown as colored, horizontal lines.

3. Hawaii Water Quality Standards

The coastal marine waters affronting the project are classified as "Class A, Generally Dry, Open Coastal Waters" of the Pacific Ocean, as per Hawaii Administrative Rules (HAR), Section 11-54-06(b)(2)(B). The Applicable standards for this class of water are summarized in Table 4 below.

Table 4

Hawaii Water Quality Standards for Class A Dry Open Coastal Waters

Parameter	Geometric Mean Not to Exceed the Given Value	Not to Exceed the Given Value More Than 10 Percent of the Time	Not to Exceed the Given Value More Than 2 Percent of the Time
Total Nitrogent, µg/L	110	180	250
Ammonia Nitrogen, µg/L	2.0	5.0	9.0
Nitrite Nitrate Nitrogen, µg/L	3.5	10.0	20.0
Total Phosphorus µg/L	16.0	30.0	45.0
Chlorophyll a µg/L	0.15	0.50	1.00
Turbidity, NTU	0.20	0.50	1.00

pH Units - Shall not deviate more than 0.5 unit from a value of 8.1
Temperature - Shall not vary more than 1°C from ambient conditions
Slainity - Shall not vary more than 10% from natural or seasonal changes considering hydrologic input and oceanographic factor.
Dissolved Oxygen - Not less than 75% saturation.

Protected uses within this classification include aesthetic enjoyment and recreation, the protection and propagation of fish, shellfish, and wildlife. All evidence indicates that these uses are being fully maintained. There has been no limitation on any water contact activity due to agriculture discharges via this outfall. There has been no limitation on any water contact activity due to outfall discharges. No limitations have been placed on the consumption of fish harvested from the vicinity.

The monitoring of ambient nutrient conditions at several stations within the existing Zone of Mixing, and a control station has been done as a condition of conformance for NPDES permit #0000086. A summary of the receiving environment nutrient data, taken from the most recent Water Quality Monitoring Report (October 1996) by Marine Research Consultants, is given (Table 5) below. The comparison with Hawaii Water Quality Standards (Table 4) indicates that the concentrations of total nitrogen, total phosphorous, turbidity, ammonia-nitrogen, and nitrate + nitrite are below the limits required. This condition is apparent at all stations, including the control station. These data indicate that the water quality of the receiving environment is currently within the limits required for conformance with Hawaii Water Quality Standards.

Table 5. **Receiving Water Quality.**
Data from the most recent monitoring report shows that the receiving environment conforms to HWQS.

Parameter	Stations 5-7	Control Station
Total Nitrogen (μg N/L)	55	56
Ammonia Nitrogen (μg NH^4-N/L)	1.5	1.4
Nitrate + Nitrite Nitrogen (μg (NO^3+NO^2)-N/L)	1.0	0.4
Total Phosphorus (μg P/L)	12	12
Chlorophyll a (μg/L)	0.09	0.13
Turbidity (NTU)	0.07	0.08
Salinity (ppt)	34.8	34.8

4. Physical Oceanographic Setting and Flushing Capacity

The site of the discharge is located on the southwesterly facing coast of Kauai, just south of the Pacific Missile Range Facility runway. The site is partially sheltered from the predominant northeasterly tradewind-generated waves, but is directly exposed to winter north Pacific swell and summer southerly swell. It is because of the relatively wide emergent limestone bench along this shoreline, that a perched sandy beach exists landward of the rocky shoreline.

Nearshore coastal circulation is dominated by tidal currents. Data obtained offshore Kokole Point (Wyrtki et al. 1969, Hawaii Institute of Geophysics Technical Report HIG-69-15, current meter station #215) indicate that the predominant current flow is in the northwesterly and southeasterly directions (generally parallel with ocean bottom contours), due to the semi-diurnal and diurnal tidal components. The semi-diurnal tidal current amplitude is 21 cm/sec, and the diurnal tidal current amplitude is 10.3 cm/sec. The data also indicate a net drift to the east-southeast (8.5 cm/sec), with the prevailing semi-diurnal reversing tidal currents superimposed. At the project site located about 2.5 miles to the northwest of Kokole Point, it is expected that the tidal current speeds would be similar, but that the direction would be parallel with the local bottom contours offshore of the site. USGS and NOAA charts show the bottom contours generally paralleling the coastline (NNW-SSE), and the perimeter of the existing ZOM reaches approximately 200-300 feet water depths offshore of the #002 discharge site.

This open, well-flushed coastal setting displays a low sensitivity to land-based discharge inputs. An analysis of the coastal environments surrounding all of the major islands was conducted in 1990 to assess the relative potential for impacts from aquaculture discharges for all shoreline areas (*Ziemann et al. 1990. USDA CTSA Technical Report #Y1. 212pp*). The key parameters used in this analysis included: the dominant biological community type, the nearshore physiography, the prevailing wind direction, and the location of the wave breakpoint. More detailed analyses considered the near-shore current patterns to ascertain the natural capability of the environment to flush the area, and the historical use of the area which reflects the degree of pristine character at the time that effluent effects are being evaluated. As shown on Figure 10, this work concluded that the ocean environment affronting the Mana plain of Kauai has a low sensitivity to aquaculture discharges. This finding, indicating a low probability for negative ecological effect from aquaculture discharge for the area, was important in CEATECH's selection of this site for its aquaculture operation. The naturally high advective forces, and open coastal character give this environment a high self-cleaning potential.

IV. Future Water Quality

1. Context

This section describes the extent to which the water quality in the area affronting the discharge is likely to be affected, and explains the procedures used to make this determination. Since the Hawaii Water Quality Standards for coastal ocean waters cannot be met by aquaculture effluents even with the best technology economically achievable, a Zone of Mixing becomes a condition of an NPDES permit (HAR 11-54-09).

The Zone of Mixing is an area around the effluent entry point that allows for initial dilution of an effluent that has received the best degree of treatment practical. It provides a realistic means of control of the quality and effects of a discharge while enabling economic development activities, maintaining a high level of water quality and protecting designated uses in the surrounding environment. Because the prospective receiving environment is currently defined as a Zone of Mixing (ZM-35) for agriculture discharge, that condition is also considered in the analysis.

2. Modeling Results for Effluent Transport and Dispersion

A rigorous hydraulic modeling effort was performed for the CEATECH discharge (Appendix B). The model selected for evaluating the mixed effluent discharge is the three-dimensional PDS Model, which was developed under EPA sponsorship. This model incorporates all the appropriate hydrodynamic processes for addressing the mixed effluent discharge. The objectives of these analyses were: (a) to assess whether the existing ZM-35 established for the Kekaha Sugar Company's discharge from the Kawaiele drainage channel is sufficient to accommodate the addition of CEATECH's discharge, and (b) whether the existing ZM-35 would appropriately accommodate CEATECH's discharge alone, exclusive of any agriculture discharge. Water quality data for the aquaculture effluent (given in section II above), and data from the agriculture discharge and receiving environment (given in section III above) were used as input to the model. Numerical modeling techniques were applied to evaluate the dilution characteristics for these discharges, to assess whether the water quality parameters at the ZM-35 boundary would be in compliance with the water quality standards applicable to this site.

Appendix B contains the graphic and tabular model outputs for both the combined effluents, and the CEATECH effluent alone. In both cases wherein the plume momentum is dissipated prior to reaching the ZM-35 radius, a Brooks-type solution was applied to account for the additional dilution of the passive plume between the termination point of the PDS model and the radius. Table 6 below gives the resultant water quality parameter concentrations at the boundary of the existing ZM-35 for both the combined effluent case, and for CEATECH's effluent alone.

The results indicate that water quality at the ZOM boundary will meet the HWQS for all discharge scenarios considered. The model results show that in both cases the HWQS for TN, TP, Ammonia-N, and Nitrate + Nitrite are met at the boundary of the existing ZM-35. The model's quantitative results are very conservative, considering that there is, extensive mixing/dilution of the initial discharge at the shoreline (due to wave energy and physiography of the coastal bench) which are not accounted for in the modeling technique. Thus, there is negligible doubt that actual concentrations at the ZM-35 boundary would be lower than those predicted by the numerical modeling, and that HWQS would be met. It is also apparent that the addition of CEATECH's saline effluent to the slightly brackish agriculture effluent, actually improves dilution/dissipation of the parameter concentrations, and **improves** the water quality at the ZM-35 boundary.

The indication that turbidity may not meet geometric mean values of the HWQS at the ZM-35 boundary requires explanation. Because turbidity is a light-scattering measurement and not directly correlated with concentrations, applying a dilution factor will not accurately represent the actual values at a given point in the time-space continuum. Despite the high turbidity of the existing discharge, the NPDES monitoring data shows that turbidity at the ZOM boundary is lower than the level required by Hawaii Water Quality Standards. Because CEATECH's effluent will have lower turbidity than the existing agriculture discharge, it is expected that the combined discharge, will also easily meet the Hawaii Water Quality Standards, as is the present case of the agriculture discharge alone (Table 5).

The projected value for chlorophyll in the aquaculture discharge, used in the modeling analysis was derived from several sources of shrimp production data that had a large variance. The absence of actual chlorophyll data during on-site production leaves the most appropriate input value uncertain. The large confidence limit associated with that chlorophyll input value influences the model's indication that predicted chlorophyll levels at the ZM-35 boundary approximate the 10% value of HWQS rather than the mean value. Given that the predicted results (Table 6) for the other particulate constituent (turbidity) far exceeded that indicated by empirical monitoring data from the area (Table 5), we expect that actual chlorophyll levels will similarly be lower than those predicted.

Table 6

Predicted Water Quality Parameters at the boundary of ZM-35 from numerical modeling results

Parameter	Combined Existing <1>	Combined Max Permitted <2>	CEATECH Only <3>	HWQS Geometric Mean	HWQS <10% Exceedence
Total Nitrogen (µg/L)	73.77	81.67	64.62	110	180
Ammonia Nitrogen (µg/L)	1.53	1.56	1.48	2.00	5.00
Nitrate + Nitrite Nitrogen (µg/L)	0.72	0.70	0.65	3.50	10.00
Total Phosphorus (µg/L)	15.98	17.45	13.73	16.00	30.00
Chlorophyll a (µg/L)	0.49	0.44	0.46	0.15	0.50
Turbidity (NTU)	0.50	0.79	0.14	0.20	0.50

<1> For existing Kekaha Sugar Company average discharge of 45 mgd combined with CEATECH proposed discharge of 55 mgd, for a total discharge of 100 mgd.

<2> For Kekaha Sugar Company maximum permitted discharge of 100 mgd combined with CEATECH proposed discharge of 55 mgd, for a maximum total discharge of 155 mgd.

<3> For CEATECH discharge only, at 55 mgd.

Results of the numerical modeling applied to evaluate the dilution characteristics for all discharge scenarios indicates that the existing ZM-35 can accommodate the CEATECH discharge without violating the HWQS at the boundary. Considering the relatively high energy wave environment, and the tidal current-dominated nearshore current regime, it is reasonable to expect even higher dilutions in practice than those predicted by the model.

These modeling results, together with the indication that addition of the saline aquaculture effluent improves dilution and mixing rates in the area, show that the protected uses, which have been protected, will continue to be fully protected under the combined effluent condition.

3. Limitations to Further Waste Treatment Techniques

The conceptual design of the waste treatment strategy (Section II) targeted the most functional means of improving the quality of this type of effluent. The treatment procedures also had to pass the threshold of reliability, and economic feasibility. Derivation of the plan followed thorough evaluation of both aquaculture and wastewater information. This examination included published literature, electronic database searches, professional experience, computer information searches, technical reports, and direct communications with professionals in several allied technical fields.

Other waste treatment procedures were considered but not included in the waste treatment plan. The rejection of further treatment alternatives occurred for one or more of the following reasons:

1. Procedures are technically *unproven* in a saltwater environment for aquaculture wastes;
2. Procedures are *ineffective and/or insufficiently robust* to reduce the low nutrient levels characteristic of aquaculture effluents, i.e., their application would not substantially reduce discharge loadings;
3. Procedures are *unreasonably expensive* such that their application would make the farming operation economically unfeasible.
4. Procedures would *jeopardize the disease-prevention principals* of the technology on which the sustainability of the venture is based.

The technical limitations of various treatment alternatives for aquaculture use are summarized in Table 7 below.

Table 7. Summary of the Constraints which Limit Application of additional waste treatment processes to this Aquaculture Effluent.

UNPROVEN IN A SEAWATER ENVIRONMENT	PROHIBITIVELY EXPENSIVE	TECHINICALLY INEFFECTIVE OR INSUFFICIENT	VIOLOATES DISEASE-PREVENTION NEEDS
Microfiltration Microstrainer TSS Removal TP Removal TN Removal Injection Well	Centrifugation Injection Well Microfiltration	Mechanical Filtration Polyculture Sedimentation Microstrainer Recirculation	Recirculation Polyculture

The small particle size, low nutrient levels, and saline quality of the effluent stream impose prominent constraints on the efficacy of many conventional treatment methods. The concentration of most dissolved and particulate constituents in sanitary wastewater operations (for which most of the wastewater treatment methods were developed and are commonly practiced) are two to ten times higher than those characterizing the aquaculture effluent.

The majority of the TSS load in the HVLC aquaculture stream consists of viable phytoplankton and bacteria. Analyses of the effluent from the prototype production units at the Sunkiss Shrimp Farm in Kekaha done by University of Hawaii scientists using a laser scatterometer, showed that over 75% of the particles are < 3um. This size characteristic precludes reasonable removal efficiencies or cost economy for processes based on sedimentation, filtration, microstraining, or centrifugation. For example, estimated energy requirements of ~2kw/l/min for centrifugation of this type of effluent illustrate the prohibitively high energy costs. Similarily, the use of injection wells is unproven for large volume seawater discharge, and is calculated to require the addition of $2.00 - $4.00 to the price of each pound of shrimp produced.

Water re-circulation and poly-culture procedures violate the disease prevention and animal health management tenets upon which the sustainability of this technology is based. The animal health management and disease prophylaxis techniques being applied here are necessary to avoid the problems that have so severely compromised the viability of shrimp farming elsewhere. Poly-culture, currently a research interest at many academic institutions, has yet to be proven to be a reliable remover of waste constituents in a commercial scale operation. Poly-culture or serial culture schemes often affect the waste form more than the waste amount, are rarely terminal acceptors of waste, and have never been shown to improve the water quality sufficiently to avoid the need for discharge into a Zone of Mixing..

The estimated impact to the necessary selling price of a pound of shrimp caused by the application or various conventional treatment processes, summarized in Table 8, indicates that their use would render the operation uncompetitive and economically infeasible.

Table 8. **Predicted Cost Impact from the application of various wastewater procedures to the aquaculture effluent.**

Target *Constituent*[1]	Typical Quality of *Effluent*[2]	Average Unit Cost *$/10^3 gal*	Estimate Treatment *Cost $/day*[4]	Needed Price Increase *$/lb shrimp*
SS	2-5*mg/l*	0.47	$25,850	$2.36
TP + SS	≥ 1*mg/l*	0.8	$44,000	$4.02
TN+TP+SS	≥ 1*mg/l*	1.63	$89,650	$8.18

1. Abbreviations used are: SS=Suspended Solids, TP=Total Phosphorous, TN=Total Nitrogen. At least three potential treatment process alternatives were included for each constituent. 2. As given by Ziemann et al., 1990. Aquaculture effluent Discharge Program Year 1 Final Report. USDA-CTSA Technical Report, 220pp. The typical turbidity level for all treatment processes is ~ 2 NTU. 3. Averaged Unit Treatment costs for various process alternatives for each target constituent. 4. Represents conservative computations because: a) calculations were done in 1990 dollars without use of ENRCCI or EPA's LCAT/SCCT indexes to update construction and labor costs, b) original power cost component ($0.10/kwh) was retained ranther than $0.17/kwh which is current case on Kauai.

That the BAT for conventional sewage treatment produces effluents having two to ten times higher nutrient concentrations than aquaculture effluents before any treatment reflects the technological limitations faced by further treatment of aquaculture effluents. This also illustrates the reason for the lack of any long-term application of such technologies in a saltwater environment. This current state of the art implies a low level of the techniques' reliability and precludes assurance that the use of these techniques to treat the aquaculture effluent would meet the Hawaii Water Quality Standards prior to discharge.

4. Proposed Monitoring Program to Confirm Key Assumptions

To assure optimization of the production and waste treatment components needed for full environmental compliance, the company will maintain a program of regular water quality monitoring throughout all facets of its aquaculture system. The monitoring protocols will provide information on the feed utilization efficiency and pond management. These data are to be used to minimize both the amount of waste and water quality variability that might effect the quality of the discharge stream from the farm. The high water quality within the farm is managed to promote the well being of aquatic organisms; this condition is also an attribute of water leaving the farm. Temperature, dissolved oxygen, and water quality clarity are assessed twice per day within each production pond. Monthly samples are also to be taken to build the database characterizing the other water quality parameters within the pond component at all stages of the production cycle.

Regular monitoring will also occur in the waste treatment subcomponents (e.g., settling ponds or other discharge mitigation units), and subsequently from the farm. The applications of these data are: to insure conformance with all permit requirements, to confirm assumptions concerning operations and treatments, to build the database for subsequent treatment optimization, and to evaluate the efficacy of various treatment strategies and discharge mitigation efforts being examined. Monthly reporting of the flow and water quality of the aquaculture effluent is planned in the sampling protocols.

The company will also perform annual monitoring within the ZM-35, and the adjacent receiving environment. This monitoring will include those parameters monitored in the discharge stream. This monitoring will also include assessment of the biological communities in the area on a biannual basis, as is the case now. Monitoring of the outside environment is to provide the record needed to confirm forecasts regarding dispersion of the effluent as well as the conservation of adjacent environment. Understanding the value of a long-term database to evaluate various assumptions concerning operations, treatments and discharges, and environmental effects, the company intends to begin development of these records immediately after starting operations.

5. On-Line Evaluation Program for Continuous Effluent Improvement.

CEATECH recognizes that the best aquaculture waste treatment system that is now available is not necessarily the best system that is possible. The Company will develop and maintain a program to evaluate novel opportunities to continuously improve the water quality of the aquaculture discharge stream. As discussed in section IV.3 above, a reason for disqualifying several treatment technologies is the lack of proven performance in a saltwater environment, and at the constituent concentrations typical of this aquaculture operation.

Both the characteristics of discharge from this type of marine shrimp farm, and site specific qualities of the Kekaha environment suggest potential to further improve the effluent quality in the future. In addition to maintaining compliance with permitting requirements, the company is committed to the evaluation of novel strategies to further reduce constituent levels within its aquaculture discharge waters. CEATECH has conceptually evaluated several treatment alternatives, which although experimental, may show some promise to improve the quality of these saline discharge waters. Such processes are unverified for commercial scale marine aquaculture, but since their evaluation will take place during actual operation, CEATECH will begin immediately to acquire the database needed to further improve the farm's waste management component.

V. Social and Economic Considerations

The project will provide substantial economic development and much needed employment within the diversified agriculture sector. The project relies on climatic and technological features where Hawaii has comparative advantage over other locales. This aquafarming effort takes advantage of the availability of land, labor, isolation, and warm climate to produce a high value commodity while retaining the rural character of the community. This phased growth effort will compliment and augment current farming in the area, and has every potential to provide additional economic stimulus through a primary industry based on existing resources.

The project is expected to substantially improve the island's export capability, and socio-economic health. CEATECH's shrimp farming can substantially mitigate the economic losses to Hawaii's slipping economy, and the associated loss of employment tax revenues. Sugar has traditionally shown an average cash yield per acre of about $2,000 per acre per year. The proven annual yield of this shrimp technology in the area is equivalent to $250,000 per acre pond per year.

Such alternate uses of Hawaii's agriculture lands, becoming available because of progressive changes in the sugar market, need to be pursued for the economic future of the area. Revenues from the 104 pond operation are estimated to exceed $20 million annually. Total construction costs for ponds and necessary infrastructure are expected to exceed $4 million. The amount of economic impact going into the local community will be substantial. Using a multiplier of 2.1 (the Hawaii input/output model uses for agriculture1.97 and 2.23 for fishing) for the indirect economic activity, the total annual economic activity generated from the operation is estimated to be over $47 million. Hawaii is at a critical stage of industry and economic development. Though tourism and military will likely continue as flagships of our economy, the agriculture component, which for years was sustainable, needs new stimulus and development. A staggering economic opportunity is presented from establishing Hawaii as a new, principal supplier of a high-value, product that is unlike any other produced elsewhere.

Unfortunately, the area currently has a large farming labor pool available due to economically difficult times. Downsizing by Kekaha Sugar Company and McBryde Sugar Company has increased unemployment in the area. New CEATECH farm personnel are expected to consist primarily of Kauai residents with experience in farming operations who are willing to participate in training programs. This new farming operation can have sustaining effects to the employment perspective for Kauai and for the entire State. The first phase of 52 ponds is expected to create more than 50 jobs, a large portion of which would be full-time positions. Similar numbers would accompany completion of the subsequent phase, which would compliment the discharge scenario described herein.

The U. S. is the target market for most of the shrimp to be produced. Americans consume over 850 million pounds of shrimp annually, 75% of which is imported. At an annual level of $2.5 billion, shrimp is consistently the largest element of the U. S. trade deficit in seafood. Most of this domestic demand has been met by aquaculture shrimp from outside the United States. It has been the intent in the years of federal funding for shrimp technology development that the shrimp component of the fisheries trade deficit could be reduced through domestic production. Successful attainment of the shrimp production projected by this project would contribute to lowering of the fisheries trade deficit.

The direct benefits to the community arising from the proposed CEATECH program include:

a. Long-term protection of prime agriculture lands from being fragmented through subdivision or other sub-plotting methods that would otherwise reduce Hawaii's capacity for future farming opportunities.
b. Long-term protection of the existing drainage infrastructure, consisting of ditches, culverts, and pumps, which maintain the lower groundwater level and allows the plains to be farmed by the various users.
c. Supporting the goals of the Waimea-Kekaha Regional Development Plan by "creating a new opportunity for a greater diversity of employment", and "to promote the improvement and expansion of the region's economy, by recognizing and carefully utilizing land and water resources".
d. Maintaining the "agricultural dedication" designation of the lands through active, responsible and profitable agriculture activities, yet provide greater revenue returns to the State and County governments.
e. Providing much needed economic impacts to Kauai's westside in particular which is one of the most economically impoverished regions on the island. The project is a positive and necessary component of Kauai's continuing efforts to recover from the devastating losses incurred by Hurricane Iniki, and to assure its future economic sustainability and social stability.

The project takes advantage of an extensive, USDA supported R&D program that developed and verified advanced shrimp farming technologies for profitable and sustainable farming in the United States business setting. Arguments for the economic sustainability of this project are due in large part to the salient differences between this newly developed technology and that practiced by conventional shrimp farms. The discharge water quality projected above is the result of the incoming water quality, the feeds used, and pond management according to application of that technology. The latter element, together with the site properties of the Mana plain, give the project its advantaged economic perspective, and the opportunity for sustainability where others have failed. The company attracted recognized and proven management and technical personnel. The officers and staff include capabilities in finance, management of public companies, shrimp aquaculture, marketing, engineering, and environmental science. Having the mix of talents to start and sustain an aquaculture enterprise, the team also consists primarily of local residents with deep roots in the Hawaiian community. The prototype operation at the Sunkiss facility was initiated by residents with extensive family histories in the Kekaha community. This production system has several, internally-linked subcomponents which produce the effluent water quality described herein. The extensive R&D effort gives a high level of confidence in the economic and environmental sustainability of the project

ZONE OF MIXING ANALYSIS
CEATECH USA, Inc.
Marine Shrimp Farming Facility
Kawaiele, Kekaha, Kauai

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TABLE OF CONTENTS

1.0 INTRODUCTION

CEATECH USA, Inc. intends to develop a large scale shrimp farming agri-business on the Mana plain on Kauai, on lands formerly leased to Kekaha Sugar Company Ltd. At full production, the proposed total discharge from the production ponds is estimated at 55 million gallons per day (mgd). The source water (seawater) for the shrimp production ponds will come from on-site wells, and the effluent from the ponds will be discharged into the existing Kawaiele drainage channel.

The objectives of this analysis were to assess whether the existing Zone of Mixing (ZOM) established for Kekaha Sugar Company's discharge from Kawaiele drainage channel is sufficient to accommodate CEATECH's additional discharge, and also whether the existing ZOM was appropriate for CEATECH's discharge in the event that Kekaha Sugar Company terminated their discharge. Numerical modeling techniques were applied to evaluate the dilution characteristics for these discharges, in order to assess whether the water quality parameters at the ZOM boundary would be in compliance with the Water Quality Standards applicable to this site. The criteria applicable for this site is provided in Table 1 (Class A open coastal waters - "dry").

Table 1
Water Quality Standard Criteria

Parameter	Geometric Mean	<10% Exceedence	<2% Exceedence
Total Nitrogen (μg N/L)	110.00	180.00	250.00
Ammonia Nitrogen (μg NH_4-N/L)	2.00	5.00	9.00
Nitrate + Nitrite Nitrogen (μg (NO_3+NO_2)-N/L)	3.50	10.00	20.00
Total Phosphorus (μg P/L)	16.00	30.00	45.00
Chlorophyll a (μg/L)	0.15	0.50	1.00
Turbidity (NTU)	0.20	0.50	1.00

2.0 RECEIVING WATER QUALITY AND EXISTING ZOM

The coastal waters of Kauai's Mana plain have received agricultural effluents for many years, but long-term monitoring in compliance with existing NPDES permits finds no evidence of negative impacts to the water quality or the aquatic flora and fauna in the receiving waters of the agricultural discharges. This reflects the high cleansing capacity and low sensitivity to discharges of the coastal environment at the site.

Several ZOMs have been established along this coastal reach. The proposed discharge location for CEATECH's effluent, Kawaiele channel, is the site of a designated 6,000-foot radial distance ZOM under NPDES Permit No. HI000086 ZM-35 issued to Kekaha Sugar Company. Based on the most recent monitoring report data for Kawaiele (outlet 002), Table 2 summarizes the water quality at a control station (#8) and at three stations at the perimeter of the ZOM.

Table 2
Receiving Water Quality <1>

Parameter	Stations 5-7	Control Station
Total Nitrogen (μg N/L)	55	56
Ammonia Nitrogen (μg NH_4-N/L)	1.5	1.4
Nitrate + Nitrite Nitrogen (μg (NO_3+NO_2)-N/L)	1.0	0.4
Total Phosphorus (μg P/L)	12	12
Chlorophyll a (μg/L)	0.09	0.13
Turbidity (NTU)	0.07	0.08
Salinity (ppt)	34.8	34.8

<1> Mean values (top, mid, bottom) from sampling date 10/20/96.

3.0 DISCHARGE WATER QUALITY

CEATECH's production technique and strategy uses the best available technology related to intensive shrimp farming, waste management and treatment. The use of lined ponds prevents seepage into the groundwater and eliminates the addition of terrigenous sediments to the discharge stream. Daily water quality monitoring within all ponds optimizes the water quality not only for the aquatic animals being farmed, but also for those exposed to the subsequent discharge waters. CEATECH's production protocols result in much greater efficiency of feed, land, and water use than the style of shrimp farming operations applied in other countries. Feed conversion ratio is optimized, resulting in minimum waste addition to the discharge stream. The farming style uses no bioactive compounds such as pesticides, antibiotics, fertilizers, or growth hormones in its production operations. Pond design includes surface skimmers to collect and remove any buoyant plant material, and screens at multiple locations to prevent escape of animals into the natural environment. Settling basins will also be constructed to collect particulate waste materials, and provide increased residence time for the assimilation of some dissolved nutrients.

Untreated aquaculture effluents are in most cases of better quality than the acceptable effluents from sanitary waste treatment facilities. Nonetheless, aquaculture effluents do not meet Hawaii Water Quality Standards (WQS), and there are currently no known practical, reliable and economical treatment technologies for aquaculture discharges which would satisfy the WQS. As the case for other agriculture and aquaculture operations in Hawaii, CEATECH seeks to obtain an NPDES ZOM permit to discharge effluent from their planned marine shrimp farming facility. Table 3 summarizes the expected water quality of CEATECH's effluent at maximum production, based on data from similar operations and best professional estimate.

Table 3
CEATECH's Discharge Water Quality

Parameter	CEATECH's Discharge
Total Nitrogen (μg N/L)	1149
Ammonia Nitrogen (μg NH_4-N/L)	15
Nitrate + Nitrite Nitrogen (μg (NO_3+NO_2)-N/L)	42
Total Phosphorus (μg P/L)	300
Chlorophyll a (μg/L)	54.3
Turbidity (NTU)	9.9
Salinity (ppt)	34

4.0 MODELING METHODOLOGY

CEATECH proposes to discharge the aquaculture effluent into the Kawaiele drainage channel. Because Kekaha Sugar Company discharges into this same channel under an existing NPDES Permit with designated ZOM radial distance of 6,000 feet from the discharge point at the shoreline, analysis was performed to establish whether the WQS could be met at the ZOM boundary with the addition of CEATECH's effluent.

4.1 Existing Discharges Plus CEATECH Discharge (Buoyant Jet)

Two scenarios were evaluated: scenario 1 is for the case where CEATECH's effluent is mixed with Kekaha Sugar Company's existing discharge, and scenario 2 is for the case where CEATECH's effluent is mixed with the maximum permitted discharge under Kekaha Sugar Company's NPDES permit. Since Kekaha Sugar's effluent is near fresh water in salinity, when mixed with CEATECH's effluent, the mixed effluent is still buoyant. Table 4 provides the water quality parameters for Kekaha Sugar Company's existing discharge, CEATECH's proposed discharge, and the combined discharges.

Table 4
Water Quality Parameters for Mixed Effluent

Parameter	Kekaha Sugar Existing <1>	CEATECH Proposed	Combined Existing <2>	Combined Max Permitted <3>
Total Nitrogen (μg N/L)	1940	1149	1505	1659
Ammonia Nitrogen (μg NH_4-N/L)	9	15	12	11
Nitrate + Nitrite Nitrogen (μg (NO_3+NO_2)-N/L)	7	42	26	19
Total Phosphorus (μg P/L)	381	300	336	352
Chlorophyll a (μg/L)	N/A	54.3	29.9	19.3
Turbidity (NTU)	63.3	9.9	33.9	44.4
Salinity (ppt)	4.5	34	21	15

<1> Kekaha Sugar Company's water quality concentrations based on analysis of discharge sampled on 5/30/97.

<2> The combined values have been weighted by the flows. For existing case, Kekaha Sugar Company's average discharge flow of 45 mgd is used together with CEATECH's proposed discharge of 55 mgd, for a total flow of 100 mgd.

<3> For maximum permitted case, Kekaha Sugar Company's max discharge of 100 mgd is used together with CEATECH's proposed discharge of 55 mgd, for a maximum flow of 155 mgd.

When the mixed effluent exits the channel, it mixes with the nearshore ambient water due to turbulent entrainment of the jet. The density difference between the discharge and the receiving water also induces a vertical force on the plume. Since the plume is already on the surface, the buoyancy force tends to collapse the plume vertical thickness while forcing the width of the plume to increase in the horizontal. Entrainment of ambient fluid is constrained to the bottom and side edges of the plume. The model selected for evaluating the mixed effluent discharge is the PDS Model (Prych-Davis-Shirazi)[1], which was developed under U.S. EPA sponsorship.

The PDS Model is a three-dimensional model which represents uniform and steady surface discharge of heated water from a rectangular channel into a large and deep body of water that is either at rest or moving at a uniform and constant velocity. While the mixed effluent discharge is not recognized as a thermal plume, the PDS Model incorporates all the appropriate hydrodynamic processes for addressing the mixed effluent discharge. The temperature of the mixed effluent discharge and ambient water could be set equal to each other, thereby terminating any temperature dependence.

The PDS model requires specification of a number of input variables associated with the characteristics of the ambient receiving waters and the mixed effluent discharge, the hydraulic flow at the channel exit, and the geometry of the channel outlet. The following summarizes the various input parameters used in the analysis:

1. Discharge channel width, Wo. Based on field observations, a channel width of 6.5' has been assumed.

2. Discharge depth within channel, Ho. For combined flow of 155 mgd, water depth is 5.25'; for combined flow of 100 mgd, water depth is 3.83'.

3. Average velocity in discharge channel. For combined flow of 155 mgd, velocity is 6.8 fps; for combined flow of 100 mgd, velocity is 6.2 fps.

4. Average ambient velocity. Current data (Wrytki et al.)[2] shows that the semi-diurnal tidal velocity is 21 cm/sec (0.69 ft/sec).

5. Specific weight of discharge (lbs/cubic ft). Specific weight is calculated based

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[1]Shirazi, M.A. and L.R. Davis (1974), "Workbook of Thermal Plume Prediction, Volume 2, Surface Discharge", Pacific Northwest Environmental Research Laboratory, National Environmental Research Center, U.S. Environmental Protection Agency, EPA-R2-72-0005b.

[2]Wyrtki, K., V. Graefe and Wm. Patzert (1969), "Current Observations in the Hawaiian Archipelago", Hawaii Institute of Geophysics, University of Hawaii, HIG-69-15, for Office of Naval Research.

on the combined temperature and salinity of the mixed effluent, using temperature of 22 degrees and 27.5 degrees for Kekaha Sugar and CEATECH, respectively, and salinity of 4.5 ppt and 34 ppt, respectively. For flow rate of 155 mgd, specific weight of discharge is 62.97 pcf; for flow rate of 100 mgd, specific weight of discharge is 63.22 pcf.

6. Temperature in the ambient receiving water. Assume average ambient temperature of 25.5 degrees C.

7. Salinity of the receiving water. The NPDES monitoring data shows receiving water salinity at 34.8 ppt.

8. Discharge angle = 90 degrees for a perpendicular discharge into the ocean.

9. Surface heat transfer factor. Input 0 for no heat transfer.

10. Dimensionless horizontal eddy diffusion coefficient, $E_h = 0.2$.

11. Ratio of vertical to horizontal turbulent diffusion coefficient, $E_v = 0.5$.

12. Entrainment coefficient, E = 0.15.

Appendix A contains the graphic and tabular output from the PDS model for the case where CEATECH's effluent is combined with Kekaha Sugar Company's existing discharge. Appendix B contains the PDS model output for the case where CEATECH's effluent is combined with Kekaha Sugar Company's maximum discharge.

In both cases, the plume momentum is dissipated prior to reaching the ZOM radius. Therefore, a Brooks-type solution was used to account for the additional dilution of the passive "plume" from the terminus of the PDS Model solution to the ZOM radius. A diffusion coefficient of 0.01 $cm^{(2/3)}$/sec was assumed for the Brooks analysis.

The dilutions at a distance of 6,000 feet from the outlet were used to determine the resultant water quality parameter concentrations for the combined effluent flows. The following Section 5.0 summarizes the results of the modeling.

4.2 CEATECH Discharge Only (Non-Buoyant Jet)

In the unlikely event that Kekaha Sugar terminates its discharges of agricultural effluent, an evaluation was also made of CEATECH's discharge only, to determine whether the WQS would be met at the existing 6,000-foot ZOM boundary. Since CEATECH's effluent is nearly identical to sea water in both salinity and temperature, being pumped from nearshore groundwater wells, we can assume that the discharged effluent has the same density as the ocean receiving waters (e.g. the jet has no buoyancy).

There is not a wealth of literature on jet flows for non-buoyant jets, but there is probably sufficient information for our purposes. For the present discussion, we will consider the simple jet with a round nozzle discharging fluid into a large, still body of fluid of the same density. We will also assume that turbulent flow conditions exist, which will be the case. The information for this analysis is found in the book "Mixing in Inland and Coastal Waters" by Fischer et al. (1979), Section 9.2.1, page 319.

The initial flow velocity distribution at the jet nozzle is a "top hat" shape, and as the jet proceeds into the water body, mixing along the edges of the jet "eats" away at the constant velocity core, and at about 6-10 jet diameters distance into the water body, the mixing reaches the center of the jet. This region is termed the Zone of Flow Establishment (ZFE).

Proceeding downstream beyond the 6-10 nozzle diameters, the centerline velocity and its concentration begins to decrease, and this region beyond the ZFE is termed the Zone of Established Flow (ZEF). Experimental measurements indicate that the velocity and concentration distributions in the ZEF can well be described by a Gaussian distribution.

It turns out that for relatively large distances from the jet nozzle, defined by the nondimensional ratio

$$\frac{s}{l_Q} \qquad (1)$$

where: s = the distance downstream from the jet nozzle along the centerline axis of the jet, and
l_Q = characteristic length scale for the jet in terms of the volume flux Q and momentum flux M,

the solution for various parameters of engineering interest become relatively simple as described below.

For the round jet nozzle,

$$l_Q = Q/M^{1/2} = \sqrt{A} = \sqrt{\frac{\Pi}{4}}\, Dia = \sqrt{\Pi}\, r \qquad (2)$$

where:
Dia = the nozzle diameter
r = the nozzle radius
Q = 1/4 π Dia^2 v , volume flux
M = 1/4 π Dia^2 v^2, momentum flux
v = the mean outflow velocity assumed uniform across the jet
A = nozzle area.

To check if the jet nozzle is in turbulent flow, the Reynolds number, $M^{1/2}/\nu$, should be greater than 4,000, where ν is the kinematic viscosity of water (approx. equal to 1 x 10^{-5} sqft/sec).

For s/l_Q >>1 say about >= 6 - 10, the following results are obtained:

Centerline Tracer Concentration, C_m, where the ambient fluid has zero concentration of the tracer, is defined as:

$$\frac{C_m}{C_o} = 5.6\left(\frac{l_Q}{s}\right) \qquad (3)$$

where: C_o = the initial concentration of the effluent.

From Eqn (3) we can define Dilution, D, as:

$$Dilution = D = \frac{C_o}{C_m} \qquad (4)$$

Mean Dilution, μ/Q, is defined as:

$$\frac{\mu}{Q} = 0.25\left(\frac{s}{l_Q}\right) \qquad (5)$$

Ratio C_m / C_{ave} :

$$\frac{C_m}{C_{ave}} = 1.4 \qquad (6)$$

where: C_{ave} = the average concentration over the jet cross-section.

It is not unusual to expect that the receiving waters would have a concentration of a particular water quality parameter that is non-zero. Thus, if the ocean receiving waters have a concentration of C_{amb}, then the concentration of any parameter, say for example the centerline concentration in the jet, C_m, would be given by:

$$C_m = C_{amb} + \frac{1}{D}(C_o - C_{amb}) \tag{7}$$

Eqn. (7) can be inverted to provide the required dilution given by:

$$D = \left(\frac{C_o - C_{amb}}{C_m - C_{amb}}\right) \tag{8}$$

Since the above solutions are axi-symmetrical, it is reasonable to assume that if we cut the solution along the nozzle axis such that we have a half-circle nozzle, the same solution could represent the discharge into a water body with a free surface. As it turns out (see Wiegel), laboratory measurements for this free surface case indicates that the above solutions are reasonable.

The next step is to apply the ½ round nozzle jet solution to CEATECH's situation, where the outlet structure resembles a rectangular cross-section of width, w_o and water depth, h_o. Since the mixing process is primarily associated with the entrainment of ambient fluids at the interface between the jet and the fluid body, equating the "wetted" perimeter between the ½ round nozzle and the rectangular open channel would represent a reasonable approximation. Thus,

$$\pi r = 2h_o + w_o \tag{9}$$

and:

$$r = \frac{2h_o + w_o}{\pi} \tag{10}$$

where: r = the equivalent nozzle radius = 3.63 feet,
h_o = water depth in the channel = 2.46 feet (for discharge of 55 mgd),
w_o = channel width = 6.5 feet,

and the characteristic length scale, l_q is defined by:

$$l_q = \sqrt{\pi}\, r \qquad \textbf{(11)}$$

where l_q = 6.44 feet for CEATECH's discharge.

The water depth of 2.46 feet for discharge of 55 mgd (85.10 cfs) was determined using Manning's equation for uniform flow, assuming a Manning's n = 0.02 (smooth earth, no weeds) and channel bottom slope S = 0.0033. The mean flow velocity is 5.3 ft/sec, and the calculated Reynolds number confirms that the flow is turbulent.

From equation 3, the calculated average dilution of 166.38 at a distance of 6,000 feet from the outlet was used to determine the resultant water quality parameter concentrations for CEATECH's effluent flow. The following Section 5.0 provides the results of the modeling.

5.0 RESULTS OF MODELING

From the modeling results, Table 5 provides the resultant water quality parameter concentrations at the 6,000-foot radial distance ZOM boundary. For the combined flow of 100 mgd, the PDS model calculations terminate at a distance of 623 feet from the discharge point, with a dilution of 40.17. Using the Brooks-type solution to extend the dilution to the ZOM radius of 6,000 feet, the resultant dilution is 81.55. For the maximum combined flow of 155 mgd, the PDS model calculations terminate at a distance of 1,457 feet from the discharge point, with a dilution of 40.34. Using the Brooks-type solution to extend the dilution to the ZOM radius, the resultant dilution is 62.46. For the case of CEATECH's discharge only (no discharge from Kekaha Sugar Company), the dilution at the ZOM radius is 166.38.

Table 5
Water Quality Parameters at the ZOM Boundary

Parameter	Combined Existing <1>	Combined Max Permitted <2>	CEATECH Only <3>	WQS Geometric Mean	WQS <10% Exceedence
Total Nitrogen (μg N/L)	73.77	81.67	64.62	110.00	180.00
Ammonia Nitrogen (μg NH_4-N/L)	1.53	1.56	1.48	2.00	5.00
Nitrate + Nitrite Nitrogen (μg (NO_3+NO_2)-N/L)	0.72	0.70	0.65	3.50	10.00
Total Phosphorus (μg P/L)	15.98	17.45	13.73	16.00	30.00
Chlorophyll a (μg/L)	0.49	0.44	0.46	0.15	0.50
Turbidity (NTU)	0.50	0.79	0.14	0.20	0.50

<1> For existing Kekaha Sugar Company average discharge of 45 mgd combined with CEATECH proposed discharge of 55 mgd, for a total discharge of 100 mgd.

<2> For Kekaha Sugar Company maximum permitted discharge of 100 mgd combined with CEATECH proposed discharge of 55 mgd, for a maximum total discharge of 155 mgd.

<3> For CEATECH discharge only, at 55 mgd.

Before discussing the resultant water quality parameter concentrations at the ZOM boundary, several points should be noted with respect to the modeling technique:

- In general, the greater the density difference between the discharge flow and seawater, the smaller the dilutions. This is because, for a buoyant plume, mixing and entrainment of ambient seawater is constrained to the bottom and side edges of the plume. In this respect, the addition of CEATECH's seawater effluent to Kekaha Sugar Company's discharge enhances the dilutions within the ZOM.

- The model results are considered conservative, considering that there is considerable mixing/dilution of the initial discharges at the shoreline due to wave energy, which cannot be accounted for in the modeling technique. When only Kekaha Sugar Company's discharge is modeled (CEATECH discharge is zero), the resultant concentrations of several water quality parameters are *higher than ambient* at the ZOM boundary (when compared with Table 2 values). The most notable is turbidity, where the model dilutions indicate a turbidity of 0.85 NTU at the ZOM boundary for existing Kekaha Sugar Company discharge only, while the monitoring data indicates ambient turbidity of about 0.07 - 0.08 NTU. Because turbidity is a light-scattering measurement and not directly correlated with concentrations, applying a dilution factor is not considered to accurately represent the expected values at the ZOM boundary.

The results of the numerical modeling indicate that, for the most part, the water quality parameters at the ZOM boundary will meet the WQS criteria for all discharge scenarios, with the following caveats:

- Total Phosphorus: For the combined maximum flow of 155 mgd, the total phosphorus concentration at the ZOM boundary of 17.45 μg/L is only slightly higher than the WQS geometric mean criteria, but well within the WQS <10% exceedence criteria.

- Chlorophyll a: For all three discharge scenarios, the chlorophyll a concentrations exceed the WQS geometric mean criteria, but are below the WQS <10% exceedence criteria. Because this parameter can be highly variable, it is quite possible that actual operational data at CEATECH's facility will yield lower chlorophyll a concentrations in the discharge.

- Turbidity: For the combined existing flow of 100 mgd, the turbidity at the ZOM boundary is higher than the WQS geometric mean, but meets the WQS <10% exceedence criteria. For the combined maximum flow of 155 mgd, the turbidity at the ZOM boundary is higher than the WQS <10% exceedence criteria but is less than the WQS <2% exceedence criteria of 1.0 NTU. Because turbidity is not directly amenable to dilution computations, and because CEATECH's effluent will have low turbidity values compared to Kekaha Sugar Company's discharges, it is expected that the turbidity of the combined discharge will be able to meet the WQS mean criteria at the existing ZOM boundary. Despite the high measured turbidity of existing Kekaha Sugar Company discharge, the NPDES monitoring data shows that turbidity measurements at the ZOM are lower than the WQS geometric mean criteria.

6.0 PROPOSED ZONE OF MIXING BOUNDARY

The most recent monitoring data for Kawaiele Outlet 002 under NPDES Permit No. HI000086 ZM-35 issued to Kekaha Sugar Company indicates that the 6,000 foot radial distance ZOM is adequate to accommodate existing average discharges from Kekaha Sugar Company's agricultural activities. Results of the numerical modeling applied to evaluate the dilution characteristics for combined discharges (Kekaha Sugar plus CEATECH) indicate that the existing ZOM can also accommodate CEATECH's discharge.

Considering the relatively high energy wave environment, and the tidal current-dominated nearshore current regime, it is reasonable to expect good dilutions of discharges and good flushing of the nearshore coastal waters. Therefore, it is recommended that the existing ZOM boundary of 6,000 foot radial distance from the Kawaiele outlet also be applied to CEATECH's proposed discharge.

APPENDIX A

PDS Model output for case where CEATECH's effluent is combined with Kekaha Sugar Company's existing discharge

CEATECH'S NPDES/ZoM ANALYSIS FOR BUOYANT JETS USING PDS MODEL
DATE: OCTOBER 13, 1997
INPUT DATA FOR THE PDS MODEL

THE FOLLOWING ARE CONSTANT VALUES FOR ALL RUNS

1. DISCHARGE CHANNEL WIDTH, Wo (ft)	6.5 ft
2. DISCHARGE ANGLE RELATIVE TO CURRENT/NEARSHORE	90 deg
3. SURFACE HEAT TRANSFER FACTOR:	0
4. DISTANCE DOWNSTREAM TO STOP COMPUTATIONS	Use Default
5. OPTION FLAG:	0
6. SSCON: Suspended Solids Concentration (lbs/cu ft)	0

VARIABLES

1. WATER DEPTH IN DISCHARGE CHANNEL	3.83 ft
2. AVERAGE VELOCITY IN DISCHARGE CHANNEL	6.22 ft/sec
3. AVERAGE AMBIENT VELOCITY: Run These Cases	
a. No Current	0 ft/sec
b. Maximum Current, 21 cm/sec based on Wrytki et al.	0.69 ft/sec
c. 1/2 Maximum Current, 10.5 cm/sec	0.35 ft/sec
4. SPECIFIC WEIGHT OF DISCHARGE:	63.22 lbs/cu ft
5. AVERAGE AMBIENT TEMPERATURE:	
Based on Kahe Point data, with the low Winter temp = 24 deg and the high Summer temp = 27 deg, Assume Ave. Temp =	25.5 dec C
6. SALINITY OF RECEIVING WATER:	
Based on NPDES monitoring data	34.8 ppt

ENTRAINMENT COEFFICIENT, E =	0.15
RATIO OF VERTICAL TO HORIZONTAL TURB. DIFF. COEF., Ev =	0.5
DIMENSIONLESS HORIZONTAL EDDY DIFF. COEFFICIENT, Eh =	0.2

THIS CASE IS FOR 100 mgd (45 Kekaha & 55 Ceatech)

CASE 32 - CURRENT = 0.69 FT/SEC

AMBIENT CONDITIONS: TEMP. TA = 25.5 DEG. C
VEL. UA = .69 FT/SEC
HEAT CONVECTION = .0000E+01
SALINITY = 34.80 PPT

DISCHARGE CONDITIONS : UNIT WEIGHT = 62.97 LBS/CU FT
VEL. UO = 6.81 FT/SEC
WIDTH WO = 6.50 FT.
DEPTH HO = 5.25 FT.
ANGLE = 90.0 DEG.
INIT. CONC. = 0.000 LBS SUS. SED./CU. FT. DISCHARGE

DISCHARGE DENSIMETRIC FROUDE NO. = 4.42

ENTRAINMENT COEFFICIENT = .1500
RATIO OF VERTICAL TO HORIZONTAL TURBULENT DIFFUSION COEFFICIENT = .5000
DIMENSIONLESS HORIZONTAL EDDY DIFFUSION COEFFICIENT = .2000

TIME (SEC)	S (FT)	X (FT)	Y (FT)	DEPTH (FT)	WIDTH (FT)	THETA (DEG)	SUS. SOLIDS (LBS/CF)	Q/QO (DILU)	EXCESS U (FT/SEC)
3.0	19.90	2.18	19.78	3.95	22.30	83.72	0.000	2.00	6.57
3.0	19.96	2.18	19.84	4.04	22.52	83.54	0.000	2.03	6.45
3.0	20.02	2.19	19.90	4.13	22.74	83.36	0.000	2.06	6.34
3.0	20.07	2.20	19.95	4.22	22.96	83.19	0.000	2.09	6.23
3.0	20.13	2.20	20.01	4.31	23.18	83.02	0.000	2.12	6.12
3.0	20.19	2.21	20.07	4.39	23.41	82.85	0.000	2.15	6.02
3.0	20.24	2.22	20.12	4.48	23.63	82.68	0.000	2.18	5.93
3.0	20.36	2.23	20.24	4.64	24.09	82.35	0.000	2.24	5.74
3.1	20.47	2.25	20.35	4.80	24.55	82.03	0.000	2.30	5.57
3.1	20.59	2.26	20.46	4.96	25.02	81.72	0.000	2.35	5.41
3.1	20.70	2.28	20.57	5.10	25.49	81.42	0.000	2.41	5.27
3.1	20.93	2.32	20.80	5.39	26.45	80.83	0.000	2.51	4.99
3.2	21.16	2.35	21.02	5.65.	27.42	80.27	0.000	2.61	4.75
3.2	21.38	2.39	21.25	5.90	28.40	79.73	0.000	2.70	4.53
3.3	21.61	2.43	21.47	6.13	29.40	79.21	0.000	2.80	4.33
3.4	22.07	2.52	21.92	6.55	31.42	78.23	0.000	2.97	3.99
3.5	22.53	2.62	22.37	6.92	33.46	77.32	0.000	3.13	3.70
3.6	22.98	2.72	22.81	7.24	35.52	76.48	0.000	3.28	3.45
3.8	23.44	2.83	23.25	7.52	37.60	75.70	0.000	3.42	3.24
4.0	24.35	3.07	24.14	7.98	41.77	74.28	0.000	3.68	2.89
4.3	25.26	3.33	25.01	8.33	45.93	73.03	0.000	3.90	2.61
4.7	26.18	3.60	25.88	8.59	50.06	71.93	0.000	4.10	2.39
5.0	27.09	3.89	26.75	8.78	54.15	70.95	0.000	4.27	2.21
5.4	28.00	4.20	27.61	8.91	58.18	70.07	0.000	4.43	2.06
6.3	29.83	4.84	29.32	9.06	66.01	68.52	0.000	4.71	1.83
7.2	31.65	5.53	31.01	9.07	73.53	67.22	0.000	4.94	1.66
8.2	33.48	6.26	32.68	8.99	80.70	66.09	0.000	5.15	1.54
9.2	35.30	7.01	34.34	8.87	87.51	65.09	0.000	5.33	1.45
10.2	37.13	7.79	35.99	8.73	93.99	64.18	0.000	5.49	1.38
11.3	38.96	8.60	37.63	8.60	100.16	63.35	0.000	5.64	1.32
12.5	40.78	9.43	39.26	8.47	106.05	62.58	0.000	5.78	1.27
13.6	42.61	10.28	40.87	8.35	111.70	61.87	0.000	5.92	1.23
16.0	46.26	12.04	44.07	8.09	122.41	60.58	0.000	6.15	1.16
16.3	46.71	12.26	44.47	8.05	123.70	60.42	0.000	6.18	1.15
16.7	47.17	12.49	44.87	8.04	124.96	60.27	0.000	6.21	1.14
17.0	47.63	12.72	45.26	8.02	126.21	60.12	0.000	6.24	1.14
17.3	48.08	12.94	45.66	8.01	127.45	59.97	0.000	6.27	1.13
17.6	48.54	13.17	46.05	7.99	128.69	59.82	0.000	6.29	1.12
17.9	49.00	13.40	46.45	7.97	129.91	59.68	0.000	6.32	1.11
18.2	49.45	13.63	46.84	7.95	131.13	59.53	0.000	6.35	1.10
18.5	49.91	13.87	47.23	7.93	132.34	59.39	0.000	6.37	1.09
19.2	50.82	14.33	48.02	7.90	134.72	59.11	0.000	6.43	1.08

BOUYANT JETS -- CEATECH NPDES/ZOM ANALYSIS
CASE 32 - CURRENT = 0.69 FT/SEC

TIME (SEC)	S (FT)	X (FT)	Y (FT)	DEPTH (FT)	WIDTH (FT)	THETA (DEG)	SUS. SOLIDS (LBS/CF)	Q/QO (DILU)	EXCESS U (FT/SEC)
19.8	51.73	14.80	48.80	7.86	137.08	58.85	0.000	6.48	1.06
20.4	52.65	15.28	49.58	7.82	139.40	58.58	0.000	6.53	1.05
21.1	53.56	15.75	50.36	7.78	141.70	58.33	0.000	6.57	1.04
21.7	54.47	16.24	51.13	7.75	143.96	58.08	0.000	6.62	1.03
23.1	56.30	17.21	52.68	7.69	148.38	57.58	0.000	6.72	1.00
24.4	58.12	18.19	54.22	7.62	152.71	57.12	0.000	6.80	.98
25.8	59.95	19.19	55.74	7.55	156.93	56.68	0.000	6.89	.96
27.1	61.77	20.20	57.27	7.49	161.05	56.24	0.000	6.97	.94
28.5	63.60	21.22	58.78	7.43	165.09	55.83	0.000	7.05	.93
31.3	67.25	23.29	61.79	7.38	172.86	54.98	0.000	7.22	.88
31.7	67.71	23.55	62.16	7.38	173.81	54.88	0.000	7.24	.88
32.0	68.16	23.81	62.53	7.36	174.76	54.78	0.000	7.26	.87
32.4	68.62	24.08	62.91	7.34	175.71	54.70	0.000	7.28	.87
32.8	69.08	24.34	63.28	7.32	176.66	54.61	0.000	7.30	.87
33.1	69.53	24.61	63.65	7.30	177.60	54.52	0.000	7.31	.87
33.5	69.99	24.87	64.02	7.28	178.54	54.43	0.000	7.33	.86
33.8	70.45	25.14	64.39	7.27	179.47	54.34	0.000	7.35	.86
34.2	70.90	25.40	64.76	7.26	180.39	54.25	0.000	7.36	.86
34.9	71.81	25.94	65.50	7.22	182.23	54.08	0.000	7.40	.85
35.6	72.73	26.47	66.24	7.20	184.05	53.90	0.000	7.43	.85
36.4	73.64	27.01	66.98	7.18	185.86	53.73	0.000	7.47	.84
37.1	74.55	27.55	67.71	7.15	187.65	53.56	0.000	7.50	.83
37.8	75.47	28.10	68.45	7.13	189.42	53.39	0.000	7.54	.83
39.3	77.29	29.19	69.91	7.08	192.92	53.06	0.000	7.60	.82
40.8	79.12	30.29	71.37	7.05	196.36	52.73	0.000	7.67	.80
42.3	80.94	31.40	72.82	7.01	199.74	52.42	0.000	7.73	.79
43.8	82.77	32.52	74.26	6.97	203.08	52.11	0.000	7.80	.78
45.3	84.59	33.64	75.70	6.94	206.36	51.80	0.000	7.86	.77
48.4	88.24	35.92	78.55	6.87	212.80	51.23	0.000	7.98	.75
51.5	91.90	38.22	81.39	6.81	219.05	50.66	0.000	8.09	.73
54.7	95.55	40.54	84.20	6.77	225.13	50.11	0.000	8.21	.71
57.8	99.20	42.90	86.99	6.70	231.07	49.61	0.000	8.32	.69
61.1	102.85	45.28	89.76	6.66	236.86	49.11	0.000	8.43	.68
64.3	106.50	47.68	92.51	6.62	242.52	48.62	0.000	8.53	.66
67.6	110.15	50.10	95.24	6.56	248.07	48.17	0.000	8.63	.65
70.9	113.80	52.55	97.95	6.52	253.49	47.72	0.000	8.73	.63
74.2	117.45	55.01	100.65	6.49	258.79	47.28	0.000	8.83	.62
77.6	121.10	57.50	103.32	6.44	264.01	46.87	0.000	8.92	.61
81.0	124.75	60.01	105.97	6.41	269.11	46.46	0.000	9.01	.60
84.4	128.41	62.53	108.61	6.38	274.12	46.06	0.000	9.11	.58
87.9	132.06	65.07	111.23	6.34	279.05	45.69	0.000	9.19	.57
91.4	135.71	67.63	113.84	6.31	283.89	45.31	0.000	9.28	.56
94.9	139.36	70.21	116.42	6.29	288.65	44.94	0.000	9.37	.55
98.4	143.01	72.80	118.99	6.25	293.34	44.59	0.000	9.45	.54
101.9	146.66	75.41	121.55	6.23	297.95	44.25	0.000	9.53	.53
105.5	150.31	78.03	124.09	6.21	302.48	43.90	0.000	9.61	.52
109.1	153.96	80.67	126.61	6.18	306.96	43.58	0.000	9.69	.51
116.4	161.27	85.98	131.62	6.17	315.70	42.88	0.000	9.87	.49
123.7	168.57	91.36	136.56	6.10	324.23	42.32	0.000	10.01	.48
131.2	175.87	96.78	141.45	6.05	332.53	41.75	0.000	10.15	.46
138.7	183.17	102.26	146.29	6.03	340.61	41.16	0.000	10.31	.45
146.3	190.47	107.78	151.07	5.97	348.50	40.66	0.000	10.44	.44
153.9	197.78	113.34	155.80	5.95	356.23	40.14	0.000	10.58	.42
157.7	201.43	116.14	158.14	5.93	360.02	39.89	0.000	10.65	.42
161.6	205.08	118.94	160.48	5.92	363.77	39.64	0.000	10.72	.41
165.5	208.73	121.76	162.80	5.90	367.48	39.40	0.000	10.78	.40
169.4	212.38	124.59	165.11	5.89	371.15	39.16	0.000	10.85	.40
173.3	216.03	127.42	167.41	5.87	374.78	38.93	0.000	10.92	.39
177.2	219.68	130.27	169.70	5.86	378.38	38.70	0.000	10.98	.39
185.2	226.98	135.98	174.24	5.84	385.47	38.23	0.000	11.12	.38
193.1	234.29	141.74	178.74	5.81	392.43	37.81	0.000	11.24	.37

CASE 32 - CURRENT = 0.69 FT/SEC

TIME (SEC)	S (FT)	X (FT)	Y (FT)	DEPTH (FT)	WIDTH (FT)	THETA (DEG)	SUS. SOLIDS (LBS/CF)	Q/QO (DILU)	EXCESS U (FT/SEC)
201.2	241.59	147.52	183.20	5.79	399.26	37.39	0.000	11.36	.36
209.3	248.89	153.34	187.61	5.79	405.96	36.94	0.000	11.50	.35
217.4	256.19	159.19	191.98	5.76	412.56	36.57	0.000	11.61	.34
225.6	263.49	165.07	196.31	5.74	419.04	36.18	0.000	11.73	.33
229.8	267.15	168.02	198.46	5.73	422.25	35.99	0.000	11.79	.33
233.9	270.80	170.98	200.60	5.72	425.42	35.81	0.000	11.85	.32
238.1	274.45	173.94	202.73	5.71	428.57	35.62	0.000	11.91	.32
242.2	278.10	176.91	204.85	5.71	431.70	35.44	0.000	11.97	.31
250.6	285.40	182.87	209.07	5.70	437.88	35.05	0.000	12.10	.30
252.7	287.23	184.37	210.12	5.71	439.41	34.94	0.000	12.14	.30
254.8	289.05	185.86	211.17	5.70	440.93	34.86	0.000	12.17	.30
256.9	290.88	187.36	212.21	5.70	442.45	34.78	0.000	12.19	.30
259.0	292.70	188.86	213.25	5.69	443.97	34.71	0.000	12.21	.30
261.1	294.53	190.36	214.29	5.68	445.48	34.63	0.000	12.24	.30
263.3	296.35	191.87	215.32	5.68	446.98	34.55	0.000	12.27	.29
265.4	298.18	193.37	216.36	5.67	448.48	34.47	0.000	12.29	.29
267.5	300.00	194.88	217.39	5.67	449.97	34.38	0.000	12.32	.29
271.7	303.66	197.89	219.44	5.66	452.94	34.23	0.000	12.37	.29
276.0	307.31	200.92	221.49	5.65	455.89	34.06	0.000	12.43	.28
280.3	310.96	203.94	223.53	5.65	458.82	33.89	0.000	12.49	.28
284.6	314.61	206.98	225.57	5.64	461.73	33.73	0.000	12.54	.28
288.9	318.26	210.02	227.59	5.64	464.62	33.57	0.000	12.60	.27
297.5	325.56	216.11	231.61	5.62	470.34	33.27	0.000	12.71	.27
306.2	332.86	222.23	235.60	5.62	475.99	32.95	0.000	12.82	.26
314.9	340.17	228.37	239.55	5.62	481.56	32.63	0.000	12.94	.25
323.6	347.47	234.53	243.48	5.60	487.07	32.36	0.000	13.04	.25
332.4	354.77	240.70	247.37	5.59	492.51	32.07	0.000	13.15	.24
341.3	362.07	246.90	251.23	5.60	497.89	31.75	0.000	13.28	.24
350.2	369.37	253.12	255.06	5.58	503.20	31.51	0.000	13.36	.23
359.1	376.68	259.36	258.86	5.58	508.46	31.23	0.000	13.47	.23
363.6	380.33	262.48	260.74	5.57	511.07	31.10	0.000	13.52	.22
368.1	383.98	265.61	262.63	5.57.	513.66	30.96	0.000	13.58	.22
372.6	387.63	268.74	264.50	5.57	516.24	30.83	0.000	13.64	.22
377.1	391.28	271.88	266.37	5.57	518.80	30.70	0.000	13.69	.22
381.6	394.93	275.02	268.23	5.57	521.35	30.57	0.000	13.74	.21
386.1	398.58	278.17	270.08	5.56	523.89	30.44	0.000	13.80	.21
390.6	402.23	281.32	271.93	5.56	526.41	30.31	0.000	13.85	.21
399.7	409.54	287.63	275.60	5.56	531.42	30.04	0.000	13.97	.20
408.9	416.84	293.95	279.25	5.56	536.38	29.80	0.000	14.07	.20
418.1	424.14	300.30	282.86	5.55	541.29	29.58	0.000	14.16	.19
427.3	431.44	306.66	286.45	5.55	546.15	29.33	0.000	14.27	.19
436.5	438.74	313.03	290.02	5.55	550.96	29.10	0.000	14.38	.19
445.8	446.05	319.42	293.55	5.54	555.73	28.88	0.000	14.47	.18
455.1	453.35	325.82	297.07	5.55	560.46	28.64	0.000	14.58	.18
464.4	460.65	332.23	300.56	5.55	565.14	28.40	0.000	14.70	.17
473.8	467.95	338.66	304.02	5.54	569.79	28.21	0.000	14.78	.17
483.2	475.25	345.11	307.46	5.54	574.39	27.98	0.000	14.90	.17
492.7	482.56	351.56	310.87	5.55	578.95	27.75	0.000	15.01	.16
502.1	489.86	358.03	314.26	5.54	583.48	27.57	0.000	15.09	.16
511.6	497.16	364.51	317.63	5.55	587.96	27.35	0.000	15.20	.15
521.2	504.46	371.00	320.97	5.55	592.41	27.13	0.000	15.32	.15
530.8	511.76	377.50	324.29	5.54	596.83	26.95	0.000	15.40	.15
540.4	519.07	384.02	327.59	5.55	601.21	26.74	0.000	15.51	.14
550.0	526.37	390.55	330.86	5.56	605.55	26.53	0.000	15.63	.14
559.6	533.67	397.08	334.11	5.55	609.86	26.36	0.000	15.71	.14
569.3	540.97	403.63	337.34	5.56	614.14	26.16	0.000	15.82	.13
579.0	548.28	410.19	340.55	5.57	618.39	25.96	0.000	15.94	.13
588.8	555.58	416.76	343.74	5.56	622.61	25.79	0.000	16.02	.13
598.6	562.88	423.34	346.90	5.57	626.80	25.60	0.000	16.13	.12
608.4	570.18	429.93	350.05	5.58	630.95	25.40	0.000	16.25	.12
618.2	577.48	436.53	353.17	5.57	635.08	25.25	0.000	16.34	.12

CASE 32 - CURRENT = 0.69 FT/SEC

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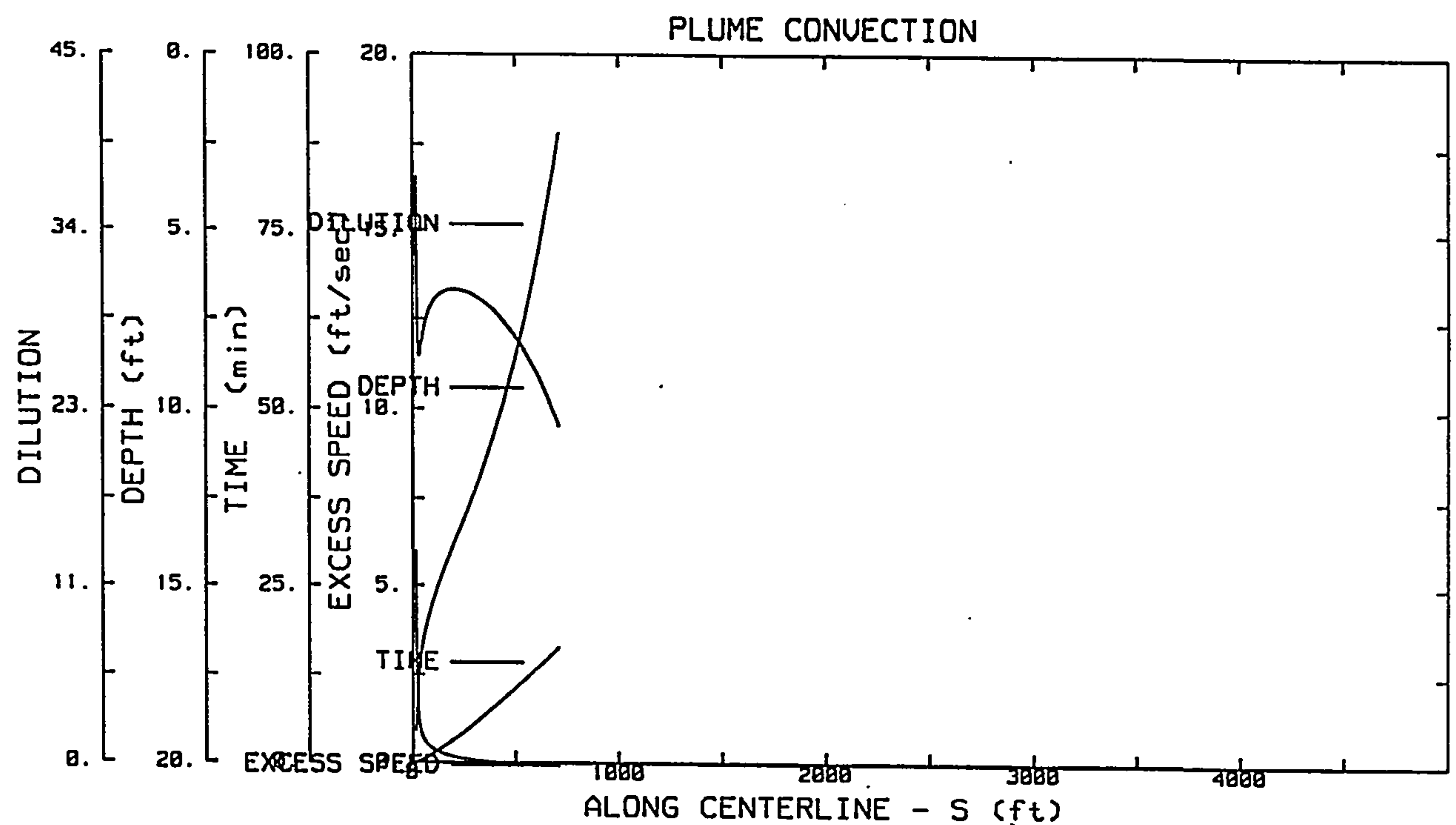
628.0	584.79	443.14	356.27	5.58	639.18	25.06	0.000	16.45	.11
637.9	592.09	449.76	359.36	5.59	643.25	24.87	0.000	16.56	.11
647.8	599.39	456.39	362.42	5.58	647.30	24.72	0.000	16.65	.11
657.8	606.69	463.03	365.46	5.59	651.32	24.54	0.000	16.76	.11
667.7	613.99	469.68	368.49	5.60	655.31	24.36	0.000	16.87	.10
677.7	621.30	476.33	371.49	5.60	659.27	24.21	0.000	16.97	.10
687.7	628.60	483.00	374.47	5.61	663.21	24.03	0.000	17.08	.10
697.8	635.90	489.67	377.44	5.62	667.13	23.86	0.000	17.19	.10
707.9	643.20	496.35	380.38	5.62	671.02	23.71	0.000	17.28	.09
717.9	650.50	503.04	383.31	5.63	674.89	23.55	0.000	17.40	.09
728.1	657.81	509.74	386.21	5.64	678.74	23.38	0.000	17.50	.09
738.2	665.11	516.45	389.10	5.64	682.56	23.23	0.000	17.60	.09
748.4	672.41	523.16	391.97	5.65	686.36	23.07	0.000	17.72	.08
768.8	687.01	536.61	397.66	5.66	693.90	22.78	0.000	17.92	.08
789.3	701.62	550.09	403.28	5.68	701.35	22.46	0.000	18.15	.07
799.5	708.92	556.84	406.06	5.69	705.04	22.31	0.000	18.26	.07
809.9	716.22	563.60	408.83	5.70	708.72	22.16	0.000	18.37	.07
820.2	723.52	570.37	411.57	5.70	712.37	22.03	0.000	18.47	.07
830.5	730.83	577.14	414.30	5.71	716.01	21.89	0.000	18.58	.06
840.9	738.13	583.92	417.02	5.72	719.63	21.74	0.000	18.69	.06
851.3	745.43	590.71	419.71	5.73	723.23	21.60	0.000	18.80	.06
861.7	752.73	597.50	422.39	5.74	726.81	21.46	0.000	18.91	.06
872.2	760.04	604.30	425.06	5.75	730.37	21.32	0.000	19.02	.06
882.6	767.34	611.10	427.70	5.76	733.91	21.18	0.000	19.14	.05
893.1	774.64	617.91	430.33	5.77	737.44	21.05	0.000	19.25	.05
903.6	781.94	624.73	432.95	5.77	740.95	20.91	0.000	19.36	.05
914.2	789.24	631.56	435.55	5.78	744.44	20.78	0.000	19.47	.05
935.3	803.85	645.22	440.70	5.81	751.38	20.50	0.000	19.72	.04
956.5	818.45	658.91	445.78	5.83	758.25	20.24	0.000	19.94	.04
977.8	833.06	672.63	450.80	5.84	765.07	20.01	0.000	20.15	.04
999.1	847.66	686.36	455.77	5.87	771.82	19.75	0.000	20.40	.03
1020.6	862.26	700.12	460.68	5.90.	778.51	19.49	0.000	20.64	.03
1042.1	876.87	713.89	465.52	5.91	785.15	19.27	0.000	20.85	.03
1063.7	891.47	727.69	470.31	5.95	791.73	19.01	0.000	21.12	.02
1085.4	906.08	741.51	475.04	5.98	798.25	18.76	0.000	21.38	.02
1107.1	920.68	755.35	479.70	5.99	804.73	18.55	0.000	21.59	.02
1128.9	935.29	769.20	484.32	6.03	811.16	18.31	0.000	21.86	.01
1139.9	942.59	776.13	486.61	6.04	814.36	18.19	0.000	21.99	.01
1150.8	949.89	783.07	488.88	6.06	817.54	18.08	0.000	22.11	.01
1161.8	957.19	790.02	491.14	6.07	820.71	17.97	0.000	22.24	.01
1172.8	964.49	796.97	493.39	6.08	823.87	17.86	0.000	22.37	.01
1183.8	971.80	803.92	495.62	6.10	827.02	17.75	0.000	22.50	.01
1194.8	979.10	810.87	497.84	6.11	830.16	17.64	0.000	22.62	0.00
1205.9	986.40	817.84	500.05	6.13	833.29	17.53	0.000	22.76	0.00
1216.9	993.70	824.80	502.24	6.14	836.40	17.42	0.000	22.89	0.00
1239.1	1008.31	838.74	506.58	6.17	842.60	17.21	0.000	23.14	-0.00
1261.3	1022.91	852.70	510.88	6.21	848.76	16.99	0.000	23.42	-0.00
1283.6	1037.51	866.68	515.12	6.24	854.88	16.78	0.000	23.70	-.01
1306.0	1052.12	880.67	519.31	6.27	860.96	16.57	0.000	23.97	-.01
1328.5	1066.72	894.67	523.45	6.31	867.00	16.36	0.000	24.26	-.01
1351.0	1081.33	908.69	527.54	6.35	873.00	16.16	0.000	24.54	-.01
1373.5	1095.93	922.73	531.58	6.38	878.97	15.96	0.000	24.83	-.02
1396.2	1110.53	936.77	535.57	6.42	884.90	15.76	0.000	25.12	-.02
1441.6	1139.74	964.91	543.41	6.51	896.66	15.36	0.000	25.74	-.02
1453.0	1147.05	971.95	545.35	6.53	899.57	15.25	0.000	25.92	-.03
1464.5	1154.35	979.00	547.26	6.55	902.49	15.16	0.000	26.06	-.03
1475.9	1161.65	986.05	549.17	6.57	905.39	15.07	0.000	26.21	-.03
1487.3	1168.95	993.10	551.06	6.58	908.29	14.98	0.000	26.35	-.03
1498.8	1176.25	1000.16	552.94	6.60	911.18	14.89	0.000	26.50	-.03
1510.3	1183.56	1007.21	554.81	6.62	914.06	14.79	0.000	26.66	-.03
1521.8	1190.86	1014.28	556.67	6.64	916.93	14.70	0.000	26.82	-.03

CASE 32 - CURRENT = 0.69 FT/SEC

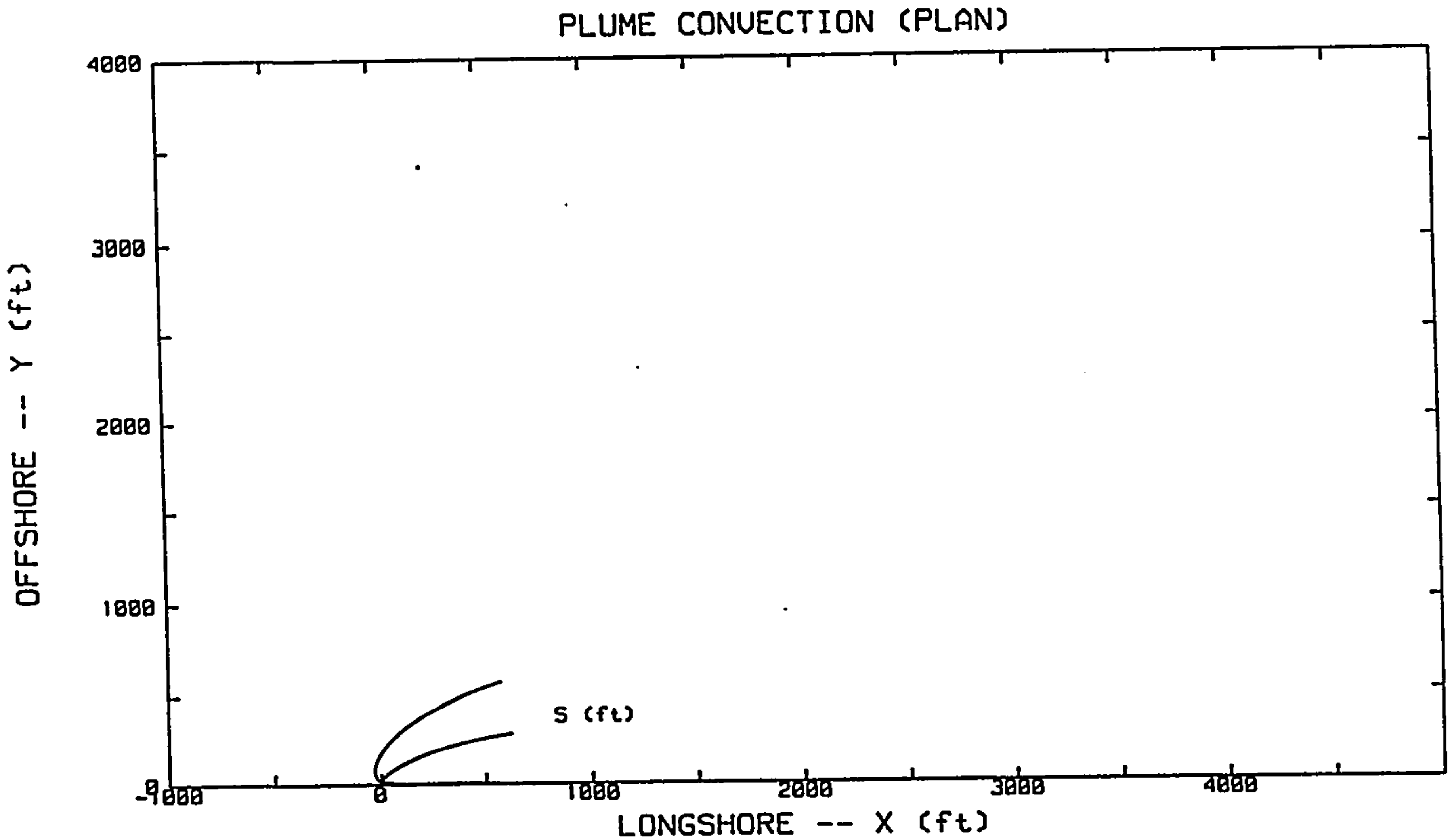
TIME (SEC)	S (FT)	X (FT)	Y (FT)	DEPTH (FT)	WIDTH (FT)	THETA (DEG)	SUS. SOLIDS (LBS/CF)	Q/QO (DILU)	EXCESS U (FT/SEC)
1533.3	1198.16	1021.34	558.52	6.67	919.80	14.61	0.000	26.98	-.03
1544.8	1205.46	1028.41	560.35	6.69	922.66	14.52	0.000	27.14	-.03
1556.3	1212.76	1035.48	562.18	6.71	925.51	14.42	0.000	27.31	-.04
1567.9	1220.07	1042.55	563.99	6.73	928.36	14.33	0.000	27.47	-.04
1591.0	1234.67	1056.71	567.58	6.78	934.03	14.15	0.000	27.81	-.04
1614.2	1249.27	1070.87	571.13	6.83	939.67	13.97	0.000	28.15	-.04
1637.5	1263.88	1085.05	574.63	6.87	945.29	13.79	0.000	28.49	-.04
1660.8	1278.48	1099.24	578.09	6.92	950.88	13.61	0.000	28.85	-.04
1684.1	1293.09	1113.44	581.51	6.97	956.45	13.44	0.000	29.21	-.05
1731.0	1322.30	1141.87	588.21	7.08	967.52	13.09	0.000	29.96	-.05
1778.1	1351.50	1170.34	594.74	7.19	978.49	12.75	0.000	30.72	-.05
1825.4	1380.71	1198.84	601.10	7.30	989.39	12.42	0.000	31.51	-.06
1872.9	1409.92	1227.39	607.30	7.43	1000.20	12.08	0.000	32.34	-.06
1920.6	1439.13	1255.96	613.34	7.55	1010.94	11.76	0.000	33.20	-.06
1968.4	1468.34	1284.58	619.21	7.68	1021.61	11.44	0.000	34.09	-.07
2016.5	1497.55	1313.22	624.93	7.82	1032.22	11.13	0.000	35.03	-.07
2064.7	1526.75	1341.89	630.48	7.97	1042.76	10.82	0.000	36.00	-.07
2113.1	1555.96	1370.60	635.89	8.12	1053.25	10.51	0.000	37.02	-.08
2161.7	1585.17	1399.33	641.14	8.28	1063.69	10.21	0.000	38.08	-.08
2210.5	1614.38	1428.09	646.25	8.45	1074.08	9.92	0.000	39.18	-.08
2259.3	1643.59	1456.87	651.21	8.62	1084.43	9.63	0.000	40.34	-.08

AREAS OF EXCESS TEMPERATURES FOR CEATECH NPDES/ZoM ANALYSIS
CASE 32 - CURRENT = 0.69 FT/SEC

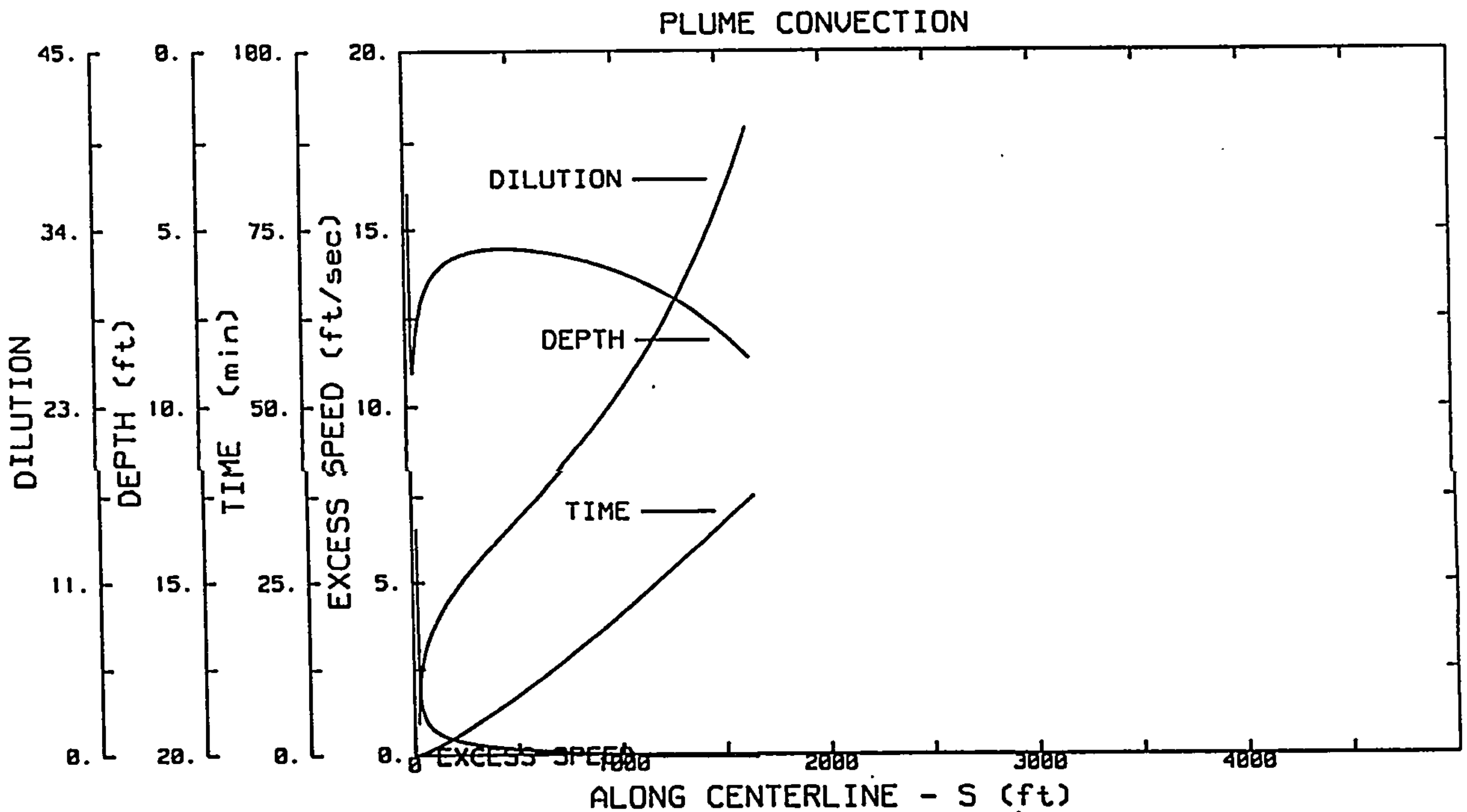
EXCESS TEMP. (DEG C)	AREA (SQ. FT)
.05	8.195E+05
.10	2.053E+05
.15	4.826E+04
.20	1.226E+04
.25	3.816E+03
.30	1.515E+03
.35	7.885E+02
.40	5.216E+02
.45	4.014E+02
.50	3.351E+02
.55	2.914E+02
.60	2.614E+02
.65	2.361E+02
.70	2.151E+02
.75	1.952E+02
.80	1.766E+02
.85	1.583E+02
.90	1.388E+02
.95	1.156E+02
1.00	6.468E+01



CASE 29 - CURRENT = 0.69 FT/SEC CEATECH NPDES/ZoM ANALYSIS

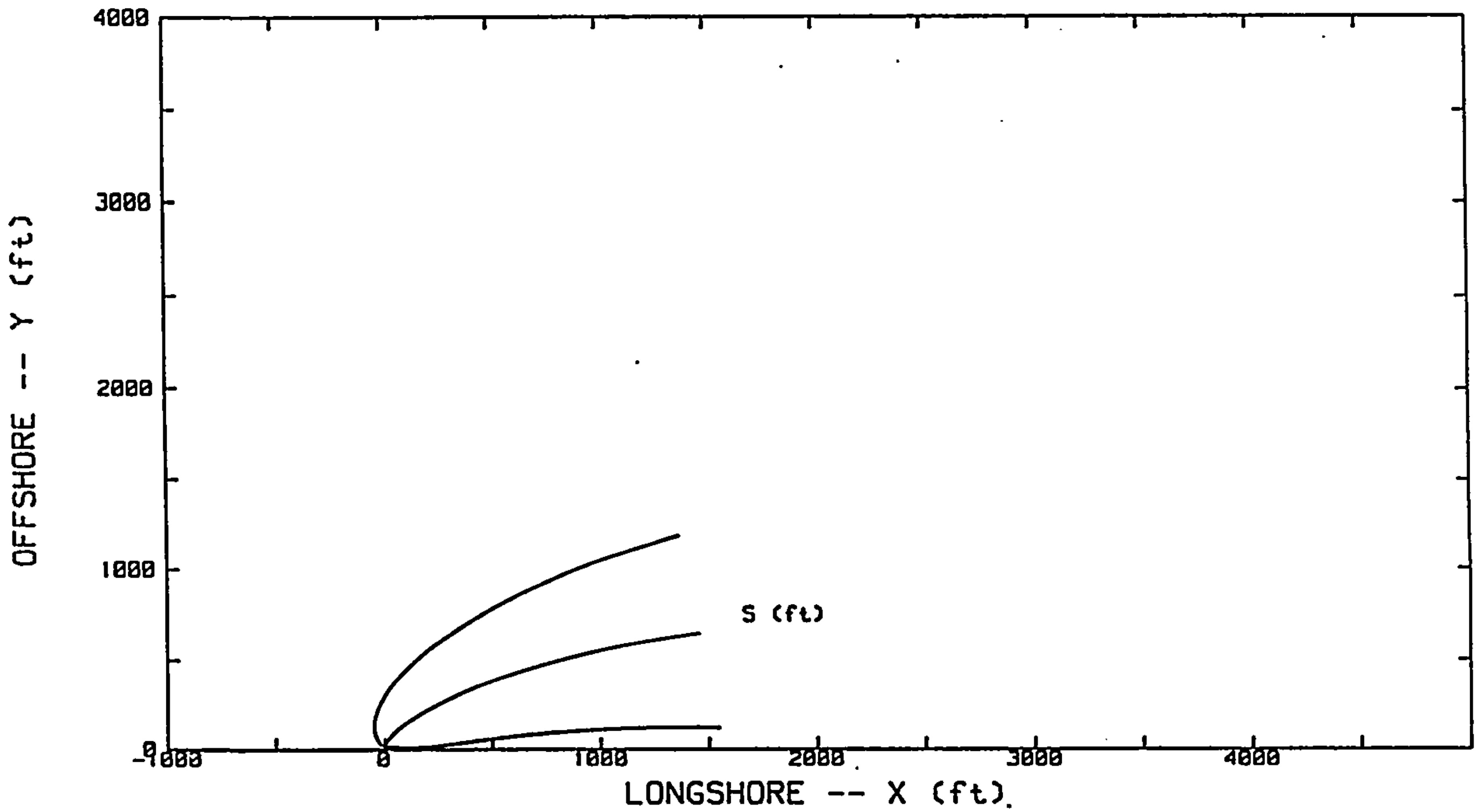


CASE 29 - CURRENT = 0.69 FT/SEC CEATECH NPDES/ZoM ANALYSIS



CASE 32 - CURRENT = 0.69 FT/SEC CEATECH NPDES/ZoM ANALYSIS

PLUME CONVECTION (PLAN)



CASE 32 - CURRENT = 0.69 FT/SEC CEATECH NPDES/ZoM ANALYSIS

APPENDIX B

PDS Model output for case where CEATECH's effluent is combined with Kekaha Sugar Company's maximum discharge

BUOYANT JETS -- CEATECH NPDES/ZOM ANALYSIS
CASE 29 - CURRENT = 0.69 FT/SEC

AMBIENT CONDITIONS: TEMP. TA = 25.5 DEG. C
VEL. UA = .69 FT/SEC
HEAT CONVECTION = .0000E+01
SALINITY = 34.80 PPT

DISCHARGE CONDITIONS : UNIT WEIGHT = 63.22 LBS/CU FT
VEL. UO = 6.22 FT/SEC
WIDTH WO = 6.50 FT.
DEPTH HO = 3.83 FT.
ANGLE = 90.0 DEG.
INIT. CONC. = 0.000 LBS SUS. SED./CU. FT. DISCHARGE

DISCHARGE DENSIMETRIC FROUDE NO. = 5.57

ENTRAINMENT COEFFICIENT = .1500
RATIO OF VERTICAL TO HORIZONTAL TURBULENT DIFFUSION COEFFICIENT = .5000
DIMENSIONLESS HORIZONTAL EDDY DIFFUSION COEFFICIENT = .2000

TIME (SEC)	S (FT)	X (FT)	Y (FT)	DEPTH (FT)	WIDTH (FT)	THETA (DEG)	SUS. SOLIDS (LBS/CF)	Q/QO (DILU)	EXCESS U (FT/SEC)
2.7	16.47	1.98	16.35	3.44	18.62	83.09	0.000	2.00	6.00
2.7	16.51	1.99	16.39	3.51	18.79	82.91	0.000	2.03	5.90
2.7	16.56	1.99	16.44	3.58	18.95	82.73	0.000	2.06	5.81
2.7	16.61	2.00	16.49	3.65	19.12	82.55	0.000	2.09	5.72
2.7	16.66	2.00	16.54	3.72	19.29	82.38	0.000	2.11	5.63
2.7	16.71	2.01	16.59	3.79	19.46	82.21	0.000	2.14	5.54
2.7	16.76	2.02	16.64	3.85	19.63	82.03	0.000	?.17	5.46
2.7	16.86	2.03	16.73	3.98	19.98	81.70	0.000	2.22	5.31
2.8	16.95	2.05	16.83	4.11	20.32	81.36	0.000	2.28	5.16
2.8	17.05	2.06	16.93	4.23	20.68	81.04	0.000	2.33	5.03
2.8	17.15	2.08	17.02	4.36	21.03	80.72	0.000	2.38	4.90
2.8	17.34	2.11	17.21	4.59	21.75	80.10	0.000	2.48	4.66
2.9	17.54	2.14	17.41	4.81	22.48	79.49	0.000	2.58	4.45
2.9	17.73	2.18	17.60	5.02	23.21	78.91	0.000	2.67	4.25
3.0	17.93	2.22	17.79	5.22	23.95	78.34	0.000	2.76	4.08
3.1	18.32	2.30	18.17	5.58	25.46	77.26	0.000	2.93	3.77
3.2	18.71	2.39	18.55	5.92	26.98	76.24	0.000	3.10	3.50
3.3	19.10	2.49	18.93	6.22	28.51	75.28	0.000	3.26	3.27
3.4	19.49	2.59	19.30	6.49	30.06	74.36	0.000	3.41	3.07
3.6	20.27	2.81	20.05	6.95	33.15	72.68	0.000	3.68	2.74
3.9	21.05.	3.05	20.79	7.33	36.25	71.17	0.000	3.93	2.47
4.2	21.83	3.31	21.53	7.63	39.32	69.80	0.000	4.16	2.26
4.5	22.61	3.59	22.25	7.86	42.36	68.56	0.000	4.37	2.08
4.9	23.38	3.88	22.98	8.05	45.36	67.43	0.000	4.56	1.93
5.6	24.94	4.51	24.41	8.32	51.21	65.43	0.000	4.90	1.70
6.5	26.50	5.18	25.81	8.46	56.84	63.72	0.000	5.20	1.52
7.3	28.06	5.88	27.20	8.53	62.25	62.23	0.000	5.46	1.38
8.3	29.62	6.63	28.57	8.54	67.43	60.91	0.000	5.69	1.28
9.3	31.18	7.40	29.93	8.53	72.40	59.72	0.000	5.91	1.19
10.3	32.74	8.20	31.27	8.49	77.16	58.64	0.000	6.10	1.12
11.4	34.30	9.02	32.59	8.45	81.73	57.65	0.000	6.28	1.06
13.6	37.42	10.73	35.20	8.34	90.37	55.88	0.000	6.61	.96
16.0	40.54	12.52	37.76	8.22	98.42	54.33	0.000	6.91	.88
18.5	43.65	14.37	40.27	8.10	105.97	52.95	0.000	7.17	.82
21.1	46.77	16.27	42.73	7.99	113.08	51.71	0.000	7.42	.76
23.7	49.89	18.23	45.16	7.89	119.82	50.57	0.000	7.65	.72
26.5	53.01	20.23	47.55	7.80	126.23	49.53	0.000	7.87	.68
29.2	56.13	22.28	49.91	7.71	132.35	48.56	0.000	8.07	.65
35.0	62.37	26.48	54.52	7.55	143.88	46.82	0.000	8.45	.59
41.0	68.60	30.81	59.00	7.43	154.57	45.27	0.000	8.80	.54
47.2	74.84	35.25	63.38	7.33	164.58	43.86	0.000	9.13	.50
53.5	81.08	39.80	67.65	7.23	174.02	42.61	0.000	9.43	.46

CASE 29 - CURRENT = 0.69 FT/SEC

TIME (SEC)	S (FT)	X (FT)	Y (FT)	DEPTH (FT)	WIDTH (FT)	THETA (DEG)	SUS. SOLIDS (LBS/CF)	Q/QO (DILU)	EXCESS U (FT/SEC)
60.0	87.31	44.43	71.83	7.16	182.97	41.45	0.000	9.73	.43
66.7	93.55	49.14	75.91	7.09	191.50	40.37	0.000	10.01	.40
73.5	99.79	53.93	79.91	7.02	199.66	39.40	0.000	10.27	.38
80.4	106.02	58.78	83.83	6.97	207.48	38.47	0.000	10.53	.36
87.4	112.26	63.69	87.67	6.92	215.01	37.60	0.000	10.78	.33
94.5	118.50	68.66	91.44	6.88	222.28	36.80	0.000	11.02	.32
101.8	124.73	73.68	95.14	6.84	229.30	36.02	0.000	11.26	.30
109.1	130.97	78.75	98.78	6.81	236.10	35.28	0.000	11.50	.28
116.5	137.21	83.86	102.35	6.78	242.71	34.59	0.000	11.72	.27
124.0	143.44	89.02	105.86	6.76	249.13	33.92	0.000	11.95	.25
131.6	149.68	94.21	109.31	6.74	255.37	33.29	0.000	12.17	.24
139.3	155.92	99.44	112.71	6.72	261.47	32.69	0.000	12.39	.23
147.0	162.15	104.71	116.05	6.71	267.41	32.10	0.000	12.61	.22
154.9	168.39	110.01	119.34	6.70	273.22	31.54	0.000	12.82	.21
170.7	180.87	120.70	125.76	6.68	284.45	30.48	0.000	13.25	.19
186.8	193.34	131.51	131.99	6.67	295.24	29.49	0.000	13.67	.17
203.2	205.81	142.41	138.04	6.67	305.63	28.56	0.000	14.09	.15
219.8	218.29	153.42	143.92	6.68	315.65	27.68	0.000	14.51	.13
236.6	230.76	164.50	149.64	6.69	325.35	26.86	0.000	14.92	.12
253.7	243.23	175.67	155.20	6.71	334.76	26.07	0.000	15.35	.11
288.3	268.18	198.22	165.87	6.75	352.80	24.64	0.000	16.17	.09
292.7	271.30	201.06	167.16	6.75	354.99	24.47	0.000	16.28	.08
297.1	274.42	203.90	168.45	6.76	357.16	24.29	0.000	16.39	.08
301.5	277.54	206.74	169.73	6.77	359.32	24.12	0.000	16.50	.08
305.9	280.66	209.59	171.00	6.78	361.47	23.95	0.000	16.61	.07
310.4	283.77	212.44	172.26	6.79	363.60	23.78	0.000	16.72	.07
314.8	286.89	215.30	173.51	6.80	365.72	23.61	0.000	16.83	.07
319.3	290.01	218.16	174.76	6.81	367.83	23.45	0.000	16.94	.07
323.7	293.13	221.02	175.99	6.82	369.93	23.29	0.000	17.05	.06
332.7	299.37	226.75	178.44	6.84	374.09	22.97	0.000	17.27	.06
341.7	305.60	232.50	180.86	6.86	378.20	22.65	0.000	17.49	.05
350.7	311.84	238.26	183.25	6.89	382.27	22.35	0.000	17.72	.05
359.8	318.08	244.04	185.61	6.91	386.29	22.05	0.000	17.94	.05
368.9	324.31	249.83	187.93	6.93	390.28	21.75	0.000	18.17	.04
387.3	336.79	261.43	192.50	6.99	398.13	21.17	0.000	18.63	.03
405.8	349.26	273.09	196.94	7.04	405.83	20.62	0.000	19.10	.03
424.4	361.73	284.78	201.28	7.10	413.40	20.08	0.000	19.58	.02
443.2	374.21	296.52	205.51	7.16	420.83	19.56	0.000	20.07	.01
462.1	386.68	308.29	209.63	7.23	428.14	19.05	0.000	20.57	.01
481.1	399.16	320.10	213.66	7.30	435.34	18.56	0.000	21.08	-0.00
500.2	411.63	331.94	217.58	7.37	442.43	18.08	0.000	21.60	-.01
538.8	436.58	355.72	225.13	7.53	456.32	17.17	0.000	22.68	-.02
577.9	461.52	379.61	232.31	7.71	469.84	16.30	0.000	23.84	-.03
617.3	486.47	403.60	239.14	7.90	483.04	15.47	0.000	25.06	-.04
657.2	511.42	427.69	245.62	8.11	495.95	14.68	0.000	26.35	-.04
697.3	536.37	451.87	251.78	8.34	508.61	13.92	0.000	27.73	-.05
737.8	561.31	476.12	257.63	8.59	521.04	13.20	0.000	29.18	-.06
778.5	586.26	500.44	263.18	8.85	533.26	12.51	0.000	30.73	-.06
819.6	611.21	524.83	268.44	9.14	545.29	11.85	0.000	32.39	-.07
860.8	636.16	549.27	273.43	9.44	557.16	11.22	0.000	34.15	-.07
902.3	661.10	573.77	278.15	9.77	568.88	10.62	0.000	36.03	-.08
943.9	686.05	598.31	282.63	10.11	580.46	10.05	0.000	38.04	-.08
985.7	711.00	622.90	286.86	10.48	591.93	9.50	0.000	40.17	-.08

CEATECH'S NPDES/ZoM ANALYSIS FOR BUOYANT JETS USING PDS MODEL
DATE: OCTOBER 13, 1997
INPUT DATA FOR THE PDS MODEL

THE FOLLOWING ARE CONSTANT VALUES FOR ALL RUNS	
1. DISCHARGE CHANNEL WIDTH, Wo (ft)	6.5 ft
2. DISCHARGE ANGLE RELATIVE TO CURRENT/NEARSHORE	90 deg
3. SURFACE HEAT TRANSFER FACTOR:	0
4. DISTANCE DOWNSTREAM TO STOP COMPUTATIONS	Use Default
5. OPTION FLAG:	0
6. SSCON: Suspended Solids Concentration (lbs/cu ft)	0
VARIABLES	
1. WATER DEPTH IN DISCHARGE CHANNEL	5.25 ft
2. AVERAGE VELOCITY IN DISCHARGE CHANNEL	6.81 ft/sec
3. AVERAGE AMBIENT VELOCITY: Run These Cases	
a. No Current	0 ft/sec
b. Maximum Current, 21 cm/sec based on Wrytki et al.	0.69 ft/sec
c. 1/2 Maximum Current, 10.5 cm/sec	0.35 ft/sec
4. SPECIFIC WEIGHT OF DISCHARGE:	62.97 lbs/cu ft
5. AVERAGE AMBIENT TEMPERATURE:	
Based on Kahe Point data, with the low Winter temp = 24 deg and the high Summer temp = 27 deg, Assume Ave. Temp =	25.5 dec C
6. SALINITY OF RECEIVING WATER:	
Based on NPDES monitoring data	34.8 ppt
ENTRAINMENT COEFFICIENT, E =	0.15
RATIO OF VERTICAL TO HORIZONTAL TURB. DIFF. COEF., Ev =	0.5
DIMENSIONLESS HORIZONTAL EDDY DIFF. COEFFICIENT, Eh =	0.2

THIS CASE IS FOR 155 mgd (100 Kekaha & 55 Ceatech)

AREAS OF EXCESS TEMPERATURES FOR CEATECH NPDES/ZoM ANALYSIS
CASE 29 - CURRENT = 0.69 FT/SEC

EXCESS TEMP. (DEG C)	AREA (SQ. FT)
.05	1.924E+05
.10	5.203E+04
.15	1.398E+04
.20	4.053E+03
.25	1.496E+03
.30	7.399E+02
.35	4.619E+02
.40	3.440E+02
.45	2.793E+02
.50	2.401E+02
.55	2.113E+02
.60	1.908E+02
.65	1.730E+02
.70	1.583E+02
.75	1.443E+02
.80	1.315E+02
.85	1.186E+02
.90	1.048E+02
.95	8.874E+01
1.00	5.351E+01

Appendix 6

Recycling Letters

KAUAI BANANA COMPANY

Post Office Box 948, Lawai Kauai, Hawaii 96765

October 12, 1997

Paul Bienfang, PhD.
Senior Vice President
Environmental Compliance & Technology
CEATECH USA, Inc.
7 Waterfront Plaza, Suite 400
500 Ala Moana Boulevard
Honolulu, Hawaii 96813

Subject: Recycling of Waste Products for Farming Applications

To confirm our discussion, the Kauai Banana Corporation is willing to be a recipient of the nitrogen rich waste material that is collected from the production ponds. We believe that this slurry can be safely applied to the banana plants with the expectation of reduced chemical requirements for fertilizers and herbicides. Please notify us of your decision to offer this product on a commercial basis. I can be reached at (808) 823-8773.

Sincerely,

Glenn Taba
President

KAUAI HEDGE & GROUND COVERS
"Hedge & Ground Cover Specialist"

P.O. Box 1221
Kalaheo, HI 96741

Telephone
(808) 332-9493

October 10, 1997

Mr. Paul Bienfang Phd.
Ceatach USA Inc.
7 Waterfront Plaza
Suite #400
500 Ala Moana Blvd.
Honolulu, Hi., 96813

Aloha Mr. Bienfang,

I have met with your representative on island regarding his thoughts on recycling the waste water from your shrimp ponds and using it for fertilizer.

I am very interested in experimenting the use of the combination of algae and pond sediments as an organic nitrogen fertilizer on my landscape projects.

Please feel free to call me at (808) 332-9493 regarding any questions.

Mahalo nui loa,

Lawrence Tachibana

October 20, 1997

Dr. Paul Bienfang
CEATECH USA, Inc.
7 Waterfront Plaza, Suite 400
500 Ala Moana Blvd.
Honolulu, HI 96813

Dear Dr. Bienfang,

I have heard of the shrimp aquaculture project by CEATECH USA, Inc. I am extremely interested in the chance to use the solid waste material that your company may be generating. I figure for one of my papaya farms alone that I could use about one dump truck per week(10 cubic yards)

I am familiar with the nemicidal properties of the shrimp shells. A partner of mine has been collecting these shells for years & believes that he gets less nematodes because of it. As I want to grow organic papayas, I feel that these shells can be an important micronutrient for my orchard.

Ideally the shells would be dried down as this would eliminate some of the odor & lessen the hauling weight to Koloa. I have also been trying to develop a compost recycling operation in the Koloa area.

I would like to have discussions of this recycled material as well as stock buying potential in the near future.

Sincerely,

Jon Schlegel

Jon Schlegel
Soil Conservationist & Papaya farmer

Appendix 7

Annual Marine Testing

AUG 26 1997

ZONE OF MIXING BIOLOGICAL MONITORING FOR OCEAN DISCHARGES FROM THE KEKAHA SUGAR COMPANY, KEKAHA, KAUAI, HAWAII

(NPDES Permit HI0000086)

Prepared for

Kekaha Sugar Company, Ltd.
P.O. Box 549
Kekaha, Kauai, Hawaii 96752

Prepared by

Marine Research Consultants
4467 Sierra Dr.
Honolulu, HI 96816

August 1997

INTRODUCTION

The Kekaha Sugar Company operates permitted discharges into the Pacific Ocean at three points along the southwest coast of Kauai between the northern boundary of Polihale State Park and Oomano Point on the south (Figures 1-3). Moving from south to north, one discharge point is the Kekaha Sugar Mill Ditch, which discharged thermal effluent from the mill for many years, but is not presently in use (Figure 1). Discharges of water pumped from sugarcane fields are located off of the Kawaiele Pumping Station (Figure 2) and near Nohili Point (Figure 3). Water pumped into the drainage discharges has a salinity of approximately 10‰ (Nance, personal communication) indicating that is approximately 1/3 seawater and 2/3 freshwater from groundwater and sugarcane irrigant leachate.

In compliance with the provisions of the Clean Water Act, Chapter 342D, Hawaii Revised Statutes, and the Administrative Rules of the Department of Health, the Kekaha Sugar Company was issued a National Pollutant Discharge Elimination System (NPDES), and Zones of Mixing (ZOM) Permit (No. HI 0000086) on May 24, 1990 to discharge sugar cane effluent from three points along the shoreline. The permit establishes three ZOM's which are defined as arcs with the center points specified as the points of discharge at the shoreline. The ZOM's extend vertically from the surface of the ocean to the sea floor. The radii of the arcs of the Nohili and Kawaiele ZOM's are 6,000 feet in length (Figures 2 and 3), while at the Kekaha Mill Ditch discharge, the radius of the arc defining the ZOM is 350 feet in length (Figure 1). Within the boundaries of the ZOM's, State of Hawaii water quality standards may be exceeded in the receiving waters; beyond the boundaries, water quality standards (including impacts to indigenous populations) cannot be exceeded.

Conditions of the Kekaha Sugar Mill NPDES/ZOM permit specify certain monitoring criteria to ensure maintenance of water quality and indigenous populations of marine organisms. With respect to monitoring of biological populations, compliance with permit conditions is assessed by comparing results of quantitative community analyses within and outside of the ZOM's conducted once during an annual cycle. The purpose of this report is to present the results of biological communities monitoring program conducted in April 1997 to assess the effects of the Kekaha Sugar Company discharges on marine communities.

To comply with conditions of the permit, surveys of the coral reef community structure (benthos and fish) were conducted at ten survey sites in April 1997. The locations of the survey sites were replicated as closely as possible to those surveyed in the previous three benthic monitoring surveys conducted in 1992 (AECOS 1993), 1994, 1995 and 1996 (Marine Research Consultants 1994, 1995, 1996). Presented below are the methods, results and conclusions of the monitoring survey at the Kekaha Sugar Mill discharge sites.

METHODS

Biotic structure of the marine environment in the vicinity of the Kekaha Sugar Mill discharges was evaluated by establishing a descriptive and quantitative baseline of benthic reef communities. Key components of reef communities include hermatypic and soft corals, benthic algae, motile macroinvertebrates, and reef fish.

The monitoring surveys were conducted on April 20 and 21, 1997. All fieldwork was carried out by divers using SCUBA equipment, working out of a 26-foot boat. Biotic structure of communities inhabiting the reef environment was evaluated on the transects that were established for the 1992 monitoring program (AECOS 1993). Listed below are the locations and water depth (in parentheses) of each transect at the three discharges:

Mill Ditch Outfall (001)

Transect 1 - (7 feet); outside the ZOM, approximately 700 feet south of the outfall and approximately 175 feet from the shoreline (southern control).

Transect 2 - (8 feet); directly seaward of the outfall, approximately midway between the shoreline and the seaward edge of the ZOM boundary (175 feet from the shoreline).

Transect 3 - (7 feet); outside the ZOM, approximately 700 feet north of the outfall and approximately 175 feet from the shoreline.

Kawaiele Outfall (002)

Transect 4 - (42 feet); outside the ZOM, approximately 9,000 feet south of the Kawaiele discharge, approximately 200 feet from the shoreline.

Transect 5 - (22 feet); within the southern portion of the ZOM, approximately one-half the distance from the outfall and the southern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 6 - (17 feet); within the northern portion of the ZOM, approximately one-half the distance from the outfall and the northern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 7 - (23 feet); outside the ZOM, approximately 7,500 feet north of the Kawaiele discharge, approximately 200 feet from the shoreline (northern control).

Nohili Outfall (003)

Transect 8 - (23 feet); outside of the ZOM, approximately midway between the boundaries of the Nohili and Kawaiele ZOM's, approximately 200 feet from the shoreline.

Transect 9 - (20 feet); within the southern portion of the ZOM approximately midway between the point of discharge and the southern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 10 - (24 feet); On the northern boundary of the ZOM, 6,000 from the point of discharge and approximately 200 feet from the shoreline. The location of this transect was changed from the 1992 survey when it was located 9,000 feet from the point of discharge. At this location, bottom composition consisted completely of scoured limestone owing to a completely different physical regime of wave stress than within the ZOM. As a result, transect 10 had been located in a totally different habitat than within the ZOM. In order to conduct the required analyses to evaluate effects from the discharges, it is essential that all transects are conducted in similar habitats. Thus, the location of transect 10 was moved to the approximate boundary of the ZOM, which was an area with similar physical stress as the rest of the survey area at Nohili.

Each transect was oriented parallel to depth contours so as to bisect a single reef zone. Care was taken to place transects in random locations that were not biased toward either peak or low coral cover. Quantitative benthic surveys were conducted by stretching a 50-meter long surveying tape in a straight line over the reef surface. An aluminum quadrat frame, with dimensions of 1 m by 0.66 m, was sequentially placed over 10 random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver knowledgeable in the taxonomy of resident species visually estimated the percent cover and occurrence of organisms and substratum type within the quadrat frame. No attempt was made to disturb substrata to observe organisms, and no attempt was made to identify and enumerate cryptic species dwelling within the reef framework. Only macrofaunal species greater than approximately 2 centimeters were noted.

Following the period of fieldwork, quadrat photographs were projected onto a grid divided into 100 equal units, and units of bottom cover for each benthic faunal species and bottom type were recorded to the nearest 1 percent. Results of the photo-quadrats were combined with the in-situ cover estimates and community structure parameters (percent cover, number of species, species diversity) were calculated. The photo-quadrat transect method is a modification of the technique described in Kinzie and Snider (1978), and has been employed in numerous field studies of Hawaiian reef communities (e.g. Dollar 1979, Grigg and Maragos 1974). The method was selected for the Kekaha monitoring program because it has proven to be particularly useful for quantifying coverage of attached benthos such as corals and large epifauna (e.g., sea urchins, sea cucumbers) that are the major components of the communities in the study area. In addition, the method provides a permanent photographic record which can be useful for comparative purposes in long-term investigations. While this methodology is quantitative for the larger exposed fauna, many coral reef invertebrates are cryptic or nocturnal. Coupled with the generally small size of cryptic invertebrates, quantitative assessment of these groups requires methodologies that are beyond the scope of the present monitoring program.

The transecting method used during the 1992 benthic monitoring survey (AECOS 1993) was somewhat different than that described above (1994-1997 surveys). In the 1992 survey, a 25 m transect line was laid across the bottom with 1 m^2 quadrats placed every 5 m. Thus, a total area of 5 m^2 was evaluated, compared to the 6.6 m^2 surveyed in the past four studies. In addition, the random location of the 10 quadrats along the transect line provides for a more representative characterization of the habitat than the 5 uniformly placed quadrats along a 25 m line. The survey technique employed in the 1992 survey utilized a point intercept method for 100 intersections within each quadrat. By utilizing only point intercepts, the probability of missing rare or small colonies is greater than the method used in the present study which accounts for the entire area (and all organisms present) within the quadrat frame. In addition, the photo-quadrat method employed for in the 1994-1997 surveys provides a permanent record of the surveyed benthos which was not provided by the point intercept method used in 1992. Thus, while the methods used in the two surveys are not identical, it appears that the techniques employed in the present program provide a better characterization of the reef communities as they exist today. Both methods, however, were similar in that cryptic fauna or organisms smaller than 2 cm in length were not evaluated. As the purpose of the monitoring is to determine if there are effects to these communities from continuous discharge of water from sugarcane activities, it does not appear that the variation in methods creates a problem in interpretation. Rather, using the best methods for describing community attributes will provide the best estimates of effect to marine communities from activities on land.

Quantitative assessment of reef fish community structure was conducted in conjunction with the benthic surveys. As the transect tape was being laid along the bottom, all fish observed within a band approximately 2 meters wide along the transect path were identified by species name and enumerated. Care was taken to conduct the fish surveys so that the minimum disturbance was created by divers, ensuring the least possible dispersal of fish. Only readily visible individuals were included in the census. No attempt was made to seek out cryptic species or individuals sheltered within coral. This transect method is an adaptation of techniques described in Hobson (1974). The method employed in the 1992 survey was slightly different in that the investigator made two passes over a 25 m transect, noting large motile fishes on the first pass, and smaller individuals that tend to seek shelter in the reef framework on the second pass. In the present survey, both types of fishes were noted on one pass over the 50 m transect line.

RESULTS AND DISCUSSION

Physical Structure

The coastal area covered in this study extends from the Kekaha Sugar Mill to north of Nohili Point. Sandy beaches comprise most of the shoreline along the length of the study area; landward of the beaches lies the Mana Coastal Plain, which is a low flat area that is presently planted in sugarcane. Owing to the low elevation of the plain, groundwater and irrigation water must be continually pumped from areas of the plain planted in sugarcane.

Seaward of the beaches that bound the study area, the shoreline is predominantly a limestone bench which extends up to 25 m offshore. Seaward of the margin of the bench, the bottom slopes gradually downward with distance offshore. The underwater physiographic structure off the Kawaiele and Kekaha Mill sites is very similar. Both of these areas are characterized by flat calcium carbonate (limestone) platforms that appear to be the result of ancient biogenic accumulation of reefal material. These platforms are predominantly flat with little structural relief other than low depressions and channels that are filled with coarse white sand. The surface of the platform is pitted, probably as a result of the boring action of several species of sea urchins. A ubiquitous feature of the reef platforms is a veneer of sandy sediment that appears to be in state of continual resuspension as a result of wave surge. The predominant biotic assemblage on the reef platform is a low algal turf composed of various species of benthic marine algae. Living coral corals are generally sparsely distributed, and occur predominantly as flat encrustations on the flat bottom. At all of the Kekaha monitoring sites, there was very little indication of terrigenous sediment deposition on the reef surface.

While the flat platform typified physiography off the Mill and Kawaiele discharge, a different type of physical structure occurred at the survey site directly off of the Nohili discharge area, especially off the northern edge of the ZOM (transect 10). In this area, the bottom is cut by numerous deep grooves, ledges and caves in what appears to be ancient coral reef platform. Vertical relief of the reef structures is generally from 1-3 m, resulting in a substantially more complex substratum than at the other two sites. Because the vertical relief afforded by the reef structures provides solid surfaces above the bottom (and shifting sediment), settlement of benthos, particularly reef corals is substantially higher than on the flat reef platforms described above.

All of the study sites are directly exposed to long-period swells generated by storms in both the north (winter) and south (summer) Pacific. In addition, the south and western coastal areas of Kauai were impacted by extremely large surf during Hurricanes Iwa (1982) and Iniki (1992). As a result of these physical processes, the nearshore areas at the monitoring sites are subjected to extreme stress from wave impact and scouring of sediment from wave action. As in many locations in the Hawaiian Islands, the composition of coral reef communities is structured primarily in response to physical forces of breaking waves (Dollar 1982, Dollar and Tribble 1993). Such is definitely the case off the Kekaha Mill monitoring sites.

Biotic Community Structure

Coral Community Structure

Appendices A, B, and C show results of the individual quadrat surveys on each transect at the Kekaha Mill, Kawaiele, and Nohili sites, respectively. Table 1 shows the quantitative summary of coral community structure from each of the 10 transects. Six species of coral were encountered on transects in 1997 (eight in 1994, seven in 1995, nine in 1996). The most species encountered on a single transect was five, which occurred on transects 7 and 9 Four species occurred on transects 2, 8 and 10; three species occurred on transects 1, 3, 4 and 6. No corals were encountered on transect 5.

Mean coral cover on transects ranged from 0% (transect 5) to 39.0% (transect 10). Pooling all transects, mean total coral cover was 15.2% of bottom cover (10% in 1995, 9.3% in 1996). The most abundant coral species on transects were *Porites lobata*, which accounted for 60% of coral cover, and 9.2% of bottom cover, and *Pocillopora meandrina*, which accounted for 15% of coral cover, and 2.3% of bottom cover. *Montipora patula* accounted for 14% of coral cover. Thus, three species comprised 90% of coral cover. In the previous surveys conducted in 1994-1996, total coral cover was consistently lower than in 1997, with total coral cover 9-10% of bottom cover. However, the three dominant species consistently comprised about 90% of coral cover.

Examination of the quantitative results in Table 1 indicate several major trends. It can be seen that percent coral cover is substantially higher at the Nohili discharge site transects than at either the Mill discharge or the Kawaiele discharge sites. As described in the section above, the physical structure of the Nohili area appears to be a more favorable habitat for reef coral growth than the flat platforms that characterize the other two sites. Coral growth on the flat reef platforms may be limited by shifting marine sands that inhibit planular settlement and abrade coral tissue. Owing to elevation off the bottom, the vertical faces and elevated top of the reef structures at Nohili are not exposed to such stress from shifting marine sands.

Examination of the survey results indicates that there does not appear to be any pattern of coral community structure that are functions of distance from the sugarcane water discharges. At the Kawaiele site, the highest coral cover occurred at transect 6, within the ZOM, while there was zero coral cover on one of the control transects for the same discharge (transect 5). Coral cover on the three transects within the ZOM of the Nohili discharge (transects 8-10) differed by only about 7% (32-39%), suggesting little effect from the outfall.

Such results are not unexpected, as there does not appear to be any forcing factors (terrigenous sediments) or changes in water chemistry that appears to extend to the distance offshore where the transects were located (see results of ZOM water quality monitoring). Rather, it appears that the distribution of coral communities is strictly a function of natural factors, primarily wave forces and substratum complexity. Similar studies of water quality in the vicinity of a cooling water effluent discharge at Port Allen, located to the southeast of the Kekaha Mill site have produced similar results as the Kekaha studies. At Port Allen, freshwater effluent is restricted to a surface layer that does not extend to the ocean floor. Thus, even if there were constituents of the discharge plume that were potentially damaging, the benthos (bottom dwellers) would rarely be exposed to these plume constituents.

Comparing the results of the 1992, 1994, 1995, 1996 and 1997 monitoring surveys may indicate if there has been an ongoing degradation of the reef community as a result of the Kekaha discharges. Table 2 shows the quantitative results of mean percent coral cover and number of coral species on transects from the four surveys, as well as the differences in cover between survey pairs. Comparing 1992 survey results with subsequent survey data, it can be seen in Table 2 that on all transects except No's 4 and 5, where coral cover was essentially zero during all surveys, greater mean coral cover occurred in the 1994-1997 surveys. The greatest difference occurred at Transect 10, which was relocated in 1994 from an area entirely composed entirely of a completely scoured bottom to a area of reef structure. However, all of the other survey sites were in approximately the same locations for the four surveys. While part of these changes in cover may be an artifact of the method used in 1994-1997 which provided higher areas of coverage than the point intercept method used in 1992, it appears that there has been no decrease in coral cover (and perhaps an increase) in the intervals between survey pairs.

Comparing changes in number of species between the 1992 and 1994-1996 surveys indicates that on at least half the transects more coral species were encountered in 1994-1997 than in 1992 for any survey pair. Again, such a result does not indicate any negative factors associated with discharge from the Kekaha Sugar Company that may have affected coral occurrence.

Comparing coral cover data from sequential surveys from 1994 to 1997 (when identical survey methods were employed) revealed increases in coral cover on seven of the ten transects between 1994-95. Similarly coral cover increased on six transects between 1995-96 and eight transects between 1996-97. Number of species on the transects increased or remained the same on eight of the ten transects in 1995 relative to 1994. Number of species increased or remained the same on nine transects between 1995 and 1996, and on seven transects between 1996 and 1997.

Applying the non-parametric Wilcoxon signed rank test to the data indicate that there are no significant ($p=0.05$) differences in transect coral cover between either the 1994-1996, 1995-1996 or 1996-1997 surveys. In sum, survey results indicate that there is no decrease in coral cover as a function of time for the ten transect data set.

In terms of number of species of coral on transects, there is either no change or an increase on all ten transects in 1996 compared to 1994, and on nine transects in 1996 compared to 1994. Wilcoxon signed rank tests indicate a significant ($p=0.05$) increase in number of coral species between 1996 and 1994, as well as between 1996 and 1995, but no significant increase between 1996-1997. Such increases or no change in number of coral species suggests that there is not a cumulative negative effect to coral community structure as a result of Sugar Mill discharge.

Other Benthic Invertebrates

The only benthic invertebrates that were observed in any frequency in the study areas were unidentified green and black sponges. Conspicuous by there absence were sea urchins, which are generally common in nearshore areas throughout the Hawaiian Islands. No urchins were encountered in any of the transects during the 1994-97 surveys. Several individuals of the urchin *Echinometra matheai* were observed in the area of transect 10; none were observed throughout the regions where the bottom consisted of a flat carbonate platform. As the 1992 monitoring report makes no mention of sea urchins or other motile benthos, it appears that the lack of benthic invertebrates has been a typical characteristic of the area over at least the last five years.

Benthic Algae

Benthic algae were common throughout the study area, particularly on the reef platforms that were essentially devoid of coral cover. The continual scouring action of sand appears to be a limiting factor for coral growth on the reef platforms, but not for many species of algae. Virtually all of the limestone reef platforms throughout the study area were covered with a short filamentous algal/diatom turf that is effective in binding sediment. In contrast to coral cover, which is amenable to quantification by assessing areal coverage, most of the algae encountered on transects was as isolated plants with little horizontal coverage of the bottom. As a result, algae abundance on transects was assessed semi-quantitatively by estimating the number of plants per transect. Table 3 shows abundance classes of algal species at each transect location. By far the most abundant algae were the red calcareous algae which were abundant on all transects.

A major difference in the results of the present survey with the 1992 survey was the lack of *Sargassum echinocarpum* during 1994-1997. In 1992, it was reported that large areas of the bottom were covered with continuous mats of *S. echinocarpum*; during 1994-1997 only several plants of this species were observed throughout the entire study area. It is apparent that the growth of this species is seasonal, with blooms occurring in the summer months. There is no indication of any effect of algal abundance related to the discharges.

Reef Fish Community Structure

The results of reef fish transects for the monitoring surveys are presented in Table 4. In 1997 the total number of species observed on all transects was 34 (compared to 50 in 1994, 47 in 1995 and 44 in 1996). Species number ranged from 2-21 per transect (compared to 6-26 in 1994, 6-28 in 1995, 3-24 in 1996). Individual fish encountered on transects ranged from 3-87 (compared to 27-145 in 1994, 41-243 in 1995 and 15-134 in 1996) (see Table 4).

In the past surveys in 1994-1995, the number of species of fish, the number of individuals, and species diversity were higher off the Nohili discharge (transects 8-10) compared to the other two sites. In 1997, the highest number of fish species and individuals was at transect 10. During 1996, however, the highest numbers of individuals were measured at transects 6 and 7 off the Kawaiele discharge.

Reef fish community structure appears to be largely determined by the topography and composition of the benthos. The flat reef platform that typified transects 1-7 results in scarcity of habitat suitable for reef fishes, which is reflected in the relatively low numbers of species and individuals. On transects 1-7, fishes were generally concentrated in small depressions which afforded a very limited amount of shelter. However, in 1996 several large aggregations of two species (*Chromis vanderbilti* and *Acanthurus nigrofuscus*) on transects 6 and 7 resulted in peak counts in the flat reef platforms. Such aggregations were not observed in 1997, hence the lower counts on these transects. On transect 10, in an area of substantially greater vertical relief than any other study site, both the number of fish species and individuals has been consistently high compared to the other locations where the bottom was predominantly flat.

Several representative groups of reef fish were most numerous on the transects. Algal-feeding acanthurids were the most numerous single group of fishes observed. The brown surgeonfish (ma'i'i'i, *Acanthurus nigrofuscus*) was the most abundant surgeonfish; other well-represented species were the convict tang (manini, *A. triostegus*), the orangeband surgeonfish (na'ena'e, *A, olivaceus*), and the goldring surgeonfish (kole, *Ctenochaetus strigosus*).

Other families of reef fish that were well-represented included: wrasses, especially the saddleback wrasse (hinalea, *Thalassoma duperrey*); dameselfishes, especially the blackfin chromis (*Chromis vanderbilti*); and goatfishes, especially the manybar goatfish (moano, *Parupeneus multifasciatus*). Also typically encountered on the transects were numerous juvenile reef fish of several species and several triggerfish species.

Comparing results of fish transect surveys in 1992, 1994, 1995, 1996 and 1997 gives an indication if there has been a decline in reef fish abundance over time (see Table 5). Inspection of Table 5 reveals that with few exceptions there were more fish species and more individuals recorded in 1994-1997 than in 1992. The increase in number of species ranged from 2 to 24, while the increase in the number of individuals ranged from 9 to 229. Even with the consideration that the location of transect 10 was moved in 1994, it appears that there is no indication of reduced reef fish populations in the area that could be attributed to the Kekaha Sugar Company discharges between the 1992 survey and the subsequent surveys in 1994-1997.

Comparing results of the 1994 and 1996 surveys reveals that there were more species observed in 1996 on 3 of the 10 transects, and more individuals observed on 4 of the 10 transects. Wilcoxon signed rank tests indicate that there is no significant change ($p=0.05$) in number of fish or numbers of species of fish between the 1994 and 1996 surveys. Similarly, comparing 1995 and 1996 survey results indicates that there were more fish species in 1996 on 3 of the 10 transects, and more individuals on only 2 of the 10 transects. However, Wilcoxon signed rank tests indicated that there were no significant differences ($p=0.05$) in either number of species or numbers of fish between 1995 and 1996.

However, when fish populations are compared between the 1996 and 1997 surveys, it appears that in all cases there is either no change or a decrease in abundance of species and individuals. There were no obvious reasons for the consistent decrease, except for the lack of schooling fishes in the most recent survey. However, as the decreased in fish populations occurred on control transects as well as transects on the boundary of the ZOM, it does not appear that the decrease is a result of mill discharge.

All of these results suggests that there has been no negative effect to fish abundance as a result of discharges from Kekaha Sugar Company.

SUMMARY

- Biological community monitoring for the Kekaha Sugar Mill discharges NPDES/ZOM permit was carried out for the fifth time in April of 1997. Ten transect survey stations that were established in 1991 were revisited and assessed for biotic structure. Stations were located within and outside of the ZOM boundaries off the Kekaha Sugar Mill Discharge (transects 1-3), off the Kawaiele irrigation water discharge (transects 4-6), between the Kawaiele and Nohili ZOM's (transect 7), and off the Nohili irrigation water discharge (transects 8-10). All transect locations were positioned as closely as possible to the locations described in the 1992 monitoring survey with the exception of transect 10, which was moved to the northern boundary of the ZOM.

- Physical structure of the nearshore region consists predominantly of sand beaches and nearshore reef platforms in the intertidal area. The predominant physical character of the nearshore reef throughout the Kekaha area consists of a flat limestone platform that is devoid of most physical relief except for low depressions and channels filled with sand. A layer of marine sediment covers the limestone platform and is constantly in motion owing to current and wave energy. The one exception to this physiography is transect 10, where bottom composition consisted of undercut ledges, grooves and channels cut from an ancient coral reef with vertical relief of 1-3 m.

- On the reef platforms, coral cover is relatively low owing to the abrasive quality of the shifting sand substratum. Mean coral cover on the ten transects in 1997 ranged from zero to 39%, with the highest cover on transects 8, 9 and 10, where relief was highest. There was no apparent difference in coral community structure as a function of location within, or outside of the ZOM. Comparison of coral cover between the 1992, 1994, 1995, 1996 and 1997 surveys suggests that there has been no decrease in coral abundance or number of coral species with time. It can therefore be implied that there is no effect to coral community structure from Sugar Mill discharge.

- A variety of marine algae are common on the reef platform that appear to be able to withstand continual abrasion from shifting sand. The widespread beds of *Sargassum echinocarpum* that were noted in the 1992 survey were not present in

1994-1997, probably because the algal blooms on a seasonal cycle. There was no indication of any effect on algal communities from sugarcane discharge.

- Reef fish community structure off the Kekaha survey sites appears to be a function of habitat complexity. Number of species and number of individuals have been substantially higher at the Nohili discharge site owing to the shelter afforded by the three dimensional aspects of the reef. Comparisons of estimates of fish abundance between 1992 and 1994-1997 indicate substantially higher numbers of individuals and species since 1992. During the 1996 survey, number of individuals of fish was also high at transects off the Kawaiele discharge as a result of large aggregations of two species. Fish abundance during the 1997 survey was reduced on all transects compared to 1996. Because the reductions occurred on all transects, regardless of the location relative to the sugar mill drainages, it does not appear that the reductions could be a result of discharges.

- None of the data obtained in the monitoring surveys indicates any impacts from the Kekaha Sugar Company discharges to marine communities on the reefs adjacent to the discharge. Such a result is not unexpected as the discharge plumes are observed to mix rapidly with ocean water to background concentrations by natural turbulent conditions. Rather, marine communities appear to be primarily controlled by natural physical factors associated with wave energy, sediment scour and substrate complexity.

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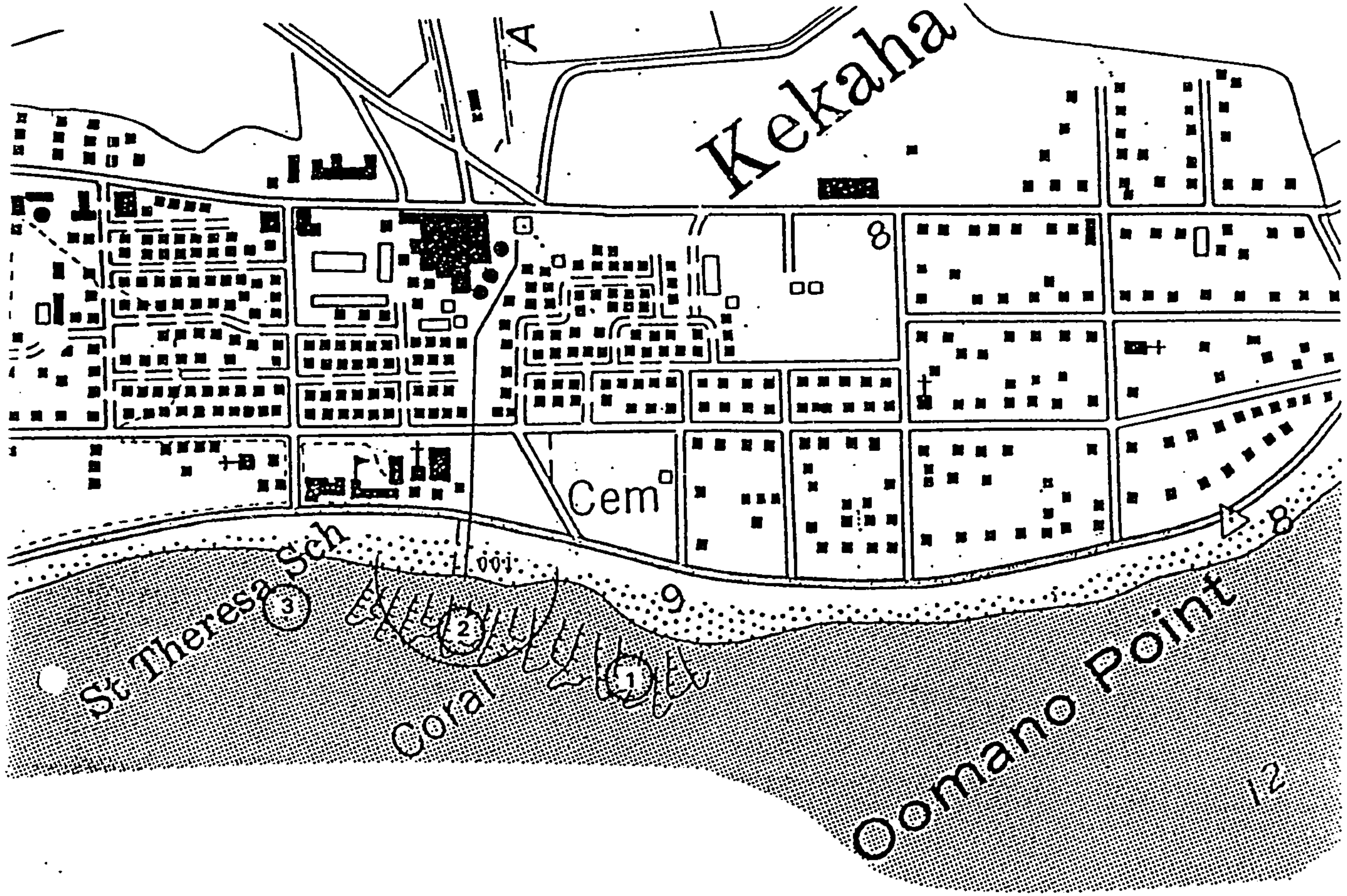

FIGURE 1. Zone of Mixing and location of benthic monitoring stations in the vicinity of the Kekaha Sugar Mill discharge.

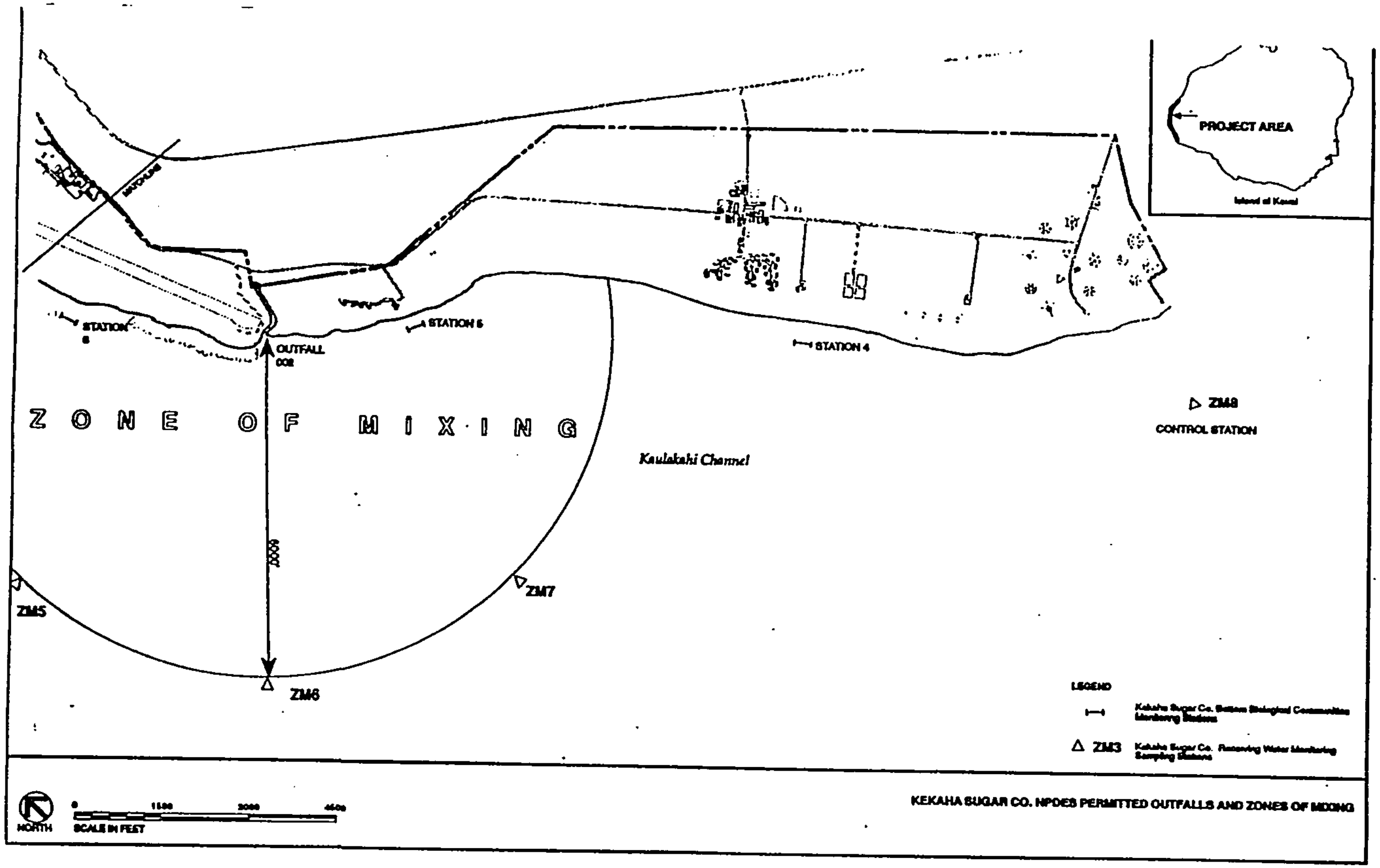

FIGURE 2. Zone of Mixing and location of benthic monitoring stations in the vicinity of the Kawaiele discharge.

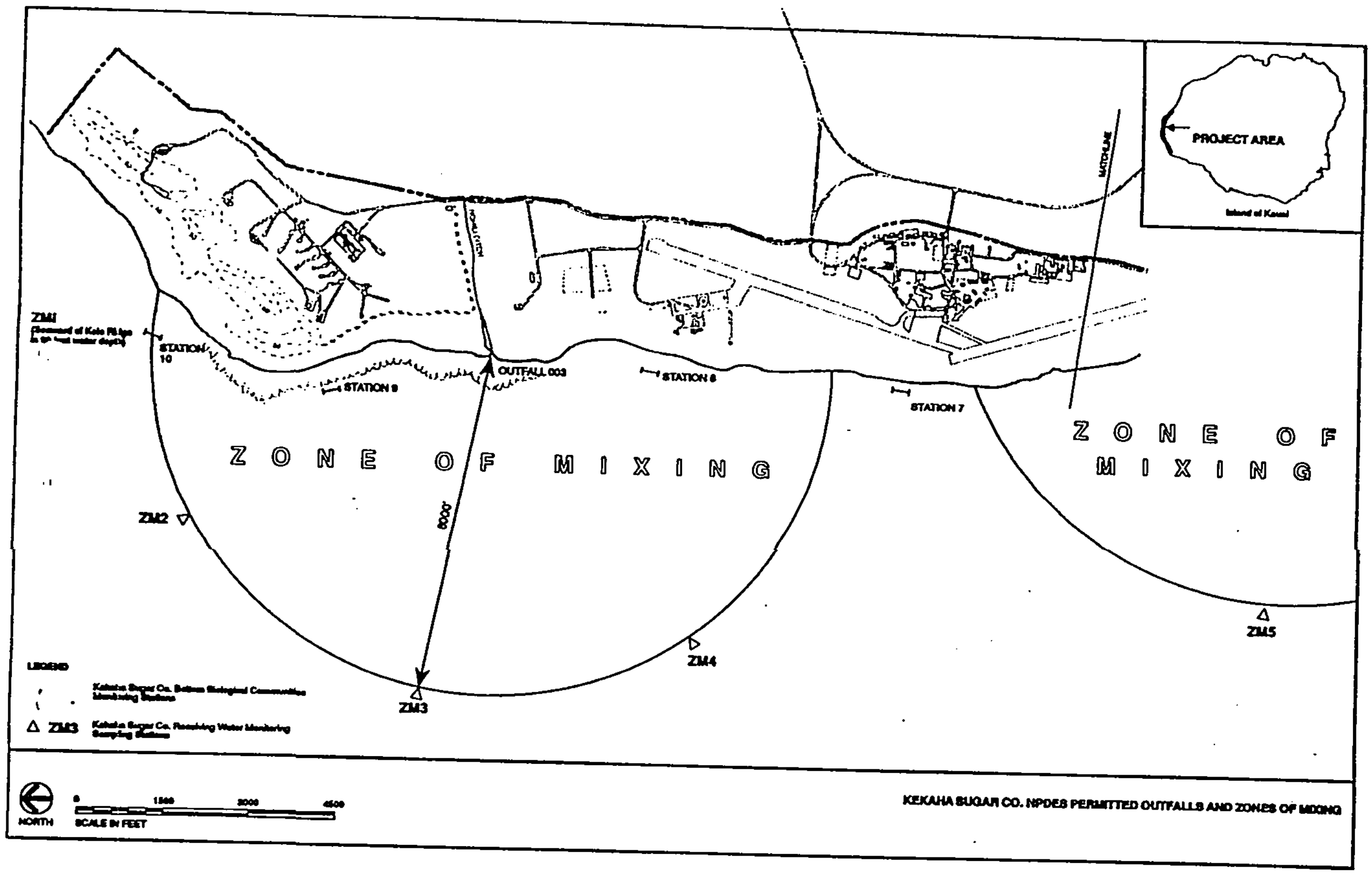

FIGURE 3. Zone of Mixing and location of benthic monitoring stations in the vicinity of the Nohili discharge.

TABLE 1. Percent coral cover and non-coral substratum cover on transects surveyed in the vicinity of the Kekaha Sugar Company discharges in April 1997. For location of survey sites, see Figures 1-3.

	MILL DISCHARGE		
CORAL SPECIES	TRANSECT 1	TRANSECT 2	TRANSECT 3
	8'	10'	6'
Porites lobata	3.0	0.3	0.6
Porites compressa	0.8	0.2	0.8
Pocillopora meandrina	0.2	0.4	0.8
Montipora patula		0.6	
TOTAL CORAL COVER	4.0	1.5	2.2
NUMBER OF SPECIES	3	4	3
CORAL COVER DIVERSITY	0.69	1.31	1.09
NON-CORAL SUBSTRATA			
Limestone	77.4	65.8	66.3
Sand	18.6	32.7	31.5

	KAWAIELE DISCHARGE			
CORAL SPECIES	TRANSECT 4	TRANSECT 5	TRANSECT 6	TRANSECT 7
	42'	20'	20'	24'
Porites lobata	1.1		18.9	7.9
Porites compressa			0.5	4.0
Pocillopora meandrina	0.5		0.2	1.6
Montipora verrucosa	0.1			0.1
Montipora patula				2.8
TOTAL CORAL COVER	1.7	0.0	19.8	16.4
NUMBER OF SPECIES	3	0	4	5
CORAL COVER DIVERSITY	0.64	0.00	0.18	1.31
NON-CORAL SUBSTRATA				
Limestone	61.1	47.1	61.3	73.0
Sand	37.2	52.9	18.9	10.6

	NOHILI DISCHARGE		
CORAL SPECIES	TRANSECT 8	TRANSECT 9	TRANSECT 10
	24'	20'	24'
Porites lobata	33.3	17.7	9.3
Porites compressa	0.3	7.1	
Pocillopora meandrina	1.4	5.1	13.3
Montipora patula	0.6	2.2	16.0
Montipora verrucosa			0.4
Pavona varians		0.2	
TOTAL CORAL COVER	35.6	32.1	39.0
NUMBER OF SPECIES	4	5	4
CORAL COVER DIVERSITY	0.30	1.14	1.12
NON-CORAL SUBSTRATA			
Limestone	64.4	67.9	61.0
Sand			

TABLE 2. Comparison of coral community data from 1992 (AECOS, 1993), 1994-1997 at Kekaha Sugar Co. Discharge sites. Positive change indicates increases in subsequent years; negative change indicates decreases in subsequent years.

TRANSECT NUMBER	MEAN % CORAL COVER					CHANGE 92-94	CHANGE 94-95	CHANGE 95-96	CHANGE 96-97
	1992	1994	1995	1996	1997				
1	0.8	9.7	10.4	2.8	4.0	8.90	0.70	-7.60	1.20
2	0.0	6.8	0.2	2.8	1.5	6.80	-6.60	2.60	-1.30
3	0.0	6.8	2.1	5.1	2.2	6.76	-4.70	3.00	-2.90
4	0.02	0.0	1.5	1.2	1.7	-0.02	1.50	-0.30	0.50
5	0.02	0.0	0.0	0.0	0.0	-0.02	0.00	0.00	0.00
6	5.9	12.1	7.0	14.8	19.8	6.20	-5.10	7.80	5.00
7	3.4	5.3	6.6	7.2	16.4	1.90	1.30	0.60	9.20
8	1.2	20.3	23.0	25.0	35.6	19.10	2.70	2.00	10.60
9	10.2	12.4	25.3	16.1	32.1	2.20	12.90	-9.20	16.00
10	0.0	23.8	24.3	18.3	39.0	23.80	0.50	-6.00	20.70
TOTAL	21.58	97.2	100.4	93.3	152.3	75.62	3.20	-7.10	59.00

TRANSECT NUMBER	NUMBER OF CORAL SPECIES					CHANGE 92-94	CHANGE 94-95	CHANGE 95-96	CHANGE 96-97
	1992	1994	1995	1996	1997				
1	2	3	5	3	3	1	2	-2	0
2	0	3	1	4	4	3	-2	3	0
3	1	3	3	4	3	2	0	1	-1
4	2	0	2	3	3	-2	2	1	0
5	2	0	0	0	0	-2	0	0	0
6	9	3	3	4	4	-6	0	1	0
7	7	5	3	5	5	-2	-2	2	0
8	3	5	5	6	4	2	0	1	-2
9	7	5	5	5	5	-2	0	0	0
10	0	5	5	5	4	5	0	0	-1
TOTAL	33	32	32	39	35	-1	0	7	-4

TABLE 3. Marine algae occurrance on survey transects off Kekaha Sugar Company discharges in April 1997. For transect locations, see Figures 1-3.
"R" = rare (0 - 5 individuals sighted on station)
"O" = occasional (5 - 20 individuals sighted on station)
"C" = common (more than 20 individuals sighted on station)

FAMILY Genus species	TRANSECT									
	KEKAHA MILL			KAWAIELE				NOHILI		
	1	2	3	4	5	6	7	8	9	10
CHLOROPHYTA										
(Green algae)										
Enteromorpha sp.	C	C	O	O	O		R	C	R	
Halimeda spp.	C	C	C	C	O	C	C	C		
Neomeris annulata	R	O	C	R	R	R	R	R		
Codium edule						R				
CYANOPHYTA										
(Blue-green algae)										
Lyngbya majuscula	R	R	R	R	R				R	
PHAEOPHYTA										
(Brown algae)										
Dictopteris app.	C	C	O	O		R				
Dictyota spp.	C	C	C	C	O	C	C	C	R	
Padina spp.	C	O	R	R	R	C	R	O	R	
Turbinaria ornata	R	R	R	R.	C	R	C	O	R	R
RHODOPHYTA										
(Red Algae)										
Asparagopsis taxiformis							R	R	R	R
Acanthophora specifera	R	R	R	C	C	R	R	R		
Desmia hornemanii		R					R	R		
Dotyella hawaiiensis		C		C	C	C	C			
Galaxaura spp.	R	R	R	C	C	O	C	R		
Hydrolithon spp.	R	C	C	C	C	C	C	C	C	C
Neogoniolithon sp.	C	C	C	C	C	C	C	C	C	C
Peysonellia rubra sp.		C	C	C	C	C	C	C	C	C
Porolithon spp.	C	C	C	C	C	C	C	C	C	C
Jania sp.	C	C	C	C	C	C	C	C	C	C

TABLE 4. Reef fish abundance on transects in the vicinity of the Kekaha Sugar Company discharges surveyed in April 1997. For location of transect sites, see Figures 1-3.

FAMILY Species	TRANSECT									
	MILL			KAWAIELE				NOHILI		
	1 8'	2 10'	3 6'	4 42'	5 20'	6 20'	7 24'	8 24'	9 20'	10 24'
KYPHOSIDAE										
Kyphosus bigibbus										5
CIRRHITIDAE										
Cirrhitus fasciatus										
Paracirrhites arcatus				1					1	1
MULLIDAE										
Parupeneus multifasciatus								1		2
P. bifasciatus						2		2	2	
SERRANIDAE										
Cephalopholis argus								1		
LUTJANIDAE										
Lutjanus kasmira						1				1
POMACENTRIDAE										
Stegastes fasciolatus	1							3		4
C. vanderbilti							1	4		6
C. ovalis				12				16	12	
LABRIDAE										
Coris venusta	2			2						1
Anampses cuvier										1
Thalassoma duperrey	1	2		7		8	5	7	11	8
T. trilobatum										
T. ballieui									1	
Gomphosus varius										1
Stethojulis balteata										2
Halichoeres ornatissimus						1				
ACANTHURIDAE										
Acanthurus achilles										1
A. triostegus						1				1
A. leucopareius								3		3
A. olivaceus						3				14
A. dussumieri				2			1	3		
A. blochii		1								
A. nigrofuscus						2				3
Ctenochaetus strigosus						8	4	8	8	26
Naso lituratus									3	8
N. unicornis								2		2
BLENNIIDAE										
Plagiotremus goslinei							1			
BALISTIDAE										
Rhinecanthus rectangulus				6						
Sufflamen bursa						1	1		2	1
S. fraenatus				1				2		2
Melichthys vidula				2			1			
M. niger								4		
TETRADONTIDAE										
Canthigaster jactator										3
NUMBER SPECIES	3	2	0	8	0	9	7	13	8	21
NUMBER INDIVIDUALS	4	3	0	33	0	27	14	56	40	87
SPECIES DIVERSITY	1.04	0.64	0.00	1.73	0.00	1.84	1.67	2.24	1.72	2.42

TABLE 5. Comparison of fish community data from 1992 (AECOS, 1993), 1994-1997 at Kekaha Sugar Co. Discharge sites. Positive change indicates increases in subsequent years; negative change indicates decreases in subsequent years.

TRANSECT NUMBER	NUMBER OF FISH SPECIES					CHANGE 92-94	CHANGE 94-95	CHANGE 95-96	CHANGE 96-97
	1992	1994	1995	1996	1997				
1	1	10	11	5	3	9	1	-6	-2
2	2	8	10	3	2	6	2	-7	-1
3	3	8	6	3	0	5	-2	-3	-3
4	6	12	11	8	8	6	-1	-3	0
5	6	8	8	4	0	2	0	-4	-4
6	4	6	12	12	9	2	6	0	-3
7	3	11	9	18	7	8	-2	9	-11
8	3	19	17	13	13	16	-2	-4	0
9	6	12	14	17	8	6	2	3	-9
10	4	26	28	24	21	22	2	-4	-3
TOTAL	38	120	126	107	71	82	6	-19	-36

TRANSECT NUMBER	NUMBER OF FISH					CHANGE 92-94	CHANGE 94-95	CHANGE 95-96	CHANGE 96-97
	1992	1994	1995	1996	1997				
1	1	102	66	22	4	101	-36	-44	-18
2	3	52	66	15	3	49	14	-51	-12
3	6	44	41	40	0	38	-3	-1	-40
4	14	76	78	41	33	62	2	-37	-8
5	18	27	77	27	0	9	50	-50	-27
6	23	33	67	128	27	10	34	61	-101
7	18	73	59	134	14	55	-14	75	-120
8	10	104	157	104	56	94	53	-53	-48
9	36	80	100	76	40	44	20	-24	-36
10	14	145	243	111	87	131	98	-132	-24
TOTAL	143	736	954	698	264	593	218	-256	-434

APPENDIX A. Quadrat coral cover at Kekaha Mill Outfall transects.

PERCENT COVER KEKAHA SUGAR MILL

TRANSECT SITE:	MILL DISCHARGE	MEAN CORAL COVER	4.0
	Transect 1, 8'	STD. DEV.	2.8
DATE:	4/20/97	SPECIES COUNT	3
		SPECIES DIVERSITY	0.687

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	2	8	8	2	4	2	4				3.0
Porites compressa	2				3	1	1	1			0.8
Pocillopora meandrina								2			0.2
QUAD CORAL TOTAL	4	8	8	2	7	3	5	3	0	0	4.0
Limestone	53	71	85	86	83	90	77	64	77	88	77.4
Sand	43	21	7	12	10	7	18	33	23	12	18.6
NON-CORAL TOTAL	96	92	92	98	93	97	95	97	100	100	96.0

TRANSECT SITE:	MILL DISCHARGE	MEAN CORAL COVER	1.5
	Transect 2, 10'	STD. DEV.	2.3
DATE:	4/20/97	SPECIES COUNT	4
		SPECIES DIVERSITY	1.310

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	1					1	1				0.3
Porites compressa				2							0.2
Pocillopora meandrina				4							0.4
Montipora patula									6		0.6
QUAD CORAL TOTAL	1	0	0	6	0	1	1	0	6	0	1.5
Limestone	76	84	72	59	55	72	83	35	59	63	65.8
Sand	23	16	28	35	45	27	16	65	35	37	32.7
NON-CORAL TOTAL	99	100	100	94	100	99	99	100	94	100	98.5

TRANSECT SITE:	MILL DISCHARGE	MEAN CORAL COVER	2.2
	Transect 3, 6'	STD. DEV.	2.6
DATE:	4/20/97	SPECIES COUNT	3
		SPECIES DIVERSITY	1.090

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	1						5				0.6
Porites compressa					2	2		4			0.8
Pocillopora meandrina		2				3	3				0.8
QUAD CORAL TOTAL	1	2	0	0	2	5	8	4	0	0	2.2
Limestone	66	73	76	47	86	49	88	49	73	56	66.3
Sand	33	25	-24	53	12	46	4	47	27	44	31.5
NON-CORAL TOTAL	99	98	100	100	98	95	92	96	100	100	97.8

APPENDIX B. Quadrat coral cover at Kawaiele Outfall transects

PERCENT COVER — KEKAHA SUGAR MILL

TRANSECT SITE: KAWAIELE OUTFALL, Transect 4, 42'
DATE: 4/20/97

MEAN CORAL COVER 1.7
STD. DEV. 2.2
SPECIES COUNT 3
SPECIES DIVERSITY 0.642

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	2	3	3		3						1.1
Pocillopora meandrina	3	2									0.5
Montipora verrucosa		1									0.1
QUAD CORAL TOTAL	5	6	3	0	3	0	0	0	0	0	1.7
Limestone	54	58	72	51	52	62	35	79	67	81	61.1
Sand	41	36	25	49	45	38	65	21	33	19	37.2
NON-CORAL TOTAL	95	94	97	100	97	100	100	100	100	100	98.3

TRANSECT SITE: KAWAIELE OUTFALL, Transect 5, 20'
DATE: 4/20/97

MEAN CORAL COVER 0.0
STD. DEV. 0.0
SPECIES COUNT 0
SPECIES DIVERSITY 0

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
QUAD CORAL TOTAL	0	0	0	0	0	0	0	0	0	0	0.0
Limestone	97	35	45	65	77	23	12	33	65	19	47.1
Sand	3	65	55	35	23	77	88	67	35	81	52.9
NON-CORAL TOTAL	100	100	100	100	100	100	100	100	100	100	100.0

TRANSECT SITE: KAWAIELE OUTFALL, Transect 6, 20'
DATE: 4/20/97

MEAN CORAL COVER 19.8
STD. DEV. 6.8
SPECIES COUNT 4
SPECIES DIVERSITY 0.184

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	15	21	38	19	17	14	24	14	13	14	18.9
Porites compressa									2	3	0.5
Pocillopora meandrina				2							0.2
Palythoa tuberculosa	1							1			0.2
QUAD CORAL TOTAL	16	21	38	21	17	14	24	15	15	17	19.8
Limestone	62	64	54	66	71	42	64	81	59	50	61.3
Sand	22	15	8	13	12	44	12	4	26	33	18.9
NON-CORAL TOTAL	84	79	62	79	83	86	76	85	85	83	80.2

TRANSECT SITE: KAWAIELE OUTFALL, Transect 7, 24'
DATE: 4/28/96

MEAN CORAL COVER 16.4
STD. DEV. 7.6
SPECIES COUNT 5
SPECIES DIVERSITY 1.131

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	2	16	6	4	2	3	22	21	1	2	7.9
Porites compressa	5	2	6	5	4	3	6	3	4	2	4.0
Pocillopora meandrina	5				5	4	1		1		1.6
Montipora verrucosa						1					0.1
Montipora patula	12	3		3	4	3		1	2		2.8
QUAD CORAL TOTAL	24	21	12	12	15	14	29	25	8	4	16.4
Limestone	68	67	79	77	83	83	50	68	70	85	73.0
Sand	8	12	9	11	2	3	21	7	22	11	10.6
NON-CORAL TOTAL	76	79	88	88	85	86	71	75	92	96	83.6

APPENDIX C. Quadrat coral cover at Nohili Outfall.

PERCENT COVER — KEKAHA SUGAR MILL

TRANSECT SITE:	NOHILI OUTFALL Transect 8, 24'	MEAN CORAL COVER	35.6 %
DATE:	4/20/97	STD. DEV.	19.1
		SPECIES COUNT	4
		SPECIES DIVERSITY	0.299

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	14	29	51	42	46	38	18	61	34	0	33.3
Porites compressa			1					2			0.3
Pocillopora meandrina					6	2		6			1.4
Montipora patula	3	3									0.6
QUAD CORAL TOTAL	17	32	52	42	52	40	18	69	34	0	35.6
Limestone	83	68	48	58	48	60	82	31	66	100	64.4
NON-CORAL TOTAL	83	68	48	58	48	60	82	31	66	100	64.4

TRANSECT SITE:	NOHILI OUTFALL Transect 9, 20'	MEAN CORAL COVER	32.1 %
DATE:	4/20/97	STD. DEV.	8.2
		SPECIES COUNT	5
		SPECIES DIVERSITY	1.138

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	15	23	22	12	23	16	10	24	18	14	17.7
Porites compressa	16	4	14	6	6		6	4	2	13	7.1
Pocillopora meandrina		15			12	6	16	1		1	5.1
Montipora patula	2		3			3		12	2		2.2
Pavona varians										2	0.2
QUAD CORAL TOTAL	33	42	39	18	41	25	32	41	22	28	32.1
Limestone	67	58	61	82	59	75	68	59	78	72	67.9
NON-CORAL TOTAL	67	58	61	82	59	75	68	59	78	72	67.9

TRANSECT SITE:	NOHILI OUTFALL Transect 10, 24'	MEAN CORAL COVER	39 %
DATE:	4/20/97	STD. DEV.	17.4
		SPECIES COUNT	4
		SPECIES DIVERSITY	1.121

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	14		8		14	4	6	34		13	9.3
Pocillopora meandrina	16	24	21	8	6		22	16	8	12	13.3
Montipora verrucosa	1				3						0.4
Montipora patula	3	6	4	28	22	14	3	4	18	58	16.0
QUAD CORAL TOTAL	34	30	33	36	45	18	31	54	26	83	39.0
Limestone	66	70	67	64	55	82	69	46	74	17	61.0
NON-CORAL TOTAL	66	70	67	64	55	82	69	46	74	17	61.0

ZONE OF MIXING BIOLOGICAL MONITORING FOR OCEAN DISCHARGES FROM THE KEKAHA SUGAR COMPANY, KEKAHA, KAUAI, HAWAII

(NPDES Permit HI0000086)

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INTRODUCTION

The Kekaha Sugar Company operates permitted discharges into the Pacific Ocean at three points along the southwest coast of Kauai between the northern boundary of Polihale State Park and Oomano Point on the south (Figures 1-3). Moving from south to north, one discharge point is the Kekaha Sugar Mill Ditch, which discharged thermal effluent from the mill for many years, but is not presently in use (Figure 1). Discharges of water pumped from sugarcane fields are located off of the Kawaiele Pumping Station (Figure 2) and near Nohili Point (Figure 3). Water pumped into the drainage discharges has a salinity of approximately 10‰ (Nance, personal communication) indicating that is approximately 1/3 seawater and 2/3 freshwater from groundwater and sugarcane irrigant leachate.

In compliance with the provisions of the Clean Water Act, Chapter 342D, Hawaii Revised Statutes, and the Administrative Rules of the Department of Health, the Kekaha Sugar Company was issued a National Pollutant Discharge Elimination System (NPDES), and Zones of Mixing (ZOM) Permit (No. HI 0000086) on May 24, 1990 to discharge sugar cane effluent from three points along the shoreline. The permit establishes three ZOM's which are defined as arcs with the center points specified as the points of discharge at the shoreline. The ZOM's extend vertically from the surface of the ocean to the sea floor. The radii of the arcs of the Nohili and Kawaiele ZOM's are 6,000 feet in length (Figures 2 and 3), while at the Kekaha Mill Ditch discharge, the radius of the arc defining the ZOM is 350 feet in length (Figure 1). Within the boundaries of the ZOM's, State of Hawaii water quality standards may be exceeded in the receiving waters; beyond the boundaries, water quality standards (including impacts to indigenous populations) cannot be exceeded.

Conditions of the Kekaha Sugar Mill NPDES/ZOM permit specify certain monitoring criteria to ensure maintenance of water quality and indigenous populations of marine organisms. With respect to monitoring of biological populations, compliance with permit conditions is assessed by comparing results of quantitative community analyses within and outside of the ZOM's conducted once during an annual cycle. The purpose of this report is to present the results of biological communities monitoring program conducted in April 1996 to assess the effects of the Kekaha Sugar Company discharges on marine communities.

To comply with conditions of the permit, surveys of the coral reef community structure (benthos and fish) were conducted at ten survey sites in April 1996. The locations of the survey sites were replicated as closely as possible to those surveyed in the previous three benthic monitoring surveys conducted in 1992 (AECOS 1993), 1994 and 1995 (Marine Research Consultants 1994, 1995). Presented below are the methods, results and conclusions of the monitoring survey at the Kekaha Sugar Mill discharge sites.

METHODS

Biotic structure of the marine environment in the vicinity of the Kekaha Sugar Mill discharges was evaluated by establishing a descriptive and quantitative baseline of benthic reef communities. Key components of reef communities include hermatypic and soft corals, benthic algae, motile macroinvertebrates, and reef fish.

The monitoring surveys were conducted on April 26 and 27, 1996. All fieldwork was carried out by divers using SCUBA equipment, working out of a 26-foot boat. Biotic structure of communities inhabiting the reef environment was evaluated on the transects that were established for the 1992 monitoring program (AECOS 1993). Listed below are the locations and water depth (in parentheses) of each transect at the three discharges:

Mill Ditch Outfall (001)

Transect 1 - (7 feet); outside the ZOM, approximately 700 feet south of the outfall and approximately 175 feet from the shoreline (southern control).

Transect 2 - (8 feet); directly seaward of the outfall, approximately midway between the shoreline and the seaward edge of the ZOM boundary (175 feet from the shoreline).

Transect 3 - (7 feet); outside the ZOM, approximately 700 feet north of the outfall and approximately 175 feet from the shoreline.

Kawaiele Outfall (002)

Transect 4 - (42 feet); outside the ZOM, approximately 9,000 feet south of the Kawaiele discharge, approximately 200 feet from the shoreline.

Transect 5 - (22 feet); within the southern portion of the ZOM, approximately one-half the distance from the outfall and the southern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 6 - (17 feet); within the northern portion of the ZOM, approximately one-half the distance from the outfall and the northern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 7 - (23 feet); outside the ZOM, approximately 7,500 feet north of the Kawaiele discharge, approximately 200 feet from the shoreline (northern control).

Nohili Outfall (003)

Transect 8 - (23 feet); outside of the ZOM, approximately midway between the boundaries of the Nohili and Kawaiele ZOM's, approximately 200 feet from the shoreline.

Transect 9 - (20 feet); within the southern portion of the ZOM approximately midway between the point of discharge and the southern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 10 - (24 feet); On the northern boundary of the ZOM, 6,000 from the point of discharge and approximately 200 feet from the shoreline. The location of this transect was changed from the previous survey when it was located 9,000 feet from the point of discharge. At this location, bottom composition consisted completely of scoured limestone owing to a completely different physical regime of wave stress than within the ZOM. As a result, transect 10 was located in a totally different habitat than within the ZOM. In order to conduct the required analyses to evaluate effects from the discharges, it is essential that all transects are conducted in similar habitats. Thus, the location of transect 10 was moved to the approximate boundary of the ZOM, which was an area with similar physical stress as the rest of the survey area at Nohili.

Each transect was oriented parallel to depth contours so as to bisect a single reef zone. Care was taken to place transects in random locations that were not biased toward either peak or low coral cover. Quantitative benthic surveys were conducted by stretching a 50-meter long surveying tape in a straight line over the reef surface. An aluminum quadrat frame, with dimensions of 1 m by 0.66 m, was sequentially placed over 10 random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver knowledgeable in the taxonomy of resident species visually estimated the percent cover and occurrence of organisms and substratum type within the quadrat frame. No attempt was made to disturb substrata to observe organisms, and no attempt was made to identify and enumerate cryptic species dwelling within the reef framework. Only macrofaunal species greater than approximately 2 centimeters were noted.

Following the period of fieldwork, quadrat photographs were projected onto a grid divided into 100 equal units, and units of bottom cover for each benthic faunal species and bottom type were recorded to the nearest 1 percent. Results of the photo-quadrats were combined with the in-situ cover estimates and community structure parameters (percent cover, number of species, species diversity) were calculated. The photo-quadrat transect method is a modification of the technique described in Kinzie « d Snider (1978), and has been employed in numerous field studies of Hawaiian reef communities (e.g. Dollar 1979, Grigg and Maragos 1974). The method was selected for the Kekaha monitoring program because it has proven to be particularly useful for quantifying coverage of attached benthos such as corals and large epifauna (e.g., sea urchins, sea cucumbers) that are the major components of the communities in the study area. In addition, the method provides a permanent photographic record which can be useful for comparative purposes in long-term investigations. While this methodology is quantitative for the larger exposed fauna, many coral reef invertebrates are cryptic or nocturnal. Coupled with the generally small size of cryptic invertebrates, quantitative assessment of these groups requires methodologies that are beyond the scope of the present monitoring program.

The transecting method used during the 1992 benthic monitoring survey (AECOS 1993) was somewhat different than that described above (1994-1996 surveys). In the 1992 survey, a 25 m transect line was laid across the bottom with 1 m^2 quadrats placed every 5 m. Thus, a total area of 5 m^2 was evaluated, compared to the 6.6 m^2 surveyed in the past three studies. In addition, the random location of the 10 quadrats along the transect line provides for a more representative characterization of the habitat than the 5 uniformly placed quadrats along a 25 m line. The survey technique employed in the 1992 survey utilized a point intercept method for 100 intersections within each quadrat. By utilizing only point intercepts, the probability of missing rare or small colonies is greater than the method used in the present study which accounts for the entire area (and all organisms present) within the quadrat frame. In addition, the photo-quadrat method employed for in the 1994-1996 surveys provides a permanent record of the surveyed benthos which was not provided by the point intercept method used in 1992. Thus, while the methods used in the two surveys are not identical, it appears that the techniques employed in the present program provide a better characterization of the reef communities as they exist today. Both methods, however, were similar in that cryptic fauna or organisms smaller than 2 cm in length were not evaluated. As the purpose of the monitoring is to determine if there are effects to these communities from continuous discharge of water from sugarcane activities, it does not appear that the variation in methods creates a problem in interpretation. Rather, using the best methods for describing community attributes will provide the best estimates of effect to marine communities from activities on land.

Quantitative assessment of reef fish community structure was conducted in conjunction with the benthic surveys. As the transect tape was being laid along the bottom, all fish observed within a band approximately 2 meters wide along the transect path were identified by species name and enumerated. Care was taken to conduct the fish surveys so that the minimum disturbance was created by divers, ensuring the least possible dispersal of fish. Only readily visible individuals were included in the census. No attempt was made to seek out cryptic species or individuals sheltered within coral. This transect method is an adaptation of techniques described in Hobson (1974). The method employed in the 1992 survey was slightly different in that the investigator made two passes over a 25 m transect, noting large motile fishes on the first pass, and smaller individuals that tend to seek shelter in the reef framework on the second pass. In the present survey, both types of fishes were noted on one pass over the 50 m transect line.

RESULTS AND DISCUSSION

Physical Structure

The coastal area covered in this study extends from the Kekaha Sugar Mill to north of Nohili Point. Sandy beaches comprise most of the shoreline along the length of the study area; landward of the beaches lies the Mana Coastal Plain, which is a low flat area that is presently planted in sugarcane. Owing to the low elevation of the plain, groundwater and irrigation water must be continually pumped from areas of the plain planted in sugarcane.

Seaward of the beaches that bound the study area, the shoreline is predominantly a limestone bench which extends up to 25 m offshore. Seaward of the margin of the bench, the bottom slopes gradually downward with distance offshore. The underwater physiographic structure off the Kawaiele and Kekaha Mill sites is very similar. Both of these areas are characterized by flat calcium carbonate (limestone) platforms that appear to be the result of ancient biogenic accumulation of reefal material. These platforms are predominantly flat with little structural relief other than low depressions and channels that are filled with coarse white sand. The surface of the platform is pitted, probably as a result of the boring action of several species of sea urchins. A ubiquitous feature of the reef platforms is a veneer of sandy sediment that appears to be in state of continual resuspension as a result of wave surge. The predominant biotic assemblage on the reef platform is a low algal turf composed of various species of benthic marine algae. Living coral corals are generally sparsely distributed, and occur predominantly as flat encrustations on the flat bottom. At all of the Kekaha monitoring sites, there was very little indication of terrigenous sediment deposition on the reef surface.

While the flat platform typified physiography off the Mill and Kawaiele discharge, a different type of physical structure occurred at the survey site directly off of the Nohili discharge area, especially off the northern edge of the ZOM (transect 10). In this area, the bottom is cut by numerous deep grooves, ledges and caves in what appears to be ancient coral reef platform. Vertical relief of the reef structures is generally from 1-3 m, resulting in a substantially more complex substratum than at the other two sites. Because the vertical relief afforded by the reef structures provides solid surfaces above the bottom (and shifting sediment), settlement of benthos, particularly reef corals is substantially higher than on the flat reef platforms described above.

All of the study sites are directly exposed to long-period swells generated by storms in both the north (winter) and south (summer) Pacific. In addition, the south and western coastal areas of Kauai were impacted by extremely large surf during Hurricanes Iwa (1982) and Iniki (1992). As a result of these physical processes, the nearshore areas at the monitoring sites are subjected to extreme stress from wave impact and scouring of sediment from wave action. As in many locations in the Hawaiian Islands, the composition of coral reef communities is structured primarily in response to physical forces of breaking waves (Dollar 1982, Dollar and Tribble 1993). Such is definitely the case off the Kekaha Mill monitoring sites.

Biotic Community Structure

Coral Community Structure

Appendices A, B, and C show results of the individual quadrat surveys on each transect at the Kekaha Mill, Kawaiele, and Nohili sites, respectively. Table 1 shows the quantitative summary of coral community structure from each of the 10 transects. Nine species of coral were encountered on transects in 1996 (eight in 1994, seven in 1995). The most species encountered on a single transect was six, which occurred on transect 8. Five species occurred on transects 7, 9 and 10; four species occurred on transects 2, 3 and 6. Three species occurred on transects 1 and 4, while on transect 5, no corals were encountered.

Mean coral cover on transects ranged from 0% (transect 5) to 25.0% (transect 8). Pooling all transects, mean total coral cover was 9.3% of bottom cover (10% in 1995). The most abundant coral species on transects were *Porites lobata*, which accounted for 46% of coral cover, and 4.4% of bottom cover, and *Pocillopora meandrina*, which accounted for 30% of coral cover, and 2.8% of bottom cover. *Montipora patula* accounted for 7% of coral cover, while *Porites compressa*, which accounted for 14% of coral cover. Thus, four species comprised 95% of coral cover, the remaining five species (*Montipora verrucosa, Pocillopora damicornis, Palythoa tuberculosa, Pavona duerdeni* and *Leptastrea purpurea*) comprised only 5% of coral cover, and 0.3% of bottom cover. In the previous surveys conducted in 1995 and 1994, results were similar, with total coral cover equaling 10% and 9.7% of bottom cover, respectively, and the four dominant species comprising 97% and 94% of coral cover, respectively.

Examination of the quantitative results in Table 1 indicate several major trends. It can be seen that coral cover, both in terms of percent cover and number of species, is higher at the Nohili discharge site transects than at either the Mill discharge or the Kawaiele discharge sites. As described in the section above, the physical structure of the Nohili area appears to be a more favorable habitat for reef coral growth than the flat platforms that characterize the other two sites. Coral growth on the flat reef platforms may be limited by shifting marine sands that inhibit planular settlement and abrade coral tissue.

Owing to elevation off the bottom, the vertical faces and elevated top of the reef structures at Nohili are not exposed to such stress from shifting marine sands.

Examination of the survey results indicates that there does not appear to be any pattern of coral community structure that are functions of distance from the sugarcane water discharges. At the Kawaiele site, the highest coral cover occurred at transect 6, within the ZOM, while there was zero coral cover on one of the *control transects for the* same discharge (transect 5). Coral cover on the three transects within the ZOM of the Nohili discharge (transects 8-10) differed by about 9% (16%-25%), with the highest cover on the transect closes to the outfall (transect 8).

Such results are not unexpected, as there does not appear to be any forcing factors (terrigenous sediments) or changes in water chemistry that appears to extend to the distance offshore where the transects were located (see results of ZOM water quality monitoring). Rather, it appears that the distribution of coral communities is strictly a function of natural factors, primarily wave forces and substratum complexity. Similar studies of water quality in the vicinity of a cooling water effluent discharge at Port Allen, located to the southeast of the Kekaha Mill site have produced similar results as the Kekaha studies. At Port Allen, freshwater effluent is restricted to a surface layer that does not extend to the ocean floor. Thus, even if there were constituents of the discharge plume that were potentially damaging, the benthos (bottom dwellers) would rarely be exposed to these plume constituents.

Comparing the results of the 1992, 1994, 1995 and 1996 monitoring surveys may indicate if there has been an ongoing degradation of the reef community as a result of the Kekaha discharges. Table 2 shows the quantitative results of mean percent coral cover and number of coral species on transects from the four surveys, as well as the differences in cover between survey pairs. Comparing 1992 survey results with subsequent survey data, it can be seen in Table 2 that on all transects except No's 4 and 5, where coral cover was essentially zero during all surveys, greater mean coral cover occurred in the 1994-1996 surveys. The greatest difference occurred at Transect 10, which was relocated in 1994 from an area entirely composed entirely of a completely scoured bottom to a area of reef structure. However, all of the other survey sites were in approximately the same locations for the four surveys. While part of these changes in cover may be an artifact of the method used in 1994-1996 which provided higher areas of coverage than the point intercept method used in 1992, it appears that there has been no decrease in coral cover (and perhaps an increase) in the intervals between survey pairs.

Comparing changes in number of species between the 1992 and 1994-1996 surveys indicates that on at least half the transects more coral species were encountered in 1994-1996 than in 1992 for any survey pair. Again, such a result does not indicate any negative factors associated with discharge from the Kekaha Sugar Company that may have affected coral occurrence.

Comparing coral cover data from the 1994 and 1995 surveys (when identical survey methods were employed) revealed increases in coral cover on 7 of the ten transects. Number of species on the transects decreased on 2 of the 10 transects in 1995 relative to 1994. As discussed above, total coral cover on pooled transects increased slightly in 1995 (10%) compared to 1994 (9.7%).

Comparing survey results from 1996 to results from 1994 and 1995 reveal similar results as described above. For each of the pairings of 1994-1996 and 1995-1996, coral cover showed a net positive change on five of the nine transects that had any coral cover. When the net changes in coral cover are summed for the entire ten transects, there is decreased cover in 1996 compared to 1994 (3.9%) and 1995 (7.1%) (Table 2). Applying the non-parametric Wilcoxon signed rank test to the two sets of data indicate that there are no significant (p=0.05) differences in transect coral cover between either the 1994-1996 or 1995-1996 surveys. In sum, survey results indicate that there is no difference in coral cover as a function of time for the ten transect data set.

In terms of number of species of coral on transects, there is either no change or an increase on all ten transects in 1996 compared to 1994, and on nine transects in 1996 compared to 1994. Wilcoxon signed rank tests indicate a significant (p=0.05) increase in number of coral species between 1996 and 1994, as well as between 1996 and 1995. Such an increase in number of coral species suggests that there is not a cumulative negative effect to coral community structure as a result of Sugar Mill discharge.

Other Benthic Invertebrates

The only benthic invertebrates that were observed in any frequency in the study areas were unidentified green and black sponges. Conspicuous by there absence were sea urchins, which are generally common in nearshore areas throughout the Hawaiian

Islands. No urchins were encountered in any of the transects in either the 1992, 1994, 1995 and 1996 surveys. Several individuals of the urchin *Echinometra matheai* were observed in the area of transect 10; none were observed throughout the regions where the bottom consisted of a flat carbonate platform. As the 1992 monitoring report makes no mention of sea urchins or other motile benthos, it appears that the lack of benthic invertebrates has been a typical characteristic of the area.

Benthic Algae

Benthic algae were common throughout the study area, particularly on the reef platforms that were essentially devoid of coral cover. The continual scouring action of sand appears to be a limiting factor for coral growth on the reef platforms, but not for many species of algae. Virtually all of the limestone reef platforms throughout the study area were covered with a short filamentous algal/diatom turf that is effective in binding sediment. In contrast to coral cover, which is amenable to quantification by assessing areal coverage, most of the algae encountered on transects was as isolated plants with little horizontal coverage of the bottom. As a result, algae abundance on transects was assessed semi-quantitatively by estimating the number of plants per transect. Table 3 shows abundance classes of algal species at each transect location. By far the most abundant algae were the red calcareous algae which were abundant on all transects.

A major difference in the results of the present survey with the 1992 survey was the lack of *Sargassum echinocarpum* during 1994-1996. In 1992, it was reported that large areas of the bottom were covered with continuous mats of *S. echinocarpum*; during 1994-1996 only several plants of this species were observed throughout the entire study area. It is apparent that the growth of this species is seasonal, with blooms occurring in the summer months. There is no indication of any effect of algal abundance related to the discharges.

Reef Fish Community Structure

The results of reef fish transects for the monitoring surveys are presented in Table 4. In 1996 the total number of species observed on all transects was 44 (compared to 50 in 1994 and 47 in 1995); species number ranged from 3-24 per transects (compared to 6-26 in 1994 and 6-28 in 1995). Individual fish encountered on transects ranged from 15-134 (compared to 27-145 in 1994 and 41-243 in 1995) (see Table 4). There were no apparent differences in fish assemblages between stations within the ZOM's and control stations at any of the discharge sites.

In the past surveys in 1994 and 1995, the number of species of fish, the number of individuals, and species diversity were higher off the Nohili discharge (transects 8-10) compared to the other two sites. In 1996, the highest number of fish species and highest diversity was at transect 10; however, the highest numbers of individuals were measured at transects 6 and 7 off the Kawaiele discharge.

Reef fish community structure appears to be largely determined by the topography and composition of the benthos. The flat reef platform that typified transects 1-7 results in scarcity of habitat suitable for reef fishes, which is reflected in the relatively low numbers of species and individuals. On transects 1-7, fishes were generally concentrated in small depressions which afforded a very limited amount of shelter. However, in 1996 several large aggregations of two species (*Chromis vanderbilti* and *Acanthurus nigrofuscus*) on transects 6 and 7 resulted in peak counts in the flat reef platforms. On transect 10, in an area of substantially greater vertical relief than any other study site, both the number of fish species and individuals has been consistently high compared to the other locations where the bottom was predominantly flat.

Several representative groups of reef fish were most numerous on the transects. Algal-feeding acanthurids were the most numerous single group of fishes observed. The brown surgeonfish (ma'i'i'i, *Acanthurus nigrofuscus*) was the most abundant surgeonfish; other well-represented species were the convict tang (manini, *A. triostegus*), the orangeband surgeonfish (na'ena'e, *A, olivaceus*), and the goldring surgeonfish (kole, *Ctenochaetus strigosus*).

Other families of reef fish that were well-represented included: wrasses, especially the saddleback wrasse (hinalea, *Thalassoma duperrey*); dameselfishes, especially the blackfin chromis (*Chromis vanderbilti*); and goatfishes, especially the manybar goatfish (moano, *Parupeneus multifasciatus*). Also typically encountered on the transects were numerous juvenile reef fish of several species and several triggerfish species.

Comparing results of fish transect surveys in 1992, 1994, 1995 and 1996 gives an indication if there has been a decline in reef fish abundance over time (see Table 5). Inspection of Table 5 reveals that on every transect there were more fish species and more individuals recorded in 1994-1996 than in 1992. The increase in number of species ranged from 2 to 24, while the increase in the number of individuals ranged from 9 to 229. Even with the consideration that the location of transect 10 was moved in 1994, it appears that there is no indication of reduced reef fish populations in the area that could be attributed to the Kekaha Sugar Company discharges between the 1992 survey and the subsequent surveys in 1994-1996.

Comparing results of the 1994 and 1996 surveys reveals that there were more species observed in 1996 on 3 of the 10 transects, and more individuals observed on 4 of the 10 transects. Wilcoxon signed rank tests indicate that there is no significant change (p=0.05) in number of fish or numbers of species of fish between the 1994 and 1996 surveys. Similarly, comparing 1995 and 1996 survey results indicates that there were more fish species in 1996 on 3 of the 10 transects, and more individuals on only 2 of the 10 transects. However, Wilcoxon signed rank tests indicated that there were no significant differences (p=0.05) in either number of species or numbers of fish between 1995 and 1996.

All of these results suggests that there has been no negative effect to fish abundance as a result of discharges from Kekaha Sugar Company.

SUMMARY

- Biological community monitoring for the Kekaha Sugar Mill discharges NPDES/ZOM permit was carried out for the fourth time in April of 1996. Ten transect survey stations that were established in 1991 were revisited and assessed for biotic structure. Stations were located with and outside of the ZOM boundaries off the Kekaha Sugar Mill Discharge (transects 1-3), off the Kawaiele irrigation water discharge (transects 4-6), between the Kawaiele and Nohili ZOM's (transect 7), and off the Nohili irrigation water discharge (transects 8-10). All transect locations were positioned as closely as possible to the locations described in the 1992 monitoring survey with the exception of transect 10, which was moved to the northern boundary of the ZOM.

- Physical structure of the nearshore region consists predominantly of sand beaches and nearshore reef platforms in the intertidal area. The predominant physical character of the nearshore reef throughout the Kekaha area consists of a flat limestone platform that is devoid of most physical relief except for low depressions and channels filled with sand. A layer of marine sediment covers the limestone platform and is constantly in motion owing to current and wave energy. The one exception to this physiography is transect 10, where bottom composition consisted of undercut ledges, grooves and channels cut from an ancient coral reef with vertical relief of 1-3 m.

- On the reef platforms, coral cover is relatively low owing to the abrasive quality of the shifting sand substratum. Mean coral cover on the ten transects ranged from zero to 25%, with the highest cover on transects 8, 9 and 10, where relief was highest. There was no apparent difference in coral community structure as a function of location within, or outside of the ZOM. Comparison of coral cover between the 1992, 1994, 1995 and 1996 surveys suggests that there has been no decrease in coral abundance or number of coral species with time. It can therefore be implied that there is no effect to coral community structure from Sugar Mill discharge.

- A variety of marine algae are common on the reef platform that appear to be able to withstand continual abrasion from shifting sand. The widespread beds of *Sargassum echinocarpum* that were noted in the 1992 survey were not present in 1994-1996, probably because the algal blooms on a seasonal cycle. There was no indication of any effect on algal communities from sugarcane discharge.

- Reef fish community structure off the Kekaha survey sites appears to be a function of habitat complexity. Number of species and number of individuals have been substantially higher at the Nohili discharge site owing to the shelter afforded by the three dimensional aspects of the reef. During the 1996 survey, number of individuals of fish was also high at transects off the Kawaiele discharge as a result of large aggregations of two species. Results of fish surveys did not reveal any obvious changes in community structure as a function of location within or beyond the ZOM boundaries. Comparisons of estimates of fish abundance between 1992 and 1994-1996 indicate substantially higher numbers of individuals and species since 1994. Similarly, there are no statistically significant reductions in numbers of fish or numbers of species in 1996 compared to 1994 and 1995. Such temporal comparisons suggests that there is no ongoing impact to fish communities as a result of discharge from the Kekaha Sugar Company.

- None of the data obtained in the monitoring surveys indicates any impacts from the Kekaha Sugar Company discharges to marine communities on the reefs adjacent to the discharge. Such a result is not unexpected as the discharge plumes are observed to mix rapidly with ocean water to background concentrations by natural turbulent conditions. Rather, marine communities appear to be primarily controlled by natural physical factors associated with wave energy, sediment scour and substrate complexity.

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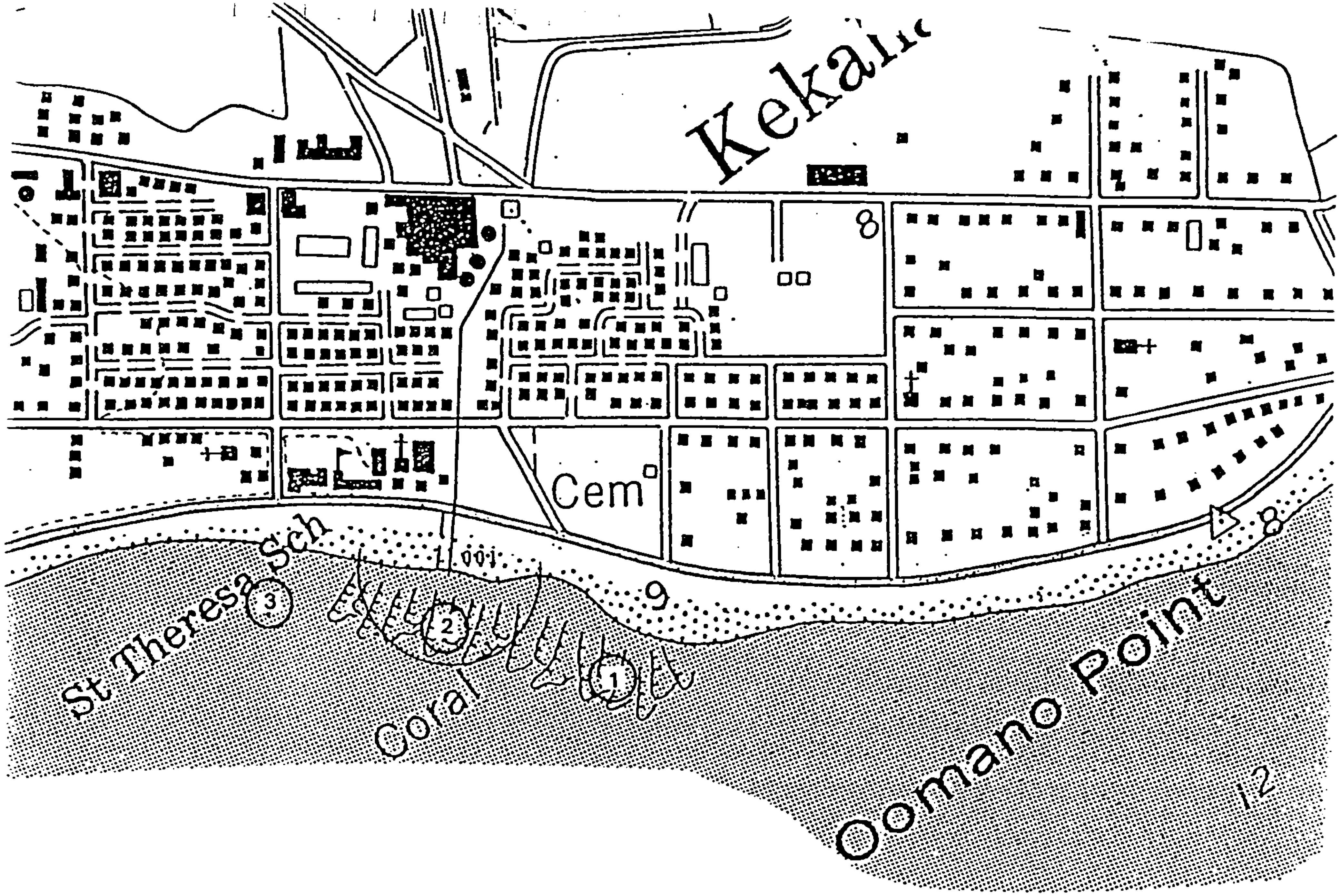

FIGURE 1. Zone of Mixing and location of benthic monitoring stations in the vicinity of the Kekaha Sugar Mill discharge.

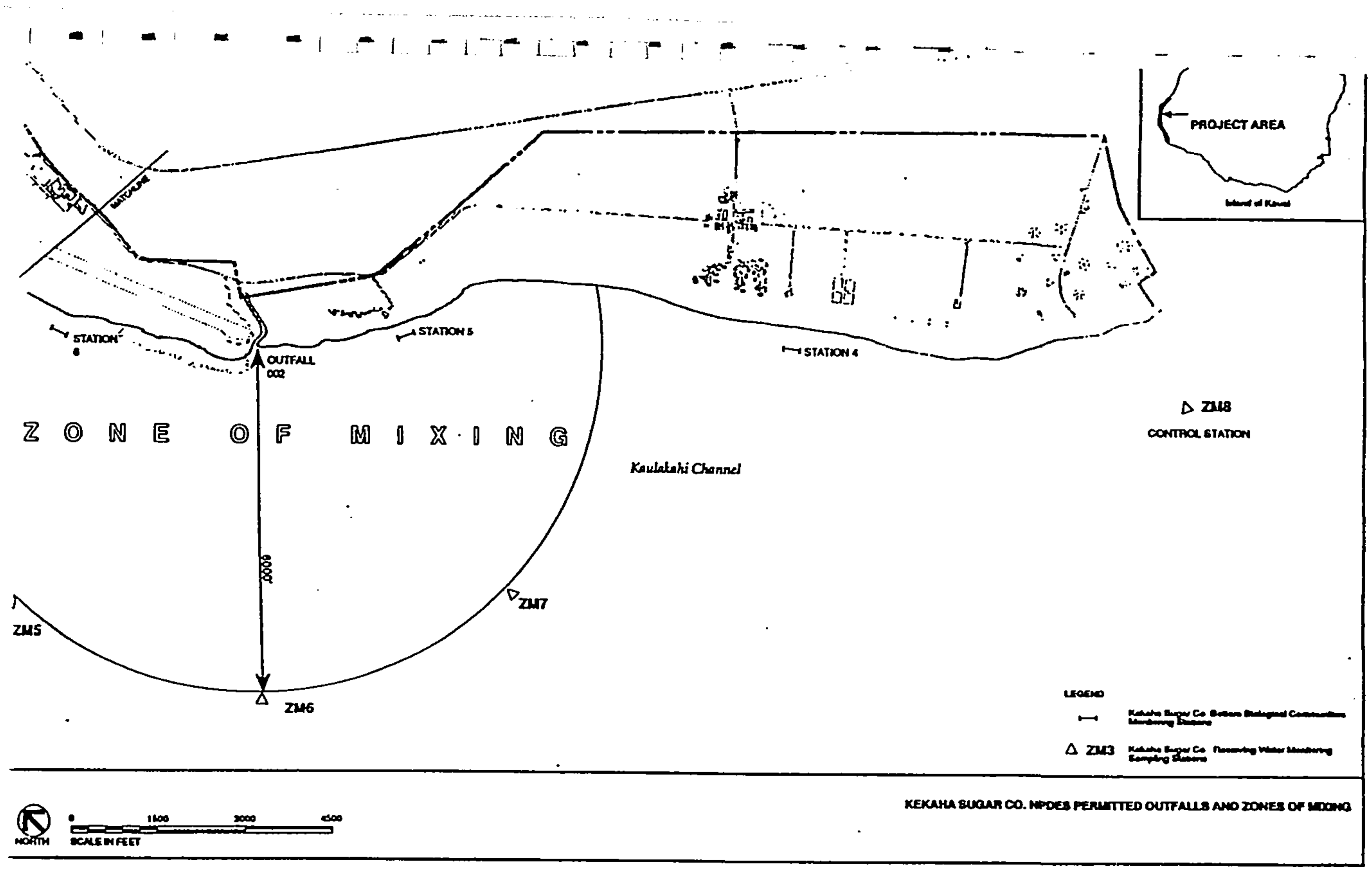

FIGURE 2. Zone of Mixing and location of benthic monitoring stations in the vicinity of the Kawaiele discharge.

TABLE 1. Percent coral cover and non-coral substratum cover on transects surveyed in the vicinity of the Kekaha Sugar Company discharges in April 1996. For location of survey sites, see Figures 1-3.

CORAL SPECIES	MILL DISCHARGE		
	TRANSECT 1	TRANSECT 2	TRANSECT 3
	8'	10'	6'
Porites lobata	1.6	1.9	1.3
Porites compressa	0.9	0.4	3.3
Pocillopora meandrina	0.3	0.3	0.3
Pocillopora damicornis		0.2	0.2
TOTAL CORAL COVER	2.8	2.8	5.1
NUMBER OF SPECIES	3	4	4
CORAL COVER DIVERSITY	0.92	0.97	0.96
NON-CORAL SUBSTRATA			
Limestone	80.1	64.4	73.6
Sand	17.1	32.6	21.3

CORAL SPECIES	KAWAIELE DISCHARGE			
	TRANSECT 4	TRANSECT 5	TRANSECT 6	TRANSECT 7
	42'	20'	20'	24'
Porites lobata	0.3		12.5	2.9
Porites compressa			0.5	1.6
Pocillopora meandrina	0.8		1.5	1.3
Montipora verrucosa	0.1			0.1
Montipora patula			0.3	1.3
TOTAL CORAL COVER	1.2	0.0	14.8	7.2
NUMBER OF SPECIES	3	0	4	5
CORAL COVER DIVERSITY	0.62	0.00	0.49	1.32
NON-CORAL SUBSTRATA				
Limestone	65.7	47.3	73.6	79.6
Sand	33.1	52.7	11.6	13.2

CORAL SPECIES	NOHILI DISCHARGE		
	TRANSECT 8	TRANSECT 9	TRANSECT 10
	24'	20'	24'
Porites lobata	14.6	6.1	2.5
Porites compressa	2.4	4.3	
Pocillopora meandrina	6.9	3.7	13.2
Montipora patula	0.7	2.0	2.3
Montipora verrucosa	0.3		0.1
Palythoa tuberculosa	0.1		1.7
Pavona duerdeni		0.1	
Leptastrea purpurea			0.2
TOTAL CORAL COVER	25.0	16.1	18.3
NUMBER OF SPECIES	6	5	5
CORAL COVER DIVERSITY	1.07	1.32	0.85
NON-CORAL SUBSTRATA			
Limestone	75.0	83.9	81.7
Sand			

TABLE 2. Comparison of coral community data from 1992 (AECOS, 1993), 1994, 1995 and 1996 at Kekaha Sugar Co. Discharge sites. Positive change indicates increases in subsequent years; negative change indicates decreases in subsequent years.

TRANSECT NUMBER	MEAN % CORAL COVER				CHANGE 92-94	CHANGE 92-95	CHANGE 92-96	CHANGE 94-95	CHANGE 94-96	CHANGE 95-96
	1992	1994	1995	1996						
1	0.8	9.7	10.4	2.8	8.90	9.60	2.00	0.70	-6.90	-7.60
2	0.0	6.8	0.2	2.8	6.80	0.20	2.80	-6.60	-4.00	2.60
3	0.0	6.8	2.1	5.1	6.76	2.06	5.06	-4.70	-1.70	3.00
4	0.02	0.0	1.5	1.2	-0.02	1.48	1.18	1.50	1.20	-0.30
5	0.02	0.0	0.0	0.0	-0.02	-0.02	-0.02	0.00	0.00	0.00
6	5.9	12.1	7.0	14.8	6.20	1.10	8.90	-5.10	2.70	7.80
7	3.4	5.3	6.6	7.2	1.90	3.20	3.80	1.30	1.90	0.60
8	1.2	20.3	23.0	25.0	19.10	21.80	23.80	2.70	4.70	2.00
9	10.2	12.4	25.3	16.1	2.20	15.10	5.90	12.90	3.70	-9.20
10	0.0	23.8	24.3	18.3	23.80	24.30	18.30	0.50	-5.50	-6.00
TOTAL	21.58	97.2	100.4	93.3	75.62	78.82	71.72	3.20	-3.90	-7.10

TRANSECT NUMBER	NUMBER OF CORAL SPECIES				CHANGE 92-94	CHANGE 92-95	CHANGE 92-96	CHANGE 94-95	CHANGE 94-96	CHANGE 95-96
	1992	1994	1995	1996						
1	2	3	5	3	1	3	1	2	0	-2
2	0	3	1	4	3	1	4	-2	1	3
3	1	3	3	4	2	2	3	0	1	1
4	2	0	2	3	-2	0	1	2	3	1
5	2	0	0	0	-2	-2	-2	0	0	0
6	9	3	3	4	-6	-6	-5	0	1	1
7	7	5	3	5	-2	-4	-2	-2	0	2
8	3	5	5	6	2	2	3	0	1	1
9	7	5	5	5	-2	-2	-2	0	0	0
10	0	5	5	5	5	5	5	0	0	0
TOTAL	33	32	32	39	-1	-1	6	0	7	7

TABLE 3. Marine algae occurrance on survey transects off Kekaha Sugar Company discharges in April 1996. For transect locations, see Figures 1-3.
"R" = rare (0 - 5 individuals sighted on station)
"O" = occasional (5 - 20 individuals sighted on station)
"C" = common (more than 20 individuals sighted on station)

FAMILY Genus species	TRANSECT KEKAHA MILL 1	2	3	KAWAIELE 4	5	6	7	NOHILI 8	9	10
CHLOROPHYTA (Green algae)										
Enteromorpha sp.	C	C	C	C	C		R	C	R	
Halimeda spp.	C	R	C	C	O	C	C	C		
Neomeris annulata	R	R	C	R	R	R	R	R		
Codium edule					C	O				
CYANOPHYTA (Blue-green algae)										
Lyngbya majuscula	R	R	R		R				R	
PHAEOPHYTA (Brown algae)										
Dictopteris app.	O	C	O	O		R				
Dictyota spp.	C	C	C	C	O	C	C	C	R	
Padina spp.	O	O	R	R	R	C	R	O	R	
Sargassum echinocarpum								C		
Turbinaria ornata	R	R	R	R	C	R	C	O		
RHODOPHYTA (Red Algae)										
Asparagopsis taxiformis							C	C	C	R
Acanthophora specifera	R	R	R	C	C		R	R		
Desmia hornemanii		R					O			
Dotyella hawaiiensis		C		C	C	C	C			
Galaxaura spp.	R	R	R	C	C	C	C	R		
Hydrolithon spp.	R	C	C	C	C	C	C	C	C	C
Neogoniolithon sp.	C	C	C	C	C	C	C	C	C	C
Peysonellia rubra sp.		C	C	C	C	C	C	C	C	C
Porolithon spp.	C	C	C	C	C	C	C	C	C	C
Jania sp.	C	C	C	C	C	C	C	C	C	C

TABLE 4. Reef fish abundance on transects in the vicinity of the Kekaha Sugar Company discharges surveyed in April 1996. For location of transect sites, see Figures 1-3.

FAMILY Species	TRANSECT									
	MILL			KAWAIELE				NOHILI		
	1	2	3	4	5	6	7	8	9	10
	8'	10'	6'	42'	20'	20'	24'	24'	20'	24'
KYPHOSIDAE										
Kyphosus bigibbus						50				9
CIRRHITIDAE										
Cirrhitus pinnulatus										1
Paracirrhites arcatus				6		1	1	1	1	2
MULLIDAE										
Parupeneus multifasciatus	2		2	2		3	6	3	3	5
P. bifasciatus										1
SERRANIDAE										
Cephalopholis argus										2
LUTJANIDAE										
Lutjanus kasmira							7	4		
L. fulvus							1			
Aphareus furcatus										
CHAETODONTIDAE										
Chaetodon quadrimaculatus						1	1		2	2
C. multicinctus									2	
C. fremblii								1		
POMACANTHIDAE										
Centropyge potteri								1		
POMACENTRIDAE										
Abudefduf abdominalis										8
Plectro. johnstonianus									2	
P. imparipennis									1	1
Stegastes fasciolatus	2					2				2
C. vanderbilti	13	10	35	15	13	35	55	55		15
LABRIDAE										
Bodianus bilunulatus				1			1		1	1
Anampses cuvier										3
Thalassoma duperrey	3	4	3	7	6	7	9	8	16	16
T. ballieui								1		
Gomphosus varius										2
Stethojulis balteata										1
Halichoeres ornatissimus						1	2			
SCARIDAE										
Calotomus sp.									1	
Scarus rubroviolaceus										1
Juvenile Scarus								6		
ACANTHURIDAE										
Acanthurus achilles							2		10	12
A. triostegus							18	6	7	
A. leucopareius									4	2
A. olivaceus						2	7	8	8	
A. dussumieri						2				
A. blochii							2			
A. nigrofuscus	2				7	22	17	8	12	11
Ctenochaetus strigosus									3	6
Naso lituratus								2		2
N. unicornis							2			
BLENNIIDAE										
Plagiotremus goslinei				6						
BALISTIDAE										
Rhinecanthus rectangulus		1					1		2	2
Sufflamen bursa				2	1	2				
S. fraenatus				2			1			
M. niger										4
TETRADONTIDAE										
Canthigaster jactator							1		1	
NUMBER SPECIES	5	3	3	8	4	12	18	13	17	24
NUMBER INDIVIDUALS	22	15	40	41	27	128	134	104	76	111
SPECIES DIVERSITY	1.24	0.80	0.46	1.76	1.16	1.64	2.03	1.74	2.42	2.76

TABLE 5. Comparison of fish community data from 1992 (AECOS, 1993), 1994, 1995 and 1996 at Kekaha Sugar Co. Discharge sites. Positive change indicates increases in subsequent years; negative change indicates decreases in subsequent years.

TRANSECT NUMBER	NUMBER OF FISH SPECIES 1992	1994	1995	1996	CHANGE 92-94	CHANGE 92-95	CHANGE 92-96	CHANGE 94-95	CHANGE 94-96	CHANGE 95-96
1	1	10	11	5	9	10	4	1	-5	-6
2	2	8	10	3	6	8	1	2	-5	-7
3	3	8	6	3	5	3	0	-2	-5	-3
4	6	12	11	8	6	5	2	-1	-4	-3
5	6	8	8	4	2	2	-2	0	-4	-4
6	4	6	12	12	2	8	8	6	6	0
7	3	11	9	18	8	6	15	-2	7	9
8	3	19	17	13	16	14	10	-2	-6	-4
9	6	12	14	17	6	8	11	2	5	3
10	4	26	28	24	22	24	20	2	-2	-4
TOTAL	38	120	126	107	82	88	69	6	-13	-19

TRANSECT NUMBER	NUMBER OF FISH 1992	1994	1995	1996	CHANGE 92-94	CHANGE 92-95	CHANGE 92-96	CHANGE 94-95	CHANGE 94-96	CHANGE 95-96
1	1	102	66	22	101	65	21	-36	-80	-44
2	3	52	66	15	49	63	12	14	-37	-51
3	6	44	41	40	38	35	34	-3	-4	-1
4	14	76	78	41	62	64	27	2	-35	-37
5	18	27	77	27	9	59	9	50	0	-50
6	23	33	67	128	10	44	105	34	95	61
7	18	73	59	134	55	41	116	-14	61	75
8	10	104	157	104	94	147	94	53	0	-53
9	36	80	100	76	44	64	40	20	-4	-24
10	14	145	243	111	131	229	97	98	-34	-132
TOTAL	143	736	954	698	593	811	555	218	-38	-256

PENDIX A. Quadrat coral cover at Kekaha Mill Outfall transects.

RCENT COVER KEKAHA SUGAR MILL

NSECT SITE: MILL DISCHARGE
Transect 1, 8'
TE: 4/28/96

MEAN CORAL COVER 2.8
STD. DEV. 2.0
SPECIES COUNT 3
SPECIES DIVERSITY 0.924

SPECIES	QUADRAT										SPECIES
	1	2	3	4	5	6	7	8	9	10	TOTAL
ites lobata		1		1	4	1	2	4	2	1	1.6
tes compressa						1	1	2		5	0.9
llopora meandrina	1								2		0.3
AD CORAL TOTAL	1	1	0	1	4	2	3	6	4	6	2.8
stone	43	67	95	97	85	97	65	81	84	87	80.1
nd	56	32	5	2	11	1	32	13	12	7	17.1
N-CORAL TOTAL	99	99	100	99	96	98	97	94	96	94	97.2

ANSECT SITE: MILL DISCHARGE
Transect 2, 10'
E: 4/28/96

MEAN CORAL COVER 2.8
STD. DEV. 2.9
SPECIES COUNT 4
SPECIES DIVERSITY 0.969

SPECIES	QUADRAT										SPECIES
	1	2	3	4	5	6	7	8	9	10	TOTAL
tes lobata	1	3		1		10		1	1	2	1.9
rites compressa				1	2	1					0.4
illopora meandrina	3										0.3
illopora damicornis							2				0.2
AD CORAL TOTAL	4	3	0	2	2	11	2	1	1	2	2.8
estone	82	82	85	89	57	43	46		69	91	64.4
d	14	15	15	6	41	46	52	99	31	7	32.6
N-CORAL TOTAL	96	97	100	95	98	89	98	99	100	98	97.0

NSECT SITE: MILL DISCHARGE
Transect 3, 6'
TE: 4/28/96

MEAN CORAL COVER 5.1
STD. DEV. 4.3
SPECIES COUNT 4
SPECIES DIVERSITY 0.963

SPECIES	QUADRAT										SPECIES
	1	2	3	4	5	6	7	8	9	10	TOTAL
ites lobata		1	2		2	1	1	3	2	1	1.3
rites compressa	2	1	14	2	3		4		4	3	3.3
ocillopora meandrina									3		0.3
illopora damicornis										2	0.2
AD CORAL TOTAL	2	2	16	2	5	1	5	3	9	6	5.1
estone	62	72	75	86	68	90	74	88	48	73	73.6
d	36	26	9	12	27	9	21	9	43	21	21.3
ON-CORAL TOTAL	98	98	84	98	95	99	95	97	91	94	94.9

APPENDIX B. Quadrat coral cover at Kawaiele Outfall transects

PERCENT COVER — KEKAHA SUGAR MILL

TRANSECT SITE: KAWAIELE OUTFALL, Transect 4, 42'
DATE: 4/28/98

MEAN CORAL COVER 1.2
STD. DEV. 2.6
SPECIES COUNT 3
SPECIES DIVERSITY 0.617

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata			2	1							0.3
Pocillopora meandrina			6	2							0.8
Montipora verrucosa				1							0.1
QUAD CORAL TOTAL	0	0	8	4	0	0	0	0	0	0	1.2
Limestone	64	54	75	45	66	67	88	74	67	57	65.7
Sand	36	46	17	51	34	33	12	26	33	43	33.1
NON-CORAL TOTAL	100	100	92	96	100	100	100	100	100	100	98.8

TRANSECT SITE: KAWAIELE OUTFALL, Transect 5, 20'
DATE: 4/28/98

MEAN CORAL COVER 0.0
STD. DEV. 0.0
SPECIES COUNT 0
SPECIES DIVERSITY 0

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
QUAD CORAL TOTAL	0	0	0	0	0	0	0	0	0	0	0.0
Limestone	87	45	76	41	11	27	43	66	21	56	47.3
Sand	13	55	24	59	89	73	57	34	79	44	52.7
NON-CORAL TOTAL	100	100	100	100	100	100	100	100	100	100	100.0

TRANSECT SITE: KAWAIELE OUTFALL, Transect 6, 20'
DATE: 4/28/98

MEAN CORAL COVER 14.8
STD. DEV. 5.7
SPECIES COUNT 4
SPECIES DIVERSITY 0.489

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	26	13	18	9	5	14	8	13	5	14	12.5
Porites compressa			2			2				1	0.5
Pocillopora meandrina		1					2	4	7	1	1.5
Montipora patula			1	1						1	0.3
QUAD CORAL TOTAL	26	14	21	10	5	16	10	17	12	17	14.8
Limestone	39	80	75	78	91	63	78	79	81	72	73.6
Sand	35	6	4	12	4	21	12	4	7	11	11.6
NON-CORAL TOTAL	74	86	79	90	95	84	90	83	88	83	85.2

TRANSECT SITE: KAWAIELE OUTFALL, Transect 7, 24'
DATE: 4/28/98

MEAN CORAL COVER 7.2
STD. DEV. 2.5
SPECIES COUNT 5
SPECIES DIVERSITY 1.321

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	2	2	5	6	1	2	7	4			2.9
Porites compressa			2	1		1	1	2	6	3	1.6
Pocillopora meandrina		2	1	3	4			1		2	1.3
Montipora verrucosa									1		0.1
Montipora patula	1		1		1	2	2		1	5	1.3
QUAD CORAL TOTAL	3	4	9	10	6	5	10	7	8	10	7.2
Limestone	95	71	89	76	93	94	69	88	43	78	79.6
Sand	2	25	2	14	1	1	21	5	49	12	13.2
NON-CORAL TOTAL	97	96	91	90	94	95	90	93	92	90	92.8

APPENDIX C. Quadrat coral cover at Nohili Outfall.

PERCENT COVER — KEKAHA SUGAR MILL

TRANSECT SITE:	NOHILI OUTFALL	MEAN CORAL COVER	25.0 %
	Transect 8, 24'	STD. DEV.	13.6
DATE:	4/28/96	SPECIES COUNT	6
		SPECIES DIVERSITY	1.070

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	26	8	12	14		8	16	29	32	1	14.6
Porites compressa	6	5	6		7						2.4
Pocillopora meandrina	7	9	6	8	9			14	16		6.9
Montipora verrucosa					2		1				0.3
Montipora patula						3	3			1	0.7
Palythoa tuberculosa							1				0.1
QUAD CORAL TOTAL	39	22	24	22	18	11	21	43	48	2	25.0
Limestone	61	78	76	78	82	89	79	57	52	98	75.0
NON-CORAL TOTAL	61	78	76	78	82	89	79	57	52	98	75.0

TRANSECT SITE:	NOHILI OUTFALL	MEAN CORAL COVER	16.1 %
	Transect 9, 20'	STD. DEV.	8.7
DATE:	4/28/96	SPECIES COUNT	5
		SPECIES DIVERSITY	1.317

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	2	6	8	5	15	3	6	3	3	10	6.1
Porites compressa	6	3	1	7	11	2	2	5	5	1	4.3
Pocillopora meandrina			6			10	12	3	3	3	3.7
Montipora patula				2			18				2.0
Pavona duerdeni			1								0.1
QUAD CORAL TOTAL	8	9	15	14	26	15	38	11	11	14	16.1
Limestone	92	91	85	86	74	85	62	89	89	86	83.9
NON-CORAL TOTAL	92	91	85	86	74	85	62	89	89	86	83.9

TRANSECT SITE:	NOHILI OUTFALL	MEAN CORAL COVER	18.3 %
	Transect 10, 24'	STD. DEV.	10.6
DATE:	4/28/96	SPECIES COUNT	5
		SPECIES DIVERSITY	0.846

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata			13			12					2.5
Pocillopora meandrina	22	3	12	8	22	23	14	12	2	14	13.2
Montipora verrucosa					1						0.1
Montipora patula	3	2	5	4	1	2	2	2		2	2.3
Leptastrea purpurea			2								0.2
QUAD CORAL TOTAL	25	5	32	12	24	37	16	14	2	16	18.3
Limestone	75	95	68	88	76	63	84	86	98	84	81.7
NON-CORAL TOTAL	75	95	68	88	76	63	84	86	98	84	81.7

ZONE OF MIXING
BIOLOGICAL MONITORING FOR
OCEAN DISCHARGES FROM THE
KEKAHA SUGAR COMPANY,
KEKAHA, KAUAI, HAWAII

(NPDES Permit HI0000086)

Prepared for

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INTRODUCTION

The Kekaha Sugar Company operates permitted discharges into the Pacific Ocean at three points along the southwest coast of Kauai between the northern boundary of Polihale State Park and Oomano Point on the south (Figures 1-3). Moving from south to north, one discharge point is the Kekaha Sugar Mill Ditch, which discharged thermal effluent from the mill for many years, but is not presently in use (Figure 1). Discharges of water pumped from sugarcane fields are located off of the Kawaiele Pumping Station (Figure 2) and near Nohili Point (Figure 3). Water pumped into the drainage discharges has a salinity of approximately 10°/₀₀ (T. Nance, personal communication) indicating that is approximately 1/3 seawater and 2/3 freshwater from groundwater and sugarcane irrigant leachate.

In compliance with the provisions of the Clean Water Act, Chapter 342D, Hawaii Revised Statutes, and the Administrative Rules of the Department of Health, the Kekaha Sugar Company was issued a National Pollutant Discharge Elimination System (NPDES), and Zones of Mixing (ZOM's) Permit (No. HI 0000086) on May 24, 1990 to discharge sugar cane effluent from three points along the shoreline. The permit establishes three ZOM's which are defined as arcs with the center points specified as the points of discharge at the shoreline. The ZOM's extend vertically from the surface of the ocean to the seafloor. The radii of the arcs of the Nohili and Kawaiele ZOM's are 6,000 feet in length (Figures 2 and 3), while at the Kekaha Mill Ditch discharge, the radius of the arc defining the ZOM is 350 feet in length (Figure 1). Within the boundaries of the ZOM's, State of Hawaii water quality standards may be exceeded in the receiving waters; beyond the boundaries, water quality standards (including impacts to indigenous populations) cannot be exceeded.

Conditions of the Kekaha Sugar Mill NPDES/ZOM permit specify certain monitoring criteria to ensure maintenance of water quality and indigenous populations of marine organisms. With respect to monitoring of biological populations, compliance with permit conditions is assessed by comparing results of quantitative community analyses within and outside of the ZOM's conducted once during an annual cycle. The purpose of this report is to present the results of biological communities monitoring program conducted in March 1995 to assess the effects of the Kekaha Sugar Company discharges on marine communities.

To comply with conditions of the permit, surveys of the coral reef community structure (benthos and fish) were conducted at ten survey sites in March 1995. The locations of the survey sites were replicated as closely as possible (with one exception) to those surveyed in the previous two benthic monitoring surveys conducted in 1992 (AECOS 1993) and 1994 (Marine Research Consultants 1994). Presented below are the methods, results and conclusions of the monitoring survey at the Kekaha Sugar Mill discharge sites.

METHODS

Biotic structure of the marine environment in the vicinity of the Kekaha Sugar Mill discharges was evaluated by establishing a descriptive and quantitative baseline of benthic reef communities. Key components of reef communities include hermatypic and soft corals, benthic algae, motile macroinvertebrates, and reef fish.

The monitoring surveys were conducted on March 18 and 25, 1995. All fieldwork was carried out by divers using SCUBA equipment, working out of a 26-foot boat. Biotic structure of communities inhabiting the reef environment was evaluated on the transects that were established for the 1992 monitoring program (AECOS 1993). Listed below are the locations and water depth (in parentheses) of each transect at the three discharges:

Mill Ditch Outfall (001)

Transect 1 - (7 feet); outside the ZOM, approximately 700 feet south of the outfall and approximately 175 feet from the shoreline (southern control).

Transect 2 - (8 feet); directly seaward of the outfall, approximately midway between the shoreline and the seaward edge of the ZOM boundary (175 feet from the shoreline).

Transect 3 - (7 feet); outside the ZOM, approximately 700 feet north of the outfall and approximately 175 feet from the shoreline.

Kawaiele Outfall (002)

Transect 4 - (42 feet); outside the ZOM, approximately 9,000 feet south of the Kawaiele discharge, approximately 200 feet from the shoreline.

Transect 5 - (22 feet); within the southern portion of the ZOM, approximately one-half the distance from the outfall and the southern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 6 - (17 feet); within the northern portion of the ZOM, approximately one-half the distance from the outfall and the northern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 7 - (23 feet); outside the ZOM, approximately 7,500 feet north of the Kawaiele discharge, approximately 200 feet from the shoreline (northern control).

Nohili Outfall (003)

Transect 8 - (23 feet); outside of the ZOM, approximately midway between the boundaries of the Nohili and Kawaiele ZOM's, approximately 200 feet from the shoreline.

Transect 9 - (20 feet); within the southern portion of the ZOM approximately midway between the point of discharge and the southern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 10 - (24 feet); On the northern boundary of the ZOM, 6,000 from the point of discharge and approximately 200 feet from the shoreline. The location of this transect was changed from the previous survey when it was located 9,000 feet from the point of discharge. At this location, bottom composition consisted completely of scoured limestone owing to a completely different physical regime of wave stress than within the ZOM. As a result, transect 10 was located in a totally different habitat than within the ZOM. In order to conduct the required analyses to evaluate effects from the discharges, it is essential that all transects are conducted in similar habitats. Thus, the location of transect 10 was moved to the approximate boundary of the ZOM, which was an area with similar physical stress as the rest of the survey area at Nohili.

Each transect was oriented parallel to depth contours so as to bisect a single reef zone. Care was taken to place transects in random locations that were not biased toward either peak or low coral cover. Quantitative benthic surveys were conducted by stretching a 50-meter long surveying tape in a straight line over the reef surface. An aluminum quadrat frame, with dimensions of 1 m by 0.66 m, was sequentially placed over 10 random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver knowledgeable in the taxonomy of resident species visually estimated the percent cover and occurrence of organisms and substratum type within the quadrat frame. No attempt was made to disturb substrata to observe organisms, and no attempt was made to identify and enumerate cryptic species dwelling within the reef framework. Only macrofaunal species greater than approximately 2 centimeters were noted.

Following the period of fieldwork, quadrat photographs were projected onto a grid divided into 100 equal units, and units of bottom cover for each benthic faunal species and bottom type were recorded to the nearest 1 percent. Results of the photo-quadrats were combined with the in-situ cover estimates and community structure parameters (percent cover, number of species, species diversity) were calculated. The photo-quadrat transect method is a modification of the technique described in Kinzie and Snider (1978), and has been employed in numerous field studies of Hawaiian reef communities (e.g. Dollar 1979, Grigg and Maragos 1974). The method was selected for the Kekaha monitoring program because it has proven to be particularly useful for quantifying coverage of attached benthos such as corals and large epifauna (e.g., sea urchins, sea cucumbers) that are the major components of the communities in the study area. In addition, the method provides a permanent photographic record which can be useful for comparative purposes in long-term investigations. While this methodology is quantitative for the larger exposed fauna, many coral reef invertebrates are cryptic or nocturnal. Coupled with the generally small size of cryptic invertebrates, quantitative assessment of these groups requires methodologies that are beyond the scope of the present monitoring program.

The transecting method used during the 1992 benthic monitoring survey (AECOS 1993) was somewhat different than that described above (1994 and 1995 surveys). In the 1992 survey, a 25 m transect line was laid across the bottom with 1 m^2 quadrats placed every 5 m. Thus, a total area of 5 m^2 was evaluated, compared to the 6.6 m^2 surveyed in the past two studies. In addition, the random location of the 10 quadrats along the transect line provides for a more representative characterization of the habitat than the 5 uniformly placed quadrats along a 25 m line. The survey technique employed in the 1992 survey utilized a point intercept method for 100 intersections within each quadrat. By utilizing only point intercepts, the probability of missing rare or small colonies is greater than the method used in the present study which accounts for the entire area (and all organisms present) within the quadrat frame. In addition, the photo-quadrat method employed for in the 1994-1995 surveys provides a permanent record of the surveyed benthos which was not provided by the point intercept method used in 1992. Thus, while the methods used in the two surveys are not identical, it appears that the techniques employed in the present program provide a better characterization of the reef communities as they exist today. Both methods, however, were similar in that cryptic fauna or organisms smaller than 2 cm in length were not evaluated. As the purpose of the monitoring is to determine if there are effects to these communities from continuous discharge of water from sugarcane activities, it does not appear that the variation in methods creates a problem in interpretation. Rather, using the best methods for describing community attributes will provide the best estimates of effect to marine communities from activities on land.

Quantitative assessment of reef fish community structure was conducted in conjunction with the benthic surveys. As the transect tape was being laid along the bottom, all fish observed within a band approximately 2 meters wide along the transect path were identified by species name and enumerated. Care was taken to conduct the fish surveys so that the minimum disturbance was created by divers, ensuring the least possible dispersal of fish. Only readily visible individuals were included in the census. No attempt was made to seek out cryptic species or individuals sheltered within coral. This transect method is an adaptation of techniques described in Hobson (1974). The method employed in the 1992 survey was slightly different in that the investigator made two passes over a 25 m transect, noting large motile fishes on the first pass, and smaller individuals that tend to seek shelter in the reef framework on the second pass. In the present survey, both types of fishes were noted on one pass over the 50 m transect line.

RESULTS AND DISCUSSION

Physical Structure

The coastal area covered in this study extends from the Kekaha Sugar Mill to north of Nohili Point. Sandy beaches comprise most of the shoreline along the length of the study area; landward of the beaches lies the Mana Coastal Plain, which is a low flat area that is presently planted in sugarcane. Owing to the low elevation of the plain, groundwater and irrigation water must be continually pumped from areas of the plain planted in sugarcane.

Seaward of the beaches that bound the study area, the shoreline is predominantly a limestone bench which extends up to 25 m offshore. Seaward of the margin of the bench, the bottom slopes gradually downward with distance offshore. The underwater physiographic structure off the Kawaiele and Kekaha Mill sites is very similar. Both of these areas are characterized by flat calcium carbonate (limestone) platforms that appear to be the result of ancient biogenic accumulation of reefal material. These platforms are predominantly flat with little structural relief other than low depressions and channels that are filled with coarse white sand. The surface of the platform is pitted, probably as a result of the boring action of several species of sea urchins. A ubiquitous feature of the reef platforms is a veneer of sandy sediment that appears to be in state of continual resuspension as a result of wave surge. The predominant biotic assemblage on the reef platform is a low algal turf composed of various species of benthic marine algae. Living coral corals are generally sparsely distributed, and occur predominantly as flat encrustations on the flat bottom. At all of the Kekaha monitoring sites, there was very little indication of terrigenous sediment deposition on the reef surface.

While the flat platform typified physiography off the Mill and Kawaiele discharge, a different type of physical structure occurred at the survey site directly off of the Nohili discharge area, especially off the northern edge of the ZOM (transect 10). In this area, the bottom is cut by numerous deep grooves, ledges and caves in what appears to be ancient coral reef platform. Vertical relief of the reef structures is generally from 1-3 m, resulting in a substantially more complex substratum than at the other two sites. Because the vertical relief afforded by the reef structures provides solid surfaces above the bottom (and shifting sediment), settlement of benthos, particularly reef corals is substantially higher than on the flat reef platforms described above.

All of the study sites are directly exposed to long-period swells generated by storms in both the north (winter) and south (summer) Pacific. In addition, the south and western coastal areas of Kauai were impacted by extremely large surf during Hurricanes Iwa *(1982) and Iniki (1992)*. As a result of these physical processes, the nearshore areas at the monitoring sites are subjected to extreme stress from wave impact and scouring of sediment from wave action. As in many locations in the Hawaiian Islands, the composition of coral reef communities is structured primarily in response to physical forces of breaking waves (Dollar 1982, Dollar and Tribble 1993). Such is definitely the case off the Kekaha Mill monitoring sites.

Biotic Community Structure

Coral Community Structure

Appendices A, B, and C show results of the individual quadrat surveys on each transect at the Kekaha Mill, Kawaiele, and Nohili sites, respectively. Table 1 shows the quantitative summary of coral community structure from each of the 10 transects. Seven species of coral were encountered on transects in 1995 (8 in 1994). The most species encountered on a single transect was five, which occurred on transects 1, 8, 9 and 10. On transects 3, 6 and 7, three species occurred, while on transect 5, no corals were encountered.

Mean coral cover on transects ranged from 0% (transect 5) to 25.3% (transect 9). Pooling all transects, mean total coral cover was 10% of bottom cover. The most abundant coral species on transects were *Porites lobata*, which accounted for 33% of coral cover, and 3.3% of bottom cover, and *Pocillopora meandrina*, which accounted for 38% of coral cover, and 3.9% of bottom cover. *Montipora patula* accounted for 14% of coral cover, while *Porites compressa*, which accounted for 12% of coral cover. Thus, four species comprised 97% of coral cover, the remaining 3 species (*Montipora verrucosa, M. flabellata*, and *Palythoa tuberculosa*) comprised only 3% of coral cover, and 0.3% of bottom cover. In the previous survey conducted in 1994, results were similar, with total coral cover equaling 9.7% of bottom cover, and the four dominant species comprising 94% of coral cover.

Examination of the quantitative results in Table 1 indicate several major trends. It can be seen that coral cover, both in terms of percent cover and number of species, is higher at the Nohili discharge site transects than at either the Mill discharge or the Kawaiele discharge sites. As described in the section above, the physical structure of the Nohili area appears to be a more favorable habitat for reef coral growth than the flat platforms that characterize the other two sites. Coral growth on the flat reef platforms may be limited by shifting marine sands that inhibit planular settlement and abrade coral tissue. Owing to elevation off the bottom, the vertical faces and elevated top of the reef structures at Nohili are not exposed to such stress from shifting marine sands.

Examination of the survey results indicates that there does not appear to be any pattern of coral community structure that are functions of distance from the sugarcane water discharges. At the Kawaiele site, the highest coral cover occurred at transect 6, within the ZOM, while there was zero coral cover on one of the control transects for the same discharge (transect 5). Coral cover on the three transects within the ZOM of the Nohili discharge (transects 8-10) differed by only 2% (23%-25%), with the highest cover on the transect closes to the outfall.

Such results are not unexpected, as there does not appear to be any forcing factors (terrigenous sediments) or changes in water chemistry that appears to extend to the distance offshore where the transects were located. Rather, it appears that the distribution of coral communities is strictly a function of natural factors, primarily wave forces and substratum complexity. Similar studies of water quality in the vicinity of a cooling water effluent discharge at Port Allen, located to the southeast of the Kekaha Mill site have produced similar results as the Kekaha studies. At Port Allen, freshwater effluent is restricted to a surface layer that does not extend to the ocean floor. Thus, even if there were constituents of the discharge plume that were potentially damaging, the benthos (bottom dwellers) would rarely be exposed to these plume constituents.

Comparing the results of the 1992, 1994, and 1995 monitoring surveys may reveal if there has been an ongoing degradation of the reef community as a result of the Kekaha discharges. Table 2 shows the quantitative results of mean percent coral cover and number of coral species on transects from the three surveys, as well as the differences in cover between successive surveys. Comparing 1992 and 1994 data, it can be seen in Table 2 that on all transects except No's 4 and 5, where coral cover was essentially zero during both surveys, greater mean coral cover occurred in the 1994 survey. The greatest difference occurred at Transect 10, which was relocated in 1994 from an area entirely composed entirely of a completely scoured bottom to a area of reef structure. However, all of the other survey sites were in approximately the same locations for the two surveys. While part of these changes in cover may be an artifact of the method used in 1994 which providing higher coverage estimates than the point intercept method used in 1992, it appears that there has been no decrease in coral cover (and perhaps an increase) in the two year interval between surveys.

Comparing changes in number of species between the two surveys indicates that on half the transects more coral species were encountered in 1992, and on half more species were encountered in 1994 (Table 2). Again, such a result does not indicate any negative factors associated with discharge from the Kekaha Sugar Company that may have affected coral occurrence.

Comparing coral cover data from the 1994 and 1995 surveys (when identical survey methods were employed) revealed increases in coral cover on 7 of the ten transects. Number of species on the transects decreased on 2 of the 10 transects in 1995 relative to 1994. As discussed above, total coral cover on pooled transects increased slightly in 1995 (10%) compared to 1994 (9.7%).

Other Benthic Invertebrates

The only benthic invertebrates that were observed in any frequency in the study areas were unidentified green and black sponges. Conspicuous by there absence were sea urchins, which are generally common in nearshore areas throughout the Hawaiian Islands. No urchins were encountered in any of the transects in either the 1992, 1994 or 1995 surveys. Several individuals of the urchin *Echinometra matheai* were observed in the area of transect 10; none were observed throughout the regions where the bottom consisted of a flat carbonate platform. As the 1992 monitoring report makes no mention of sea urchins or other motile benthos, it appears that the lack of benthic invertebrates has been a typical characteristic of the area.

Benthic Algae

Benthic algae were common throughout the study area, particularly on the reef platforms that were essentially devoid of coral cover. The continual scouring action of sand appears to be a limiting factor for coral growth on the reef platforms, but not for many species of algae. Virtually all of the limestone reef platforms throughout the study area were covered with a short filamentous algal/diatom turf that is effective in binding sediment. In contrast to coral cover, which is amenable to quantification by assessing areal coverage, most of the algae encountered on transects was as isolated plants with little horizontal coverage of the bottom. As a result, algae abundance on transects was assessed semi-quantitatively by estimating the number of plants per transect. Table 3 shows abundance classes of algal species at each transect location. By far the most abundant algae were the red calcareous algae which were abundant on all transects.

A major difference in the results of the present survey with the 1992 survey was the lack of *Sargassum echinocarpum* during 1994 and 1995. In 1992, it was reported that large areas of the bottom were covered with continuous mats of *S. echinocarpum*; during 1994 and 1995 only several plants of this species were observed throughout the entire study area. It is apparent that the growth of this species is seasonal, with blooms occurring in the summer months. There is no indication of any effect of algal abundance related to the discharges.

Reef Fish Community Structure

The results of reef fish transects for the monitoring surveys are presented in Table 4. The total number of species observed on all transects was 47 (compared to 50 in 1994); species number ranged from 6 to 28 per transects (compared to 6 to 26 in 1994). Individual fish encountered on transects ranged from 41 to 243 (compared to 27 to 145 in 1994) (see Table 4). There were no apparent differences in fish assemblages between stations within the ZOM's and control stations at any of the discharge sites.

In general, the number of species, the number of individuals, and species diversity were higher off the Nohili discharge (transects 8-10) compared to the other two sites. Reef fish community structure appears to be largely determined by the topography and composition of the benthos. The flat reef platform that typified transects 1-7 results in scarcity of habitat suitable for reef fishes, which is reflected in the relatively low numbers of species and individuals. On transects 1-7, fishes were generally concentrated in small depressions which afforded a very limited amount of shelter. On transect 10, in an area of substantially greater vertical relief than any other study site, both the number of fish species and individuals was substantially greater than at the other locations where the bottom was predominantly flat.

Several representative groups of reef fish were most numerous on the transects. Algal-feeding acanthurids were the most numerous single group of fishes observed. The brown surgeonfish (ma'i'i'i, *Acanthurus nigrofuscus*) was the most abundant surgeonfish; other well-represented species were the convict tang (manini, *A. triostegus*), the orangeband surgeonfish (na'ena'e, *A, olivaceus*), and the goldring surgeonfish (kole, *Ctenochaetus strigosus*).

Other families of reef fish that were well-represented included: wrasses, especially the saddleback wrasse (hinalea, *Thalassoma duperrey*); dameselfishes, especially the blackfin chromis (*Chromis vanderbilti*); and goatfishes, especially the manybar goatfish (moano, *Parupeneus multifasciatus*). Also typically encountered on the transects were numerous juvenile reef fish of several species and several triggerfish species.

Comparing results of fish transect surveys in 1992, 1994 and 1995 gives an indication if there has been a decline in reef fish abundance over time (see Table 2). Inspection of Table 2 reveals that on every transect there were more fish species and more individuals recorded in 1994 relative to 1992. The increase in number of species ranged from 2 (transects 5 and 6) to 22 (transect 10), while the increase in the number of individuals ranged from 9 (transect 5) to 131 (transect 10). Even with the consideration that the location of transect 10 was moved in 1994, it appears that there is no indication of reduced reef fish populations in the area that could be attributed to the Kekaha Sugar Company discharges between these two surveys. Comparing results of the 1994 and 1995 reveals that there were more species observed in 1995 on 5 transects, and no change on 1 transect. Comparing numbers of fish, there were more individuals on 7 of the 10 transects in 1995. The greatest differences between both sets of surveys with regard to number of fish occurred on transect 10. In 1994 there were 131 more fish than in 1992, while in 1995 there were 98 more fish than in 1994. None of these results suggests that there was any negative effect to fish abundance as a result of discharges from Kekaha Sugar Company.

SUMMARY

1. Biological community monitoring for the Kekaha Sugar Mill discharges NPDES/ZOM permit was carried out for the third time in March 1995. Ten transect survey stations that were established in 1991 were revisited and assessed for biotic structure. Stations were located with and outside of the ZOM boundaries off the Kekaha Sugar Mill Discharge (transects 1-3), off the Kawaiele irrigation water discharge (transects 4-6), between the Kawaiele and Nohili ZOM's (transect 7), and off the Nohili irrigation water discharge (transects 8-10). All transect locations were positioned as closely as possible to the locations described in the 1992 monitoring survey with the exception of transect 10, which was moved to the northern boundary of the ZOM.

2. Physical structure of the nearshore region consists predominantly of sand beaches and nearshore reef platforms in the intertidal area. The predominant physical character of the nearshore reef throughout the Kekaha area consists of a flat limestone platform that is devoid of most physical relief except for low depressions and channels filled with sand. A layer of marine sediment covers the limestone platform and is constantly in motion owing to current and wave energy. The one exception to this physiography is transect 10, where bottom

composition consisted of undercut ledges, grooves and channels cut from an ancient coral reef with vertical relief of 1-3 m.

3. On the reef platforms, coral cover is relatively low owing to the abrasive quality of the shifting sand substratum. Mean coral cover on the ten transects ranged from zero to 25%, with the highest cover on transects 9 and 10, where relief was highest. There was no apparent difference in coral community structure as a function of location within, or outside of the ZOM. Comparison of coral cover between the 1992, 1994 and 1995 surveys suggests that there has been no decrease in coral abundance with time. Rather, it appears that coral communities may be increasing in coverage over the three year span of monitoring.

4. A variety of marine algae are common on the reef platform that appear to be able to withstand continual abrasion from shifting sand. The widespread beds of *Sargassum echinocarpum* that were noted in the 1992 survey were not present in 1994 or 1995, probably because the algal blooms on a seasonal cycle. There was no indication of any effect on algal communities from sugarcane discharge.

5. Reef fish community structure off the Kekaha survey sites appears to be a function of habitat complexity. Number of species and number of individuals were substantially higher at the Nohili discharge site owing to the shelter afforded by the three dimensional aspects of the reef. Results of fish surveys did not reveal any obvious changes in community structure as a function of location within or beyond the ZOM boundaries. Comparisons of estimates of fish abundance between 1992 and 1994 indicate substantially higher numbers of individuals and species in the most recent survey. Similarly, there are no indications of reduced fish species or individuals in 1995 compared to 1994. Such temporal comparisons suggests that there is no ongoing impact to fish communities as a result of discharge from the Kekaha Sugar Company.

6. None of the data obtained in the monitoring surveys indicates any impacts from the Kekaha Sugar Company discharges to marine communities on the reefs adjacent to the discharge. Such a result is not unexpected as the discharge plumes are observed to mix rapidly with ocean water to background concentrations by natural turbulent conditions. Rather, marine communities appear to be primarily controlled by natural physical factors associated with wave energy, sediment scour and substrate complexity.

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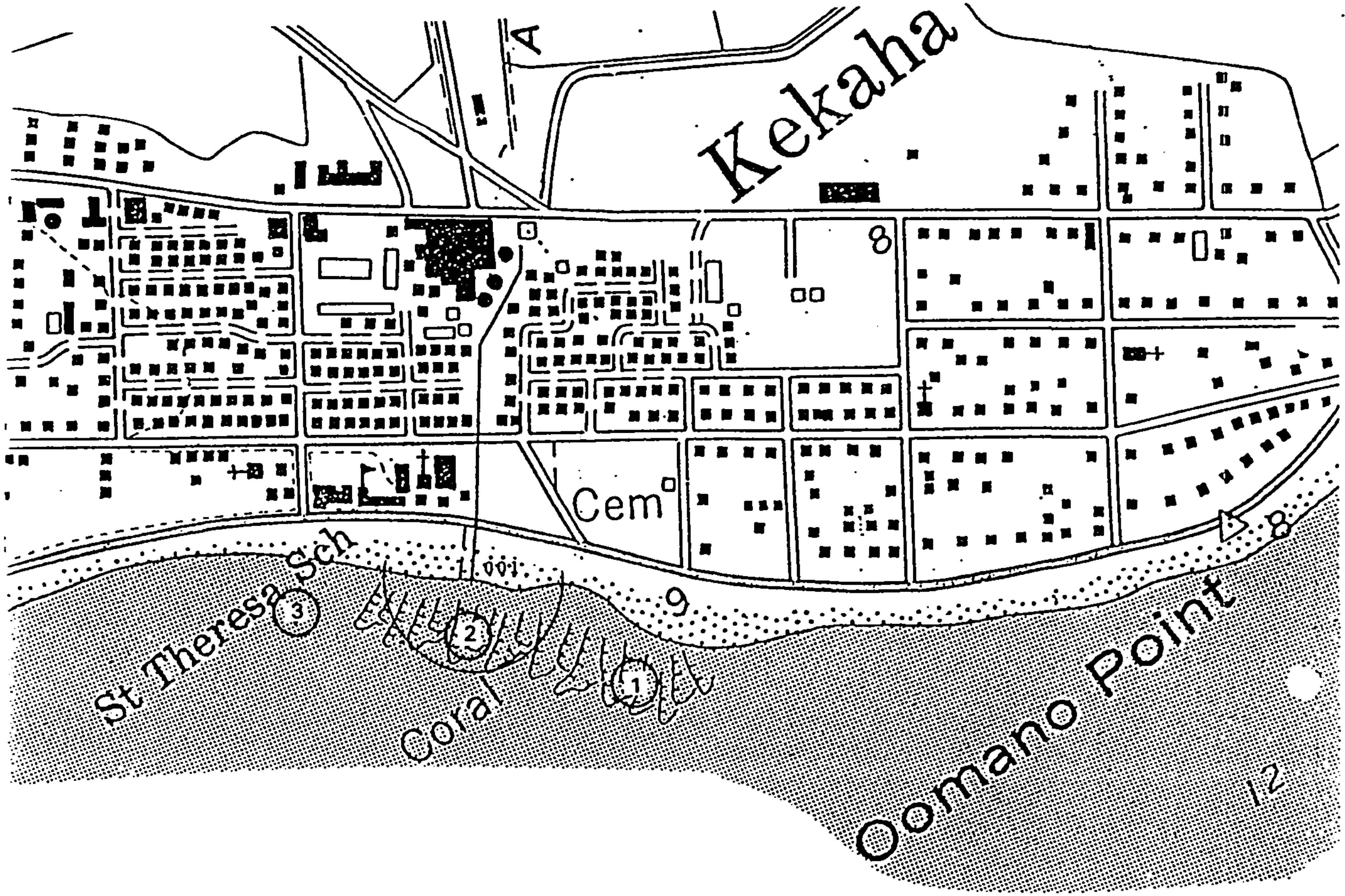

FIGURE 1. Zone of Mixing and location of benthic monitoring stations in the vicinity of the Kekaha Sugar Mill discharge.

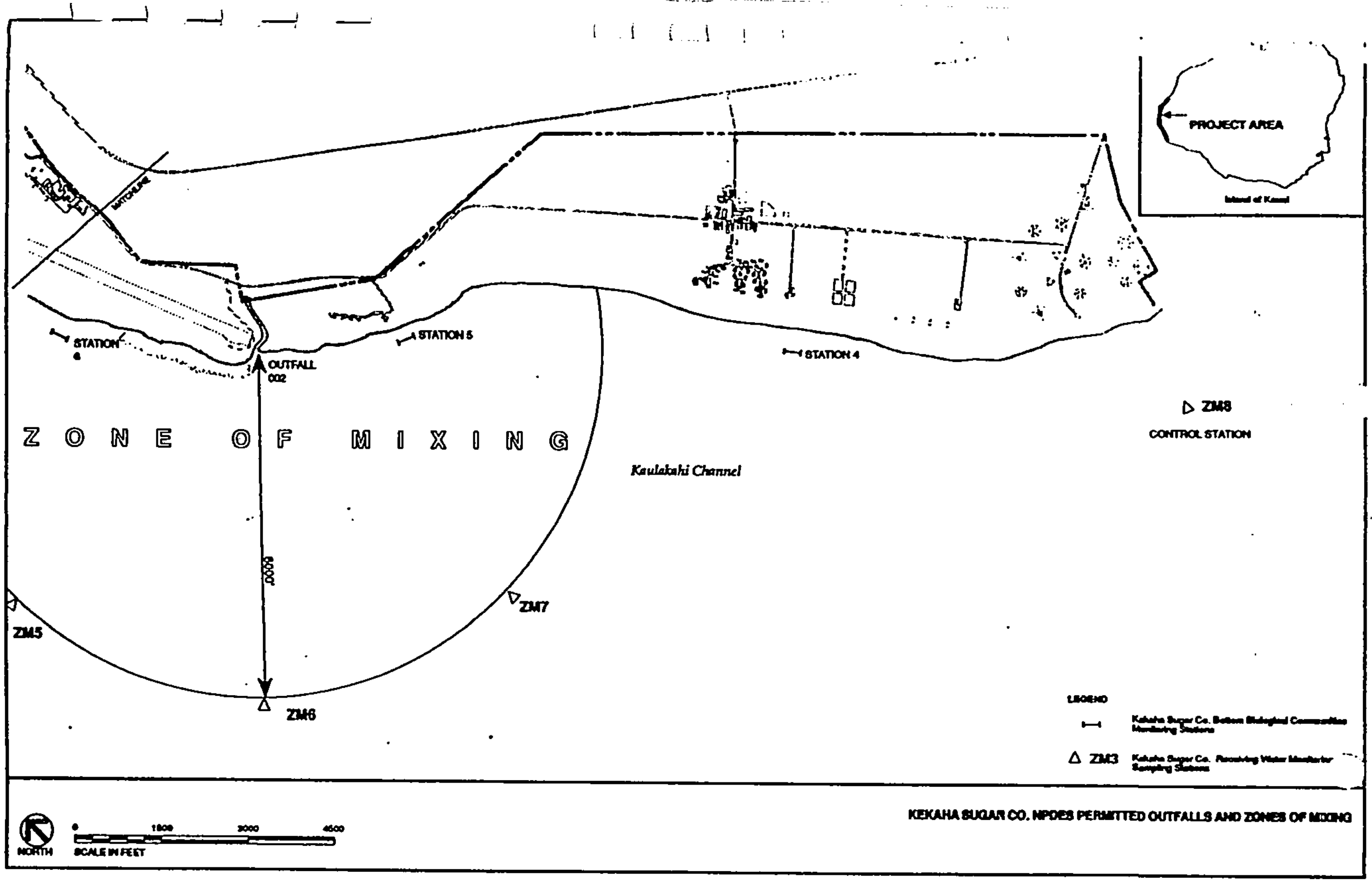

FIGURE 2. Zone of Mixing and location of benthic monitoring stations in the vicinity of the Kawaiele discharge.

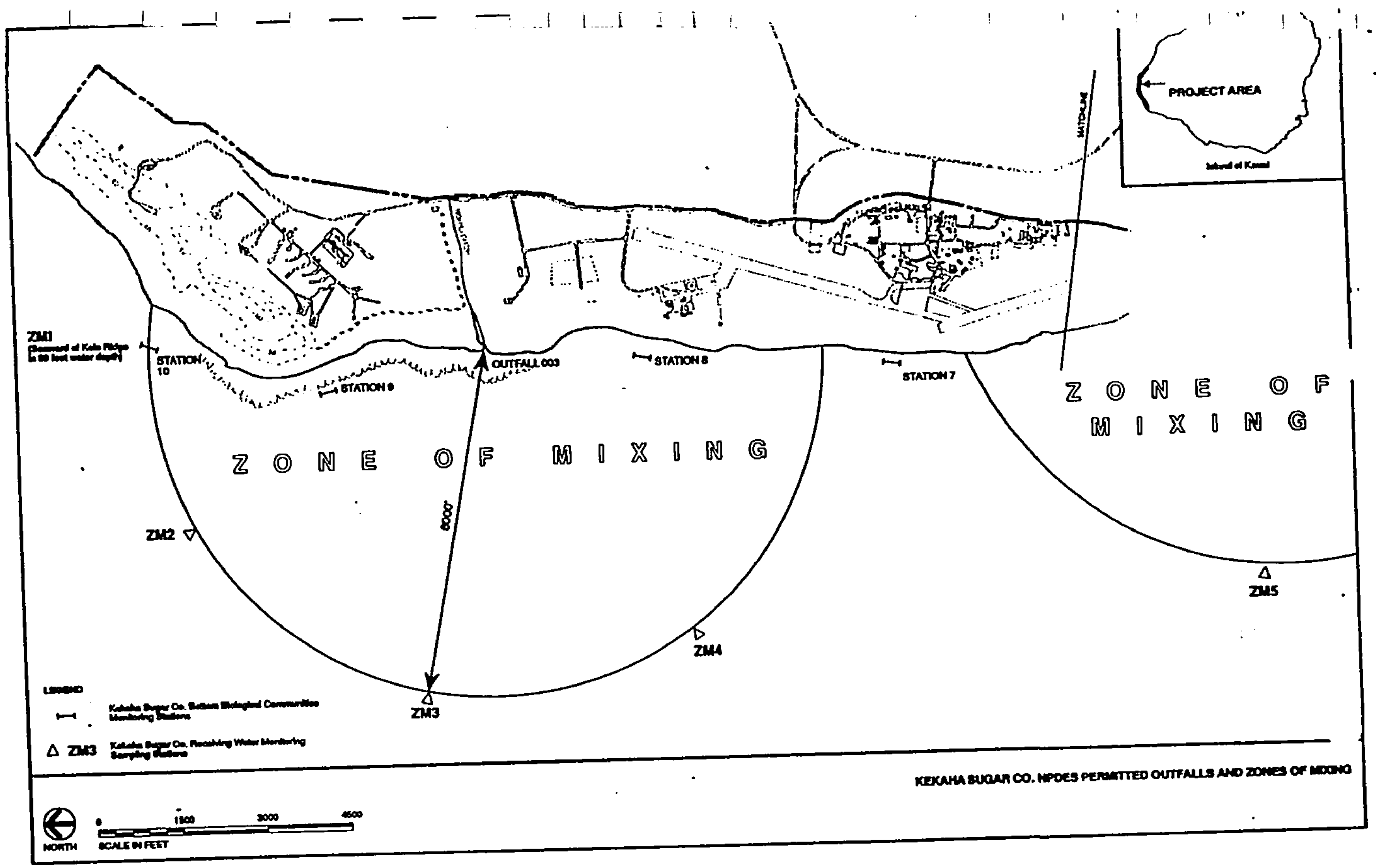

FIGURE 3. Zone of Mixing and location of benthic monitoring stations in the vicinity of the Nohili discharge.

TABLE 1. Percent coral cover and non-coral substratum cover on transects surveyed in the vicinity of the Kekaha Sugar Company discharges in March 1995. For location of survey sites, see Figures 1-3.

	MILL DISCHARGE		
CORAL SPECIES	TRANSECT 1	TRANSECT 2	TRANSECT 3
	8'	10'	6'
Porites lobata	6.7		0.8
Porites compressa	1.4		1.1
Pocillopora meandrina	1.9	0.2	0.2
Montipora patula	0.1		
Palythoa tuberculosa	0.3		
TOTAL CORAL COVER	10.4	0.2	2.1
NUMBER OF SPECIES	5	1	3
CORAL COVER DIVERSITY	0.86	0.00	0.93
NON-CORAL SUBSTRATA			
Limestone	78.2	63.9	83.8
Sand	11.4	35.9	14.1

	KAWAIELE DISCHARGE			
CORAL SPECIES	TRANSECT 4	TRANSECT 5	TRANSECT 6	TRANSECT 7
	42'	20'	20'	24'
Porites lobata	0.9		5.9	2.6
Porites compressa			0.5	0.5
Pocillopora meandrina	0.6		0.6	3.5
TOTAL CORAL COVER	1.5	0.0	7.0	6.6
NUMBER OF SPECIES	2	0	3	3
CORAL COVER DIVERSITY	0.64	0.00	0.54	0.90
NON-CORAL SUBSTRATA				
Limestone	70.6	60.5	80.6	76.3
Sand	27.9	39.5	12.4	18.3

	NOHILI DISCHARGE		
CORAL SPECIES	TRANSECT 8	TRANSECT 9	TRANSECT 10
	24'	20'	24'
Porites lobata	7.4	8.1	0.4
Porites compressa	4.1	4.5	
Pocillopora meandrina	11.0	5.2	15.4
Montipora patula	0.2	7.2	6.6
Montipora verrucosa	0.3	0.3	0.2
Montipora flabellata		0.2	1.7
TOTAL CORAL COVER	23.0	25.3	24.3
NUMBER OF SPECIES	5	5	5
CORAL COVER DIVERSITY	1.12	1.41	0.94
NON-CORAL SUBSTRATA			
Limestone	77.0	74.7	75.7
Sand			

TABLE 2. Comparison of benthic and fish transect data from 1992 (AECOS, 1993), 1994 and 1995 at Kekaha Sugar Company Discharge sites. Positive change indicates increased counts in 1994 relative to 1992; and in 1995 relative to 1994; negative change indicates decreased counts in 1994 relative to 1992, and in 1995 relative to 1994.

TRANSECT NUMBER	MEAN % CORAL COVER					NUMBER OF CORAL SPECIES				
	1992	1994	1995	CHANGE 92-94	CHANGE 94-95	1992	1994	1995	CHANGE 92-94	CHANGE 94-95
1	0.8	9.7	10.4	8.9	0.7	2	3	5	1	2
2	0.0	6.8	0.2	6.8	-6.6	0	3	1	3	-2
3	0.0	6.8	2.1	6.8	-4.7	1	3	3	2	0
4	0.02	0.0	1.5	-0.02	1.5	2	0	2	-2	2
5	0.02	0.0	0.0	-0.02	0.0	2	0	0	-2	0
6	5.9	12.1	7.0	6.2	-5.1	9	3	3	-6	0
7	3.4	5.3	6.6	1.9	1.3	7	5	3	-2	-2
8	1.2	20.3	23.0	19.1	2.7	3	5	5	2	0
9	10.2	12.4	25.3	2.2	12.9	7	5	5	-2	0
10	0.0	23.8	24.3	23.8	0.5	0	5	5	5	0

TRANSECT NUMBER	NUMBER FISH SPECIES					NUMBER OF FISH				
	1992	1994	1995	CHANGE 92-94	CHANGE 94-95	1992	1994	1995	CHANGE 92-94	CHANGE 94-95
1	1.0	10.0	11.0	9.0	1.0	1	102	66	101	-36
2	2.0	8.0	10.0	6.0	2.0	3	52	66	49	14
3	3.0	8.0	6.0	5.0	-2.0	6	44	41	38	-3
4	6.00	12.0	11.0	6.00	-1.0	14	76	78	62	2
5	6.00	8.0	8.0	2.00	0.0	18	27	77	9	50
6	4.0	6.0	12.0	2.0	6.0	23	33	67	10	34
7	3.0	11.0	9.0	8.0	-2.0	18	73	59	55	-14
8	3.0	19.0	17.0	16.0	-2.0	10	104	157	94	53
9	6.0	12.0	14.0	6.0	2.0	36	80	100	44	20
10	4.0	26.0	28.0	22.0	2.0	14	145	243	131	98

TABLE 3. Marine algae occurrance on survey transects off Kekaha Sugar Company discharges in March 1995.
For transect locations, see Figures 1-3.
"R" = rare (0 - 5 individuals sighted on station)
"O" = occasional (5 - 20 individuals sighted on station)
"C" = common (more than 20 individuals sighted on station)

	KEKAHA MILL			KAWAIELE				NOHILI		
TRANSECT	1	2	3	4	5	6	7	8	9	10
CHLOROPHYTA										
(Green algae)										
Enteromorpha sp.	C	C	O				R	C	R	
Halimeda spp.	C	R	O	C	O	C	R			
Neomeris annulata	R	R	C	R	R		R	R		
Codium edule					C	O				
CYANOPHYTA										
(Blue-green algae)										
Lyngbya majuscula		R	R						R	
PHAEOPHYTA										
(Brown algae)										
Dictopteris app.	O	C	O			R				
Dictyota spp.	C	C	C	O	O	C	C	C	R	
Padina spp.	O	O	R	R	R	C	R	O	R	
Sargassum echinocarpum								C		
Turbinaria ornata	R	R		R	C	R	C	O		
RHODOPHYTA										
(Red Algae)										
Asparagopsis taxiformis							C	C	C	R
Acanthophora specifera	R	R					R	R		
Amansia glomerata					R					
Desmia hornemanii		R					O			
Dotyella hawaiiensis		C		C	C	C	C			
Galaxaura spp.	R	R	R	C	C	C	C	R		
Hydrolithon spp.	R	C	C	C	C	C	C	C	C	C
Neogoniolithon sp.	C	C	C	C	C	C	C	C	C	C
Peysonellia rubra sp.		C	C	C	C	C	C	C	C	C
Porolithon spp.	C	C	C	C	C	C	C	C	C	C
Jania sp.	C	C	C	C	C	C	C	C	C	C

TABLE 4. Reef fish ab...ance on transects in the vicinity of the Kekaha ...gar Company discharges surveyed in March 1995. For location of transect sites, see Figures 1-3.

	TRANSECT									
	MILL			KAWAIELE				NOHILI		
FAMILY	1	2	3	4	5	6	7	8	9	10
Species	6'	10'	6'	42'	20'	20'	24'	24'	20'	24'
KYPHOSIDAE										
Kyphosus bigibbus	2									7
CIRRHITIDAE										
Paracirrhites arcatus								2	3	
MULLIDAE										
Parupeneus multifasciatus	3	4		5	4	6	2	4	7	
P. porphyreus	1		2							
SERRANIDAE										
Cephalopholis argus						1				
CARANGIDAE										
Caranx melamphygus						2		1		
LUTJANIDAE										
Lutjanus kasmira	20				20					20
L. fulvus	2									2
CHAETODONTIDAE										
Chaetodon lunula										2
C. quadrimaculatus									2	2
C. ornatissimus										2
C. multicinctus						2		2		4
C. auriga								2		
POMACENTRIDAE										
Abudefduf abdominalis			6							12
Plectro. imparipennis							2			2
Stegastes fasciolatus	3	2				2			3	3
Dascyllus albisella										
Chromis vanderbilti		25	20	30	15	25	20	42	12	
C. ovalis			4	3	2					
LABRIDAE										
Bodianus bilunulatus									1	
Coris venusta				2						
Anampses cuvier										1
Thalassoma duperrey	9	8	8	7	21	3	6	16	17	12
T. trilobatum			1							
Gomphosus varius										2
Halichoeres ornatissimus								2	2	
SCARIDAE										
Scarus sordidus		3								3
S. perspicillatus								2		2
juvenile Scarus	4							3		8
ACANTHURIDAE										
Acanthurus achilles										11
A. triostegus		3					14	12	12	12
A. leucopareius										16
A. olivaceus				4				39	16	3
A. dussumieri	2									7
A. blochii	2	4				2		6		8
A. nigrofuscus	18	12		13	11	17	8	16	21	33
Ctenochaetus strigosus		3		6	3	3				42
Naso lituratus								2		
N. unicornis							1			
ZANCLIDAE										
Zanclus cornutus						2		2		2
BLENNIIDAE										
Plagiotremus goslinei				2						
BALISTIDAE										
Rhinecanthus rectangulus						2	2	2	1	1
R. aculeatus										
Sufflamen bursa				4			2		2	
S. fraenatus				1	1					
Melichthys niger										22
TETRADONTIDAE										
Canthigaster jactator		2							2	2
NUMBER SPECIES	11	10	6	11	8	12	9	17	14	28
NUMBER INDIVIDUALS	68	66	41	78	77	67	69	167	100	243
SPECIES DIVERSITY	1.93	1.91	1.42	1.96	1.73	1.90	1.78	2.16	2.22	2.82

APPENDIX A. Quadrat coral cover at Kekaha Mill Outfall transects.

PERCENT COVER KEKAHA SUGAR MILL

TRANSECT SITE: MILL DISCHARGE
Transect 1, 8'
DATE: 3/25/95

MEAN CORAL COVER 10.4
STD. DEV. 4.1
SPECIES COUNT 5
SPECIES DIVERSITY 0.864

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata		2		11	7	6	9	2	17	14	6.7
Porites compressa				3	1	2		8			1.4
Pocillopora meandrina		10	8								1.8
Montipora patula			1							1	0.1
Palythoa tuberculosa	2				1						0.3
QUAD CORAL TOTAL	2	12	9	14	9	7	9	10	17	16	10.4
Limestone	50	78	86	79	91	93	72	90	65	78	78.2
Sand	48	10	5	7			19		18	7	11.4
NON-CORAL TOTAL	98	88	91	86	91	93	91	90	83	85	89.6

TRANSECT SITE: MILL DISCHARGE
Transect 2, 10'
DATE: 3/25/95

MEAN CORAL COVER 0.2
STD. DEV. 0.6
SPECIES COUNT 1
SPECIES DIVERSITY 0.000

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Pocillopora meandrina	2										0.2
QUAD CORAL TOTAL	2	0	0	0	0	0	0	0	0	0	0.2
Limestone	83	83	87	97	66	58			78	87	63.9
Sand	15	17	13	3	34	42	100	100	22	13	35.9
NON-CORAL TOTAL	98	100	100	100	100	100	100	100	100	100	99.8

TRANSECT SITE: MILL DISCHARGE
Transect 3, 6'
DATE: 3/25/95

MEAN CORAL COVER 2.1
STD. DEV. 2.0
SPECIES COUNT 3
SPECIES DIVERSITY 0.930

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	3	1	1						2	1	0.8
Porites compressa			3		5				3		1.1
Pocillopora meandrina										2	0.2
QUAD CORAL TOTAL	3	1	4	0	5	0	0	0	5	3	2.1
Limestone	66	73	92	94	52	94	83	92	95	97	83.8
Sand	31	26	4	6	43	6	17	8			14.1
NON-CORAL TOTAL	97	99	96	100	95	100	100	100	95	97	97.9

APPENDIX B. Quadrat coral cover at Kawaiele Outfall transects

PERCENT COVER	KEKAHA SUGAR MILL										
TRANSECT SITE:	KAWAIELE OUTFALL				MEAN CORAL COVER				1.6		
	Transect 4, 42'				STD. DEV.				3.4		
DATE:	3/25/95				SPECIES COUNT				2		
					SPECIES DIVERSITY				0.673		
SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata					5					4	0.9
Pocillopora meandrina					6						0.6
QUAD CORAL TOTAL	0	0	0	0	11	0	0	0	0	4	1.5
Limestone	76	73	84	51	74	73	61	75	73	66	70.6
Sand	24	27	16	49	15	27	39	25	27	30	27.9
NON-CORAL TOTAL	100	100	100	100	89	100	100	100	100	96	98.5

TRANSECT SITE:	KAWAIELE OUTFALL				MEAN CORAL COVER				0.0		
	Transect 5, 20'				STD. DEV.				0.0		
DATE:	3/25/95				SPECIES COUNT				0		
					SPECIES DIVERSITY				0		
SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
QUAD CORAL TOTAL	0	0	0	0	0	0	0	0	0	0	0.0
Limestone	83	78	64	43	55	78	73	76	0	55	60.5
Sand	17	22	36	57	45	22	27	24	100	45	39.5
NON-CORAL TOTAL	100	100	100	100	100	100	100	100	100	100	100.0

TRANSECT SITE:	KAWAIELE OUTFALL				MEAN CORAL COVER				7.0		
	Transect 6, 20'				STD. DEV.				7.2		
DATE:	3/25/95				SPECIES COUNT				3		
					SPECIES DIVERSITY				0.543		
SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	6	7	10	22	8			5	1		5.9
Porites compressa	1				2			2			0.5
Pocillopora meandrina				1	5						0.6
QUAD CORAL TOTAL	7	7	10	23	15	0	0	7	1	0	7.0
Limestone	47	89	85	66	85	84	88	76	90	96	80.6
Sand	46	4	5	11		16	12	17	9	4	12.4
NON-CORAL TOTAL	93	93	90	77	85	100	100	93	99	100	93.0

TRANSECT SITE:	KAWAIELE OUTFALL				MEAN CORAL COVER				6.6		
	Transect 7, 24'				STD. DEV.				5.7		
DATE:	3/25/95				SPECIES COUNT				3		
					SPECIES DIVERSITY				0.899		
SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	2	14	1	1		2		2	2	2	2.6
Porites compressa	3		1							1	0.5
Pocillopora meandrina				2	6	3			8	16	3.5
QUAD CORAL TOTAL	5	14	2	3	6	5	0	2	10	19	6.6
Limestone	95	56	97	74	81	95	76	93	44	52	76.3
Sand		30	1	23	13		24	7	56	29	18.3
NON-CORAL TOTAL	95	86	98	97	94	95	100	100	100	81	94.6

APPENDIX C. Quadrat coral cover at Nohili Outfall.

PERCENT COVER — KEKAHA SUGAR MILL

TRANSECT SITE:	NOHILI OUTFALL Transect 8, 24'	MEAN CORAL COVER	23.0 %
		STD. DEV.	12.0
DATE:	3/25/95	SPECIES COUNT	5
		SPECIES DIVERSITY	1.123

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	18	9	10	6	6	16	6	2	2		7.4
Porites compressa	3		8	7	8	9	4		2		4.1
Pocillopora meandrina	20	8	12	14	11	3	6	35		1	11.0
Montipora verrucosa						1			2		0.3
Montipora patula									2		0.2
QUAD CORAL TOTAL	41	17	30	27	25	29	16	37	8	1	23.0
Limestone	59	83	70	73	75	71	85	63	92	99	77.0
NON-CORAL TOTAL	59	83	70	73	75	71	85	63	92	99	77.0

TRANSECT SITE:	NOHILI OUTFALL Transect 9, 20'	MEAN CORAL COVER	25.3 %
		STD. DEV.	11.6
DATE:	3/25/95	SPECIES COUNT	6
		SPECIES DIVERSITY	1.407

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	12	2	2	14	2	1	21	6		21	8.1
Porites compressa	2	2	12	2	3	2		12	4	6	4.6
Pocillopora meandrina		3	5			10	4	10	16	4	6.2
Montipora verrucosa			1							2	0.3
Montipora patula	21	2		2		12	14		21		7.2
Montipora flabellata										2	0.2
QUAD CORAL TOTAL	35	9	20	18	5	25	39	28	41	33	25.3
Limestone	65	91	80	82	95	75	61	72	59	67	74.7
NON-CORAL TOTAL	65	91	80	82	95	75	61	72	59	67	74.7

TRANSECT SITE:	NOHILI OUTFALL Transect 10, 24'	MEAN CORAL COVER	24.3 %
		STD. DEV.	9.3
DATE:	3/25/95	SPECIES COUNT	5
		SPECIES DIVERSITY	0.936

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata			3	1							0.4
Pocillopora meandrina	4	22	18	1	24	2	16	21	22	24	15.4
Montipora verrucosa									2		0.2
Montipora patula	5		1	4	3	14	1	14	14	10	6.6
Montipora flabellata	3	2		8		1			3		1.7
QUAD CORAL TOTAL	12	24	22	14	27	17	17	35	41	34	24.3
Limestone	88	76	78	86	73	83	83	65	59	66	75.7
NON-CORAL TOTAL	88	76	78	86	73	83	83	65	59	66	75.7

ZONE OF MIXING BIOLOGICAL MONITORING FOR OCEAN DISCHARGES FROM THE KEKAHA SUGAR COMPANY, KEKAHA, KAUAI, HAWAII

(NPDES Permit HI0000086)

Prepared for

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April 1994

INTRODUCTION

The Kekaha Sugar Company operates permitted discharges into the Pacific Ocean at three points along the southwest coast of Kauai between the northern boundary of Polihale State Park and Oomano Point on the south (Figures 1-3). Moving from south to north, one discharge point is the Kekaha Sugar Mill Ditch, which discharged thermal effluent from the mill for many years, but is not presently in use (Figure 1). Discharges of water pumped from sugarcane fields are located off of the Kawaiele Pumping Station (Figure 2) and near Nohili Point (Figure 3). Water pumped into the drainage discharges has a salinity of approximately 10°/oo (T. Nance, *personal communication*) indicating that is approximately 1/3 seawater and 2/3 freshwater from groundwater and sugarcane irrigant leachate.

In compliance with the provisions of the Clean Water Act, Chapter 342D, Hawaii Revised Statutes, and the Administrative Rules of the Department of Health, the Kekaha Sugar Company was issued a National Pollutant Discharge Elimination System (NPDES), and Zones of Mixing (ZOM's) Permit (No. HI 0000086) on May 24, 1990 to discharge sugar cane effluent from three points along the shoreline. The permit establishes three ZOM's which are defined as arcs with the center points specified as the points of discharge at the shoreline. The ZOM's extend vertically from the surface of the ocean to the seafloor. The radii of the arcs of the Nohili and Kawaiele ZOM's are 6,000 feet in length (Figures 2 and 3), while at the Kekaha Mill Ditch discharge, the radius of the arc defining the ZOM is 350 feet in length (Figure 1). Within the boundaries of the ZOM's, State of Hawaii water quality standards may be exceeded in the receiving waters; beyond the boundaries, water quality standards (including impacts to indigenous populations) cannot be exceeded.

Conditions of the Kekaha Sugar Mill NPDES/ZOM permit specify certain monitoring criteria to ensure maintenance of water quality and indigenous populations of marine organisms. With respect to monitoring of biological populations, compliance with permit conditions is assessed by comparing results of quantitative community analyses within and outside of the ZOM's conducted once during an annual cycle. The purpose of this report is to present the results of biological communities monitoring program conducted in April 1994 to assess the effects of the Kekaha Sugar Company discharges on marine communities.

To comply with conditions of the permit, surveys of the coral reef community structure (benthos and fish) were conducted at ten survey sites in April 1994. The locations of the survey sites were replicated as closely as possible (with one exception) to those surveyed in the previous benthic monitoring survey conducted in 1992 (AECOS 1993). Presented below are the methods, results and conclusions of the monitoring survey at the Kekaha Sugar Mill discharge sites.

METHODS

Biotic structure of the marine environment in the vicinity of the Kekaha Sugar Mill discharges was evaluated by establishing a descriptive and quantitative baseline of benthic reef communities. Key components of reef communities include hermatypic and soft corals, benthic algae, motile macroinvertebrates, and reef fish.

The monitoring surveys were conducted on April 16-17, 1994. All fieldwork was carried out by divers using SCUBA equipment, working out of a 26-foot boat. Biotic structure of communities inhabiting the reef environment was evaluated on the transects that were established for the 1992 monitoring program (AECOS 1993). Listed below are the locations and water depth (in parentheses) of each transect at the three discharges:

Mill Ditch Outfall (001)

Transect 1 - (7 feet); outside the ZOM, approximately 700 feet south of the outfall and approximately 175 feet from the shoreline (southern control).

Transect 2 - (8 feet); directly seaward of the outfall, approximately midway between the shoreline and the seaward edge of the ZOM boundary (175 feet from the shoreline).

Transect 3 - (7 feet); outside the ZOM, approximately 700 feet north of the outfall and approximately 175 feet from the shoreline.

Kawaiele Outfall (002)

Transect 4 - (42 feet); outside the ZOM, approximately 9,000 feet south of the Kawaiele discharge, approximately 200 feet from the shoreline.

Transect 5 - (22 feet); within the southern portion of the ZOM, approximately one-half the distance from the outfall and the southern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 6 - (17 feet); within the northern portion of the ZOM, approximately one-half the distance from the outfall and the northern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 7 - (23 feet); outside the ZOM, approximately 7,500 feet north of the Kawaiele discharge, approximately 200 feet from the shoreline (northern control).

Nohili Outfall (003)

Transect 8 - (23 feet); outside of the ZOM, approximately midway between the boundaries of the Nohili and Kawaiele ZOM's, approximately 200 feet from the shoreline.

Transect 9 - (20 feet); within the southern portion of the ZOM approximately midway between the point of discharge and the southern boundary of the ZOM, approximately 200 feet from the shoreline.

Transect 10 - (24 feet); On the northern boundary of the ZOM, 6,000 from the point of discharge and approximately 200 feet from the shoreline. The location of this transect was changed from the previous survey when it was located 9,000 feet from the point of discharge. At this location, bottom composition consisted completely of scoured limestone owing to a completely different physical regime of wave stress than within the ZOM. As a result, transect 10 was located in a totally different habitat than within the ZOM. In order to conduct the required analyses to evaluate effects from the discharges, it is essential that all transects are conducted in similar habitats. Thus, the location of transect 10 was moved to the approximate boundary of the ZOM, which was an area with similar physical stress as the rest of the survey area at Nohili.

Each transect was oriented parallel to depth contours so as to bisect a single reef zone. Care was taken to place transects in random locations that were not biased toward either peak or low coral cover. Quantitative benthic surveys were conducted by stretching a 50-meter long surveying tape in a straight line over the reef surface. An aluminum quadrat frame, with dimensions of 1 m by 0.66 m, was sequentially placed over 10 random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver knowledgeable in the taxonomy of resident species visually estimated the percent cover and occurrence of organisms and substratum type within the quadrat frame. No attempt was made to disturb substrata to observe organisms, and no attempt was made to identify and enumerate cryptic species dwelling within the reef framework. Only macrofaunal species greater than approximately 2 centimeters were noted.

Following the period of fieldwork, quadrat photographs were projected onto a grid divided into 100 equal units, and units of bottom cover for each benthic faunal species and bottom type were recorded to the nearest 1 percent. Results of the photo-quadrats were combined with the in-situ cover estimates and community structure parameters (percent cover, number of species, species diversity) were calculated. The photo-quadrat transect method is a modification of the technique described in Kinzie and Snider (1978), and has been employed in numerous field studies of Hawaiian reef communities (e.g. Dollar 1979, Grigg and Maragos 1974). The method was selected for the Kekaha monitoring program because it has proven to be particularly useful for quantifying coverage of attached benthos such as corals and large epifauna (e.g., sea urchins, sea cucumbers) that are the major components of the communities in the study area. In addition, the method provides a permanent photographic record which can be useful for comparative purposes in long-term investigations. While this methodology is quantitative for the larger exposed fauna, many coral reef invertebrates are cryptic or nocturnal. Coupled with the generally small size of cryptic invertebrates, quantitative assessment of these groups requires methodologies that are beyond the scope of the present monitoring program.

The transecting method used during the 1992 benthic monitoring survey (AECOS 1993) was somewhat different than the present survey. In the 1992 survey, a 25 m transect line was used with 1 m^2 quadrats placed every 5 m. Thus, a total area of 5 m^2 was evaluated, compared to the 6.6 m^2 surveyed in the present program. In addition, the random location of the 10 quadrats along the transect line provides for a more representative characterization of the habitat than the 5 uniformly placed quadrats along a 25 m line. The survey technique employed in the 1992 survey utilized a point intercept method for 100 intersections within each quadrat. By utilizing only point intercepts, the probability of missing rare or small colonies is greater than the method used in the present study which accounts for the entire area (and all organisms present) within the quadrat frame. In addition, the photo-quadrat method employed for the present survey provides a permanent record of the surveyed benthos which was not provided by the point intercept method used in 1992. Thus, while the methods used in the two surveys are not identical, it appears that the techniques employed in the present program provide a better characterization of the reef communities as they exist today. Both methods, however, were similar in that cryptic fauna or organisms smaller than 2 cm in length were not evaluated. As the purpose of the monitoring is to determine if there are effects to these communities from continuous discharge of water from sugarcane activities, it does not appear that the variation in methods creates a problem in interpretation. Rather, using the best methods for describing community attributes will provide the best estimates of effect to marine communities from activities on land.

Quantitative assessment of reef fish community structure was conducted in conjunction with the benthic surveys. As the transect tape was being laid along the bottom, all fish observed within a band approximately 2 meters wide along the transect path were identified by species name and enumerated. Care was taken to conduct the fish surveys so that the minimum disturbance was created by divers, ensuring the least possible dispersal of fish. Only readily visible individuals were included in the census. No attempt was made to seek out cryptic species or individuals sheltered within coral. This transect method is an adaptation of techniques described in Hobson (1974). The method employed in the 1992 survey was slightly different in that the investigator made two passes over a 25 m transect, noting large motile fishes on the first pass, and smaller individuals that tend to seek shelter in the reef framework on the second pass. In the present survey, both types of fishes were noted on one pass over the 50 m transect line.

RESULTS AND DISCUSSION

Physical Structure

The coastal area covered in this study extends from the Kekaha Sugar Mill to north of Nohili Point. Sandy beaches comprise most of the shoreline along the length of the study area; landward of the beaches lies the Mana Coastal Plain, which is a low flat area that is presently planted in sugarcane. Owing to the low elevation of the plain, groundwater and irrigation water must be continually pumped from areas of the plain planted in sugarcane.

Seaward of the beaches that bound the study area, the shoreline is predominantly a limestone bench which extends up to 25 m offshore. Seaward of the margin of the bench, the bottom slopes gradually downward with distance offshore. The underwater physiographic structure off the Kawaiele and Kekaha Mill sites is very similar. Both of these areas are characterized by flat calcium carbonate (limestone) platforms that appear to be the result of ancient biogenic accumulation of reefal material. These platforms are predominantly flat with little structural relief other than low depressions and channels that are filled with coarse white sand. The surface of the platform is pitted, probably as a result of the boring action of several species of sea urchins. A ubiquitous feature of the reef platforms is a veneer of sandy sediment that appears to be in state of continual resuspension as a result of wave surge. The predominant biotic assemblage on the reef platform is a low algal turf composed of various species of benthic marine algae. Living coral corals are generally sparsely distributed, and occur predominantly as flat encrustations on the flat bottom. At all of the Kekaha monitoring sites, there was very little indication of terrigenous sediment deposition on the reef surface.

While the flat platform typified physiography off the Mill and Kawaiele discharge, a different type of physical structure occurred at the survey site directly off of the Nohili discharge area, especially off the northern edge of the ZOM (transect 10). In this area, the bottom is cut by numerous deep grooves, ledges and caves in what appears to be ancient coral reef platform. Vertical relief of the reef structures is generally from 1-3 m, resulting in a substantially more complex substratum than at the other two sites. Because the vertical relief afforded by the reef structures provides solid surfaces above the bottom (and shifting sediment), settlement of benthos, particularly reef corals is substantially higher than on the flat reef platforms described above.

All of the study sites are directly exposed to long-period swells generated by storms in both the north (winter) and south (summer) Pacific. In addition, the south and western coastal areas of Kauai were impacted by extremely large surf during Hurricanes Iwa (1982) and Iniki (1992). As a result of these physical processes, the nearshore areas of the monitoring areas is subjected to extreme stress from wave impact and scouring of sediment from wave action. As in many locations in the Hawaiian Islands, the composition of coral reef communities is structured primarily in response to physical forces of breaking waves (Dollar 1982, Dollar and Tribble 1993). Such is definitely the case off the Kekaha Mill monitoring sites.

Biotic Community Structure

Coral Community Structure

Appendices A, B, and C show results of the individual quadrat surveys on each transect at the Kekaha Mill, Kawaiele, and Nohili sites, respectively. Table 1 shows the quantitative summary of coral community structure from each of the 10 transects. Eight species of coral were encountered on transects in 1994. The most species encountered on a single transect was five, which occurred on transects 7-10. On transects 1-3 and 6, three species occurred, while on transects 4 and 5, no corals were encountered.

Mean coral cover on transects ranged from 0% (transects 4 and 5) to 23.8% (transect 10). The most abundant coral species on transects were *Porites lobata*, which accounted for 38% of coral cover, *Pocillopora meandrina*, which accounted for 31% of coral cover, and *Porites compressa*, which accounted for 14% of coral cover. As these three species comprised 83% of coral cover, the remaining 4 species (*Montipora patula, M. verrucosa, Pocillopora eydouxi, Pavona varians,* and *Palythoa tuberculosa*) comprised only 17% of coral cover.

Examination of the quantitative results in Table 1 indicate several major trends. It can be seen that coral cover, both in terms of percent cover and number of species, is higher at the Nohili discharge site transects than at either the Mill discharge or the Kawaiele discharge sites. As described in the section above, the physical structure of the Nohili area appears to be a more favorable habitat for reef coral growth than the flat platforms that characterize the other two sites. Coral growth on the flat reef platforms may be limited by shifting marine sands that inhibit planular settlement and abrade coral tissue. Owing to elevation off the bottom, the vertical faces and elevated top of the reef structures at Nohili are not exposed to such stress from shifting marine sands.

Examination of the survey results indicates that there does not appear to be any pattern of coral community parameters as functions of distance from the sugarcane water discharges. At the Kawaiele site, the highest coral cover occurred at transect 6, within the ZOM, while there was zero coral cover on one of the control transects for the same discharge (transect 4). The highest coral cover (23.8%) occurred on transect 10, at the northern boundary of the ZOM off the Nohili discharge. Such results are not unexpected, as there does not appear to be any forcing factors (terrigenous sediments) or changes in water chemistry that appears to extend to the distance offshore where the transects were located. Rather, it appears that the distribution of coral communities is strictly a function of natural factors, primarily wave forces and substratum complexity. Similar studies of water quality in the vicinity of a cooling water effluent discharge at Port Allen, located to the southeast of the Kekaha Mill site, indicates that freshwater effluent is restricted to a surface layer that does not extend to the ocean floor. Thus, even if there were constituents of the discharge plume that were potentially damaging, the benthos (bottom dwellers) would rarely be exposed to these plume constituents.

Comparing the results of the 1992 and 1994 monitoring surveys may reveal if there has been an ongoing degradation of the reef community as a result of the Kekaha discharges. Table 2 shows the quantitative results of mean percent coral cover and number of coral species on transects from the two surveys. While the methodologies employed in the two surveys differed somewhat, the results can be compared to provide an indication if major changes have occurred to the coral communities. It can be seen in Table 2 that on all transects except No's 4 and 5, where coral cover was essentially zero during both surveys, greater mean coral cover occurred in the 1994 survey. The greatest difference occurred at Transect 10, which was relocated in 1994 from an area entirely composed entirely of a completely scoured bottom to a area of reef structure. However, all of the other survey sites were in approximately the same locations for the two surveys. While part of these changes in cover may be an artifact of the method used in 1994 which providing higher coverage estimates than the point intercept method used in 1992, it appears that there has been no decrease in coral cover (and perhaps an increase) in the two year interval between surveys.

Comparing changes in number of species between the two surveys indicates that on half the transects more coral species were encountered in 1992, and on half more species were encountered in 1994 (Table 2). Again, such a result does not indicate any negative factors associated with mill discharge that may have affected coral occurrence.

Other Benthic Invertebrates

The only benthic invertebrates that were observed in any frequency in the study areas were unidentified green and black sponges. Conspicuous by there absence were sea urchins, which are generally common in nearshore areas throughout the Hawaiian Islands. No urchins were encountered in any of the transects in either the 1992 or 1994 surveys. Several individuals of the urchin *Echinometra matheai* were observed in the area of transect 10; none were observed throughout the regions where the bottom consisted of a flat carbonate platform. As the 1992 monitoring report makes no mention of sea urchins or other motile benthos, it appears that the lack of benthic invertebrates has been a typical characteristic of the area.

Benthic Algae

Benthic algae were common throughout the study area, particularly on the reef platforms that were essentially devoid of coral cover. The continual scouring action of sand appears to be a limiting factor for coral growth on the reef platforms, but not for many species of algae. Virtually all of the limestone reef platforms throughout the study area were covered with a short filamentous algal/diatom turf that is effective in binding sediment. In contrast to coral cover, which s amenable to quantification by assessing areal coverage, most of the algae encountered on transects was as isolated plants with little horizontal coverage of the bottom. As a result, algae abundance on transects was assessed semi-quantitatively by estimating the number of plants per transect. Table 3 shows abundance classes of algal species at each transect location. By far the most abundant algae were the red calcareous algae which were abundant on all transects.

A major difference in the results of the present survey with the 1992 survey was the lack of *Sargassum echinocarpum* during 1994. In 1992, it was reported that large areas of the bottom were covered with continuous mats of *S. echinocarpum*; during 1994 only several plants of this species were observed throughout the entire study area. It is apparent that the growth of this species is seasonal, with blooms occurring in the summer months. There is no indication of any effect of algal abundance related to the discharges.

Reef Fish Community Structure

The results of reef fish transects for the monitoring surveys are presented in Table 4. The total number of species observed on all transects was 50; species number ranged from 6 to 26 per transects. Individual fish encountered on transects ranged from 27 to 145 (see Table 4). There were no apparent differences in fish assemblages between stations within the ZOM's and control stations at any of the discharge sites.

In general, the number of species, the number of individuals, and species diversity were higher off the Nohili discharge (transects 8-10) compared to the other two sites. Reef fish community structure appears to be largely determined by the topography and composition of the benthos. The flat reef platform results in scarcity of habitat suitable for reef fishes is reflected in the relatively low numbers of species and individuals. Across most of the habitat, fishes were concentrated in small depressions which afforded a very limited amount of shelter. On transect 10, in an area of substantial vertical relief, both the number of fish species and individuals was substantially greater than at the other locations where the bottom was predominantly flat.

Several representative groups of reef fish were most numerous on the transects. Algal-feeding acanthurids were the most numerous single group of fishes observed. The brown surgeonfish (ma'i'i'i, *Acanthurus nigrofuscus*) was the most abundant surgeonfish; other well-represented species were the convict tang (manini, *A. triostegus*), the orangeband surgeonfish (na'ena'e, *A, olivaceus*), and the goldring surgeonfish (kole, *Ctenochaetus strigosus*).

Other families of reef fish that were well-represented included: wrasses, especially the saddleback wrasse (hinalea, *Thalassoma duperrey*); dameselfishes, especially the blackfin chromis (*Chromis vanderbilti*); and goatfishes, especially the manybar goatfish (moano, *Parupeneus multifasciatus*). Also typically encountered on the transects were numerous juvenile reef fish of several species and several triggerfish species.

Comparing results of fish transect surveys in 1992 and 1994 gives an indication if there has been a decline in reef fish abundance over time (see Table 2). As with the coral transect surveys, the difference in methodological approach used for fish censusing undoubtedly causes some variability in survey results. While the transect line was twice as long in 1994, the 1992 survey, involved covering the transect line twice, once noting large individuals that were likely to avoid divers, and one noting smaller individuals that take shelter in the reef. Thus, it might be expected that the surveys would produce roughly equivalent estimates of fish populations. Inspection of Table 2, however, indicates that on every transect there were more fish species and more individuals recorded in 1994 relative to 1992. The increase in number of species ranged from 2 (transects 5 and 6) to 22 (transect 10), while the increase in the number of individuals ranged from 9 (transect 5) to 131 (transect 10). Even with the consideration that the location of transect 10 was moved in 1994, it appears that there is no indication of reduced reef fish populations in the area that could be attributed to the sugar mill discharges.

SUMMARY

1. Biological community monitoring for the Kekaha Sugar Mill discharges NPDES/ZOM permit was carried out in April 1994. Ten transect survey stations that were established in 1991 were revisited and assessed for biotic structure. Stations were located with and outside of the ZOM boundaries off the Kekaha Sugar Mill Discharge (transects 1-3), off the Kawaiele irrigation water discharge (transects 4-6), between the Kawaiele and Nohili ZOM's (transect 7), and off the Nohili irrigation water discharge (transects 8-10). All transect locations were positioned as closely as possible to the locations described in the 1992 monitoring survey with the exception of transect 10, which was moved to the northern boundary of the ZOM.

2. Physical structure of the nearshore region consists predominantly of sand beaches and nearshore reef platforms in the intertidal area. The predominant physical character of the nearshore reef throughout the Kekaha area consists of a flat limestone platform that is devoid of most physical relief except for low depressions and channels filled with sand. A layer of marine sediment covers the limestone platform and is constantly in motion owing to current and wave energy. The one exception to this physiography is transect 10, where bottom. composition consisted of undercut ledges, grooves and channels cut from an ancient coral reef with vertical relief of 1-3 m.

3. On the reef platforms, coral cover is relatively low owing to the abrasive quality of the shifting sand substratum. Mean coral cover on the ten transects ranged from zero to 24%, with the highest cover at transect 10, where relief was highest. There is no apparent difference in coral community structure as a function of location within, or outside of the ZOM. Comparison of coral cover between the 1992 and 1994 surveys suggests that there has been no decrease in coral abundance since the last survey. While some of the differences in cover may be an artifact of difference in transect methods, it appears that coral communities may be richer now than in 1992.

4. A variety of marine algae are common on the reef platform that appear to be able to withstand continual abrasion from shifting sand. The widespread beds of *Sargassum echinocarpum* that were noted in the 1992 survey were not present in 1994, probably because the algal blooms on a seasonal cycle. There was no indication of any effect on algal communities from sugarcane discharge.

5. Reef fish community structure off the Kekaha survey sites appears to be a function of habitat complexity. Number of species and number of individuals were substantially higher at the Nohili discharge site owing to the shelter afforded by the three dimensional aspects of the reef. Results of fish surveys did not reveal any obvious changes in community structure as a

function of location within or beyond the ZOM boundaries. Comparisons of estimates of fish abundance between 1992 and 1994 indicate substantially higher numbers of individuals and species in the most recent survey. Such a temporal comparison suggests that there is no ongoing impact to fish communities as a result of sugarcane discharge.

6. None of the data suggest that there are any impacts from the Kekaha Sugar Mill discharges to marine communities on the reefs adjacent to the discharge. Such a result is not unexpected as the discharge plumes are observed to mix rapidly with ocean water to background concentrations by natural turbulent conditions. Rather, marine communities appear to be primarily controlled by natural physical factors associated with wave energy, sediment scour and substrate complexity.

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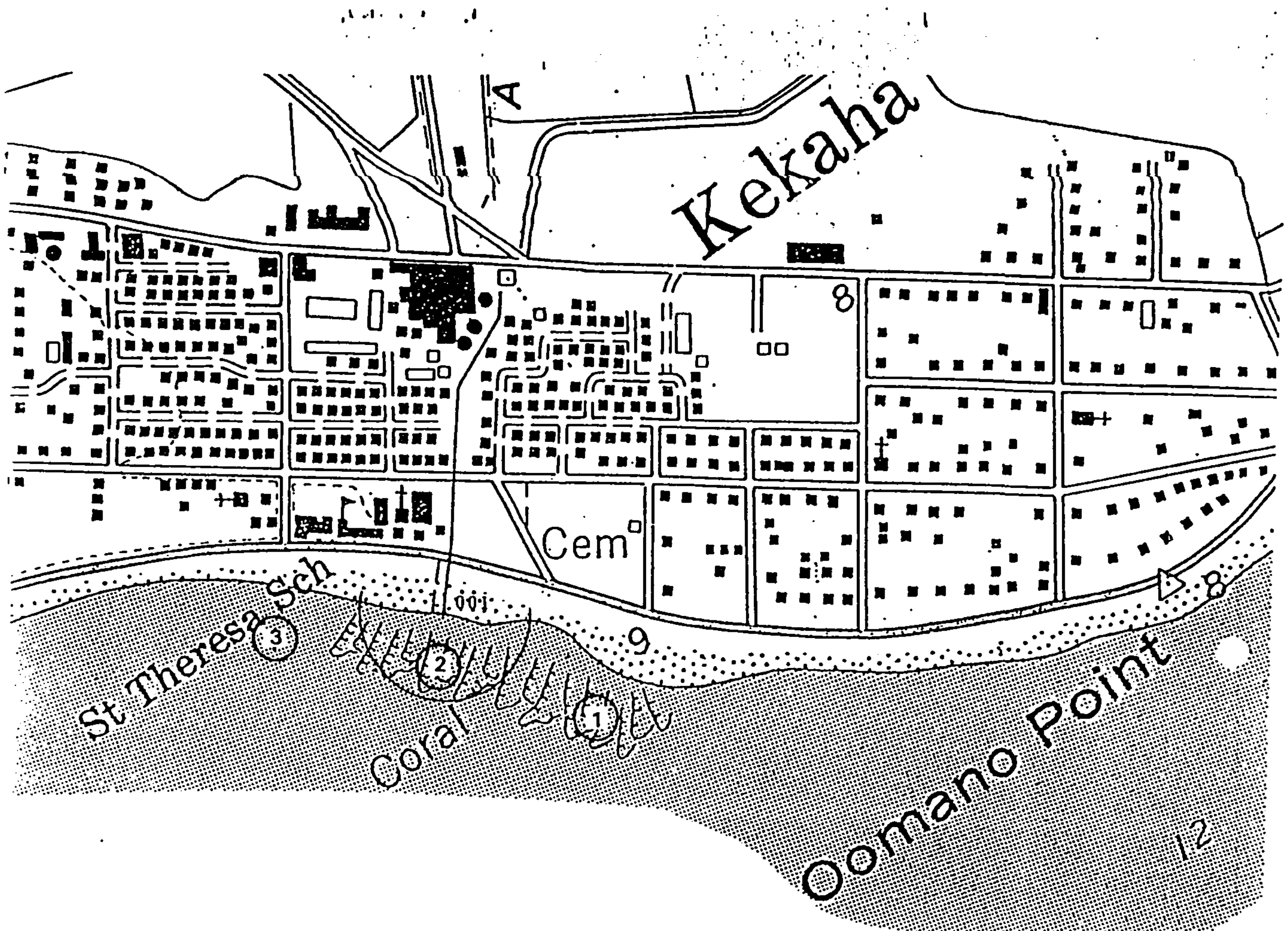

FIGURE 1. Zone of Mixing and location of benthic monitoring stations in the vicinity of the Kekaha Sugar Mill discharge.

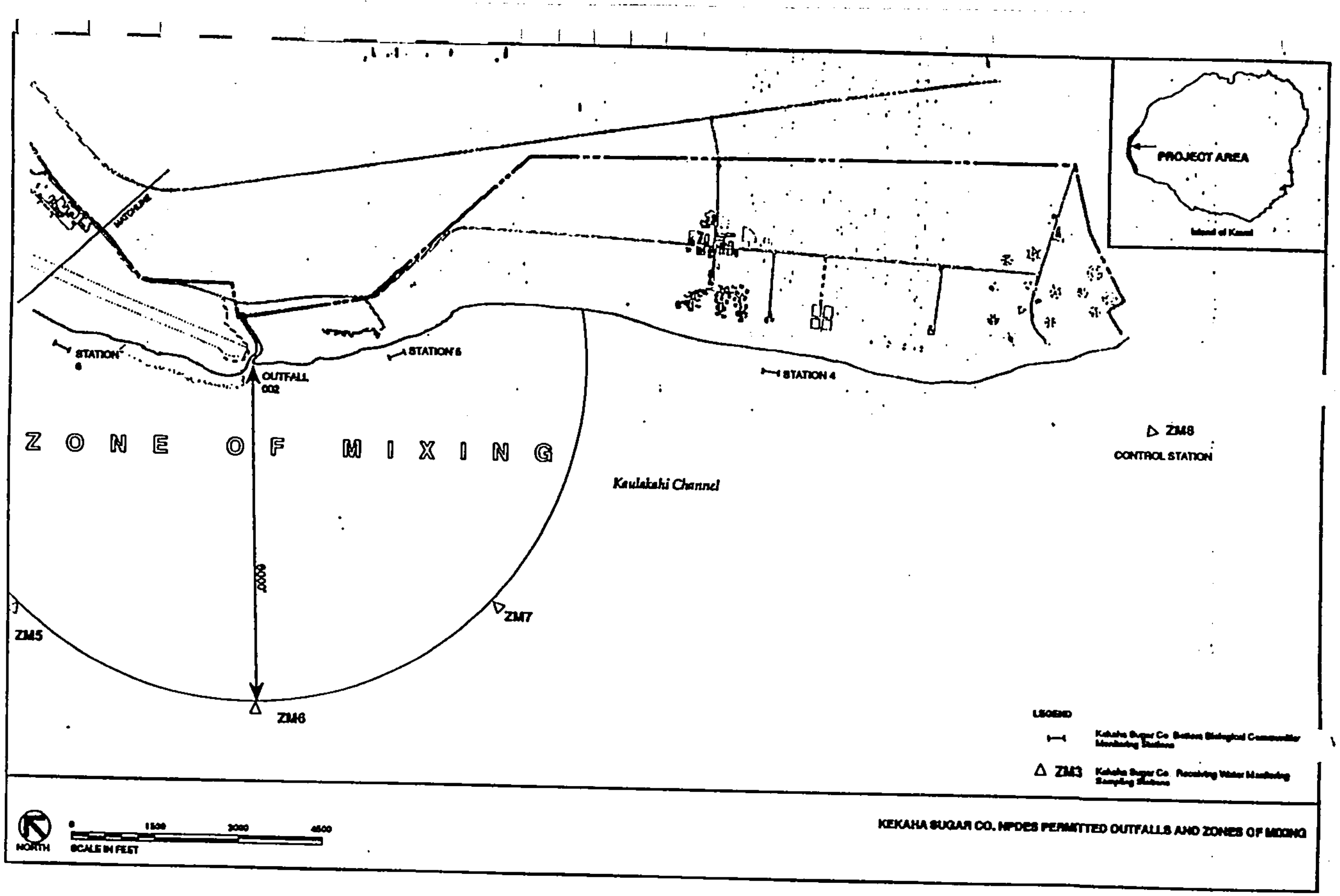

FIGURE 2. Zone of Mixing and location of benthic monitoring stations in the vicinity of the Kawaiele discharge.

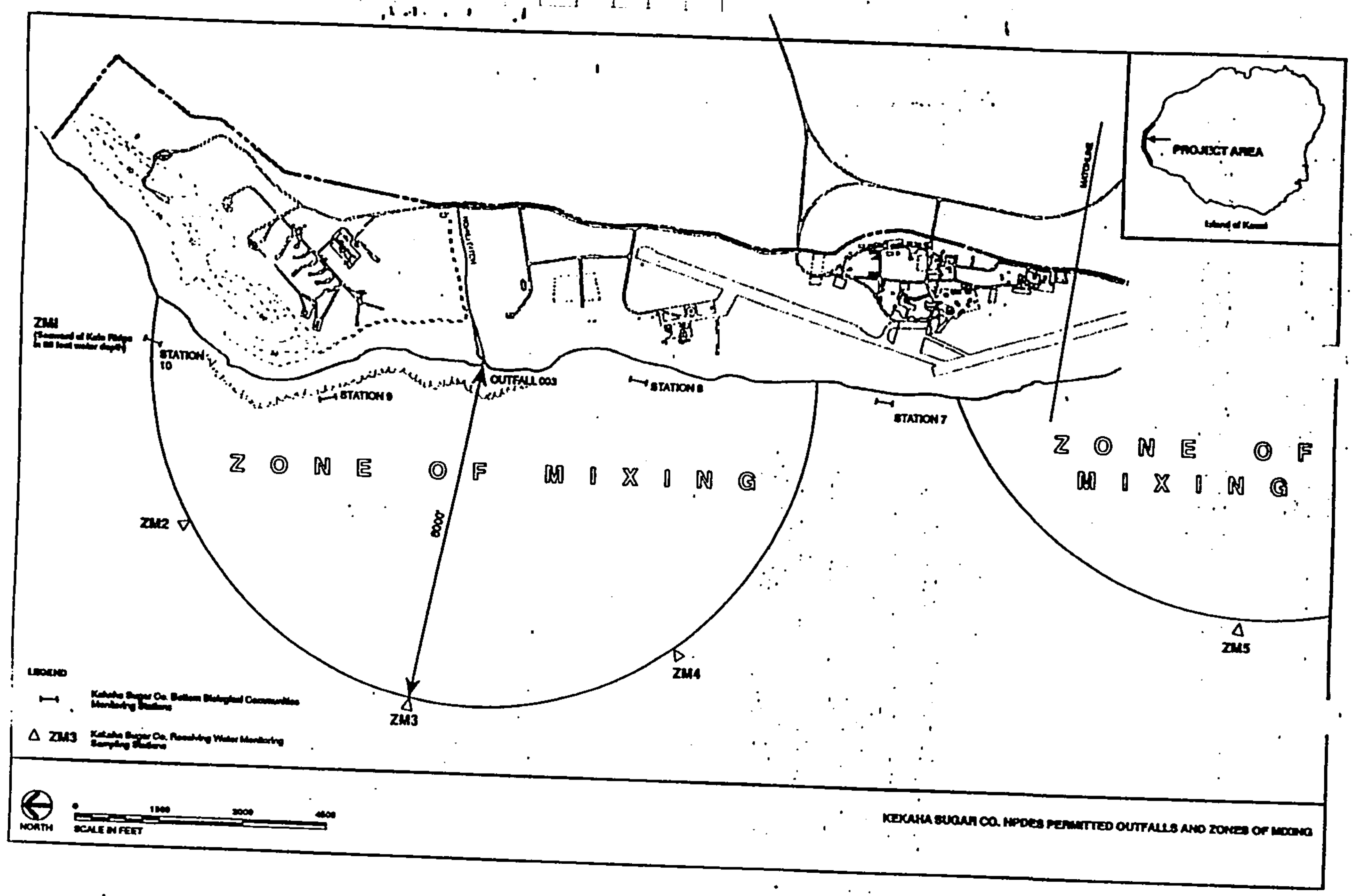

FIGURE 3. Zone of Mixing and location of benthic monitoring stations in the vicinity of the Nohili discharge.

TABLE 1. Percent coral cover a non–coral substratum cover on transec urveyed in the vicinity of the Kekaha Sugar Mill discharges in April 1994. For location of survey sites, see Figures 1–3.

MILL DISCHARGE			
	TRANSECT 1	TRANSECT 2	TRANSECT 3
CORAL SPECIES	8'	10'	6'
Porites lobata	5.2	4.1	2.6
Porites compressa	2.7	1.4	2.4
Pocillopora meandrina	1.8	1.3	1.8
TOTAL CORAL COVER	9.7	6.8	6.8
NUMBER OF SPECIES	3	3	3
CORAL COVER DIVERSITY	1.00	0.95	1.09
NON–CORAL SUBSTRATA			
Limestone	79.1	61.1	83.8
Sand	11.2	32.1	9.4

KAWAIELE DISCHARGE				
	TRANSECT 4	TRANSECT 5	TRANSECT 6	TRANSECT 7
CORAL SPECIES	42'	20'	20'	24'
Porites lobata			11.0	1.7
Porites compressa			0.5	2.0
Pocillopora meandrina			0.6	1.2
Montipora patula				0.3
Palythoa tuberculosa				0.1
TOTAL CORAL COVER	0.0	0.0	12.1	5.3
NUMBER OF SPECIES	0	0	3	5
CORAL COVER DIVERSITY	0.00	0.00	0.37	1.31
NON–CORAL SUBSTRATA				
Limestone	71.7	62.9	82.8	76.1
Sand	28.3	37.1	5.1	18.6

NOHILI DISCHARGE			
	TRANSECT 8	TRANSECT 9	TRANSECT 10
CORAL SPECIES	24'	20'	24'
Porites lobata	6.6	5.5	0.4
Porites compressa	2.9	2.0	
Pocillopora meandrina	9.4	3.3	10.9
Montipora patula	0.4	1.5	5.3
Montipora verrucosa		0.1	2.2
Pocillopora eydouxi	1.0		
Pavona varians			5.0
TOTAL CORAL COVER	20.3	12.4	23.8
NUMBER OF SPECIES	5	5	5
CORAL COVER DIVERSITY	1.23	1.30	1.31
NON–CORAL SUBSTRATA			
Limestone	73.2	75.1	76.2
Sand	6.5	12.5	

TABLE 2. Comparison of benthic and fish transect data from 1992 (AECOS, 1993) and 1994 at Kekaha Sugar Mill Discharge sites. Positive change indicates increased counts in 1994 relative to 1992; negative change indicates decreased counts in 1994 relative to 1992.

TRANSECT NUMBER	MEAN % CORAL COVER			NUMBER CORAL SPECIES			NUMBER FISH SPECIES			NUMBER FISH		
	1992	1994	CHANGE	1992	1994	CHANGE	1992	1994	CHANGE	1992	1994	CHANGE
1	0.8	9.7	8.9	2	3	1	1	10	9	1	102	101
2	0.0	6.8	6.8	0	3	3	2	8	6	3	52	49
3	0.0	6.8	6.8	1	3	2	3	8	5	6	44	38
4	0.02	0.0	-0.02	2	0	-2	6	12	6	14	76	62
5	0.02	0.0	-0.02	2	0	-2	6	8	2	18	27	9
6	5.9	12.1	6.2	9	3	-6	4	6	2	23	33	10
7	3.4	5.3	1.9	7	5	-2	3	11	8	18	73	55
8	1.2	20.3	19.1	3	5	2	3	19	16	10	104	94
9	10.2	12.4	2.2	7	5	-2	6	12	6	36	80	44
10	0.0	23.8	23.8	0	5	5	4	26	22	14	145	131

TABLE 3. Marine algae occurrence at on survey transects off the Kekaha Sugar Mill discharges. For transect locations, see Figures 1–3.
"R" = rare (0 – 5 individuals sighted on station)
"O" = occasional (5 – 20 individuals sighted on station)
"C" = common (more than 20 individuals sighted on station)

	KEKAHA MILL			KAWAIELE				NOHILI		
TRANSECT	1	2	3	4	5	6	7	8	9	10
CHLOROPHYTA (Green algae)										
Enteromorpha sp.	C	C	O				C	C	O	
Halimeda spp.	R	R	O	C	O	C	R			
Neomeris annulata	R	R	C	R	R		R	R	R	R
Codium edule					C	O				
CYANOPHYTA (Blue–green algae)										
Lyngbya majuscula	R	R	R						R	
PHAEOPHYTA (Brown algae)										
Dictopteris app.	O	C	O			R	C		R	
Dictyota spp.	C	C	C	O	O	C	C	C	R	
Padina spp.	O	O	R	R	R	C	C	C	R	R
Sargassum echinocarpum								C		
Turbinaria ornata	R	R		R	C	R	C	O		R
RHODOPHYTA (Red Algae)										
Asparagopsis taxiformis							R	C	C	C
Acanthophora specifera	R	R					R	R		
Amansia glomerata					C	R				
Desmia hornemanii		R					O			
Dotyella hawaiiensis		C		C	C	C	C		R	
Galaxaura spp.	R	R	R	C	C	C	C	R		
Hydrolithon spp.	C	C	C	C	C	C	C	C	C	C
Neogoniolithon sp.	C	C	C	C	C	C	C	C	C	C
Peysonellia rubra sp.		C	C	C	C	C	C	C	C	C
Porolithon spp.	C	C	C	C	C	C	C	C	C	C
Jania sp.	C	C	C	C	C	C	C	C	C	C
Wrangelia penicillata					O					

TABLE 4. Reef fish abundance on transects in the vicinity of the Kekaha Sugar Mill discharges. For location of transect sites, see Figures 1–3.

FAMILY Species	TRANSECT 1 8'	MILL 2 10'	3 6'	4 42'	KAWAIELE 5 20'	6 20'	7 24'	8 24'	NOHILI 9 20'	10 24'
KYPHOSIDAE										
Kyphosus bigibbus										4
CIRRHITIDAE										
Cirrhitops fasciatus							1	1		
Cirrhitus pinnulatus			1							
Paracirrhites arcatus					2		3			1
P. forsteri								1		
MULLIDAE										
Parupeneus multifasciatus	2	4	2	7		3	7	4		4
P. pleurostigma				2						
P. bifasciatus										1
P. porphyreus										1
SERRANIDAE										
Cephalopholis argus								1		1
CARANGIDAE										
Caranx melamphygus		1								5
LUTJANIDAE										
Lutjanus kasmira								11		
Prion virescens				1						
LETHRINIDAE										
Monotaxis grandoculis								1		
CHAETODONTIDAE										
Chaetodon quadrimaculatus								1		
C. unimaculatus		2							2	
C. multicinctus								2		
POMACANTHIDAE										
Plecto. imparipennis					2		2		2	2
Stegastes fasciolatus										3
Chromis agilis									3	
C. vanderbilti	35	20	12	25	8		30	32	15	35

TABLE 4. continued.

FAMILY Species	TRANSECT MILL 1 8'	2 10'	3 6'	KAWAIELE 4 42'	5 20'	6 20'	7 24'	NOHILI 8 24'	9 20'	10 24'
LABRIDAE										
Bodianus bilunulatus				1						
Coris flavovittata								1		
Thalassoma duperrey	15	11	12	12	5	11	12	18	13	17
T. trilobatum			1			1		2	3	
T. ballieui								2		
Gomphosus varius								1		
Labroides phthirophagus								3		1
Stethojulis balteata			1							
Halichoeres ornatissimus	1									
SCARIDAE										
Scarus sordidus										2
S. perspicillatus										2
S. psittacus								1		
S. rubroviolaceus										1
juvenile Scarus	2									
ACANTHURIDAE										
Acanthurus achilles										3
A. triostegus	17	3							5	20
A. leucopareius									3	3
A. olivaceus	4			3			4	1	8	2
A. nigrofuscus	21	9	14	13	6	15	11	19	10	10
Ctenochaetus strigosus				4	2				14	18
Naso lituratus										3
N. unicornis		2								
BLENNIIDAE										
Ptereleotris heteropterus				3						
BALISTIDAE										
Rhinecanthus rectangulus	1		1			1			2	1
Sufflamen bursa				3	1	2	2	2		2
S. fraenatus				2	1		1			
Melichthys niger	4									
TETRADONTIDAE										
Arothron meleagris							1			1
NUMBER SPECIES	10	8	8	12	8	6	11	19	12	26
NUMBER INDIVIDUALS	102	52	44	76	27	33	73	104	80	145
SPECIES DIVERSITY	1.77	1.69	1.56	2.02	1.83	1.32	1.8	2.15	2.22	2.58

APPENDIX A. Quadrat coral cover at Kekaha Mill Outfall transects.

PERCENT COVER	KEKAHA SUGAR MILL		
TRANSECT SITE:	MILL DISCHARGE	MEAN CORAL COVER	9.7 %
	Transect 1, 8'	STD. DEV.	6.0
DATE:	4/16/94	SPECIES COUNT	3
		SPECIES DIVERSITY	1.002

SPECIES	QUADRAT										SPECIES
	1	2	3	4	5	6	7	8	9	10	TOTAL
Porites lobata	1	4	5	3	2	5	6	5	4	17	5.2
Porites compressa	2	2	2	1	3	2	1	10		4	2.7
Pocillopora meandrina				3	3		12				1.8
QUAD CORAL TOTAL	3	6	7	7	8	7	19	15	4	21	9.7
Limestone	52	83	88	84	92	93	64	85	74	76	79.1
Sand	45	11	5	9			17		22	3	11.2
NON-CORAL TOTAL	97	94	93	93	92	93	81	85	96	79	90.3

TRANSECT SITE:	MILL DISCHARGE	MEAN CORAL COVER	6.8 %
	Transect 2, 10'	STD. DEV.	5.6
DATE:	4/16/94	SPECIES COUNT	3
		SPECIES DIVERSITY	0.946

SPECIES	QUADRAT										SPECIES
	1	2	3	4	5	6	7	8	9	10	TOTAL
Porites lobata	2	2	8	4			5	5	14	1	4.1
Porites compressa	1	2	2	3			3	3			1.4
Pocillopora meandrina		3		10							1.3
QUAD CORAL TOTAL	3	7	10	17	0	0	8	8	14	1	6.8
Limestone	84	81	90	83	69	62			64	78	61.1
Sand	13	12			31	38	92	92	22	21	32.1
NON-CORAL TOTAL	97	93	90	83	100	100	92	92	86	99	93.2

TRANSECT SITE:	MILL DISCHARGE	MEAN CORAL COVER	6.8 %
	Transect 2, 6'	STD. DEV.	2.5
DATE:	4/16/94	SPECIES COUNT	3
		SPECIES DIVERSITY	1.087

SPECIES	QUADRAT										SPECIES
	1	2	3	4	5	6	7	8	9	10	TOTAL
Porites lobata	6	3	5	4	2	2		3	1		2.6
Porites compressa	3		2	4	1	4	4		2	4	2.4
Pocillopora meandrina	2			3	2	1	2	5	3		1.8
QUAD CORAL TOTAL	11	3	7	11	5	7	6	8	6	4	6.8
Limestone	66	73	93	89	61	93	81	92	94	96	83.8
Sand	23	24			34		13				9.4
NON-CORAL TOTAL	89	97	93	89	95	93	94	92	94	96	93.2

APPENDIX B. Quadrat coral cover at Kawaiele Outfall transects

PERCENT COVER . KEKA . SUGAR MILL

TRANSECT SITE: KAWAIELE OUTFALL
Transect 4, 42'
DATE: 4/16/94

MEAN CORAL COVER 0.0 %
STD. DEV. 0.0
SPECIES COUNT 0
SPECIES DIVERSITY 0

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
QUAD CORAL TOTAL	0	0	0	0	0	0	0	0	0	0	0
Limestone	76	73	84	51	83	73	61	75	73	68	71.7
Sand	24	27	16	49	17	27	39	25	27	32	28.3
NON-CORAL TOTAL	100	100	100	100	100	100	100	100	100	100	100.0

TRANSECT SITE: KAWAIELE OUTFALL
Transect 5, 20'
DATE: 4/16/94

MEAN CORAL COVER 0.0 %
STD. DEV. 0.0
SPECIES COUNT 0
SPECIES DIVERSITY 0

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
QUAD CORAL TOTAL	0	0	0	0	0	0	0	0	0	0	0.0
Limestone	87	74	55	76	62	90	87		44	54	62.9
Sand	13	26	45	24	38	10	13	100	56	46	37.1
NON-CORAL TOTAL	100	100	100	100	100	100	100	100	100	100	100.0

TRANSECT SITE: KAWAIELE OUTFALL
Transect 6, 20'
DATE: 4/16/94

MEAN CORAL COVER 12.1 %
STD. DEV. 5.8
SPECIES COUNT 3
SPECIES DIVERSITY 0.367

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	14	13	20	1	15	14	10	8	10	5	11.0
Porites compressa	3	2									0.5
Pocillopora meandrina					3	2			1		0.6
QUAD CORAL TOTAL	17	15	20	1	18	16	10	8	11	5	12.1
Limestone	51	85	80	80	82	84	90	92	89	95	82.8
Sand	32			19							5.1
NON-CORAL TOTAL	83	85	80	99	82	84	90	92	89	95	87.9

TRANSECT SITE: KAWAIELE OUTFALL
Transect 7, 24'
DATE: 4/16/94

MEAN CORAL COVER 5.3 %
STD. DEV. 4.0
SPECIES COUNT 5
SPECIES DIVERSITY 1.306

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	1	1	1	11			1	1	1		1.7
Porites compressa	1	5	2	2	1	3		3	3		2.0
Pocillopora meandrina	2	3	3				1		3		1.2
Montipora patula	1			1	1						0.3
Palythoa tuberculosa		1									0.1
QUAD CORAL TOTAL	5	10	6	14	2	3	2	4	7	0	5.3
Limestone	95	55	94	66	85	97	74	88	42	65	76.1
Sand		35		20	13		24	8	51	35	18.6
NON-CORAL TOTAL	95	90	94	86	98	97	98	96	93	100	94.7

APPENDIX C. Quadrat coral cover at Nohili Outfall.

PERCENT COVER KEKAHA SUGAR MILL

TRANSECT SITE: NOHILI OUTFALL
Transect 8, 24'
DATE: 4/16/94

MEAN CORAL COVER 20.3 %
STD. DEV. 8.3
SPECIES COUNT 5
SPECIES DIVERSITY 1.225

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	1	5	14	13	16	15	1	1			6.6
Porites compressa	3	3	12	1	3	3	3	1			2.9
Pocillopora meandrina	1	2	1	3	2	12	13	13	25	22	9.4
Pocillopora eydouxi					10						1.0
Montipora patula						1	1			2	0.4
QUAD CORAL TOTAL	5	10	27	17	31	31	18	15	25	24	20.3
Limestone	95	90	73	83	69	69	82	85	75	76	79.7
NON-CORAL TOTAL	95	90	73	83	69	69	82	85	75	76	79.7

TRANSECT SITE: NOHILI OUTFALL
Transect 9, 20'
DATE: 4/16/94

MEAN CORAL COVER 12.4 %
STD. DEV. 4.8
SPECIES COUNT 5
SPECIES DIVERSITY 1.301

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	1	12	10	5		1	5	5	10	6	5.5
Porites compressa	2	6	3	3	1	1	2	1		1	2.0
Pocillopora meandrina	3		5	3		10		4	4	4	3.3
Montipora verrucosa	1										0.1
Montipora patula	8					4	3				1.5
QUAD CORAL TOTAL	15	18	18	11	1	16	10	10	14	11	12.4
Limestone	85	82	82	89	99	84	90	90	86	89	87.6
NON-CORAL TOTAL	85	82	82	89	99	84	90	90	86	89	87.6

TRANSECT SITE: NOHILI OUTFALL
Transect 10, 24'
DATE: 4/16/94

MEAN CORAL COVER 23.8 %
STD. DEV. 14.3
SPECIES COUNT 5
SPECIES DIVERSITY 1.308

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata			3	1							0.4
Pocillopora meandrina	10	19	18	2	2	24	8	12		14	10.9
Montipora verrucosa			3						19		2.2
Montipora patula		16		18					19		5.3
Pavona varians					24		1	3	22		5.0
QUAD CORAL TOTAL	10	35	24	21	26	24	9	15	60	14	23.8
Limestone	90	65	76	79	74	76	91	85	40	86	76.2
NON-CORAL TOTAL	90	65	76	79	74	76	91	85	40	86	76.2

Appendix 8

Water Quality

Kekaha Sugar Company, Ltd.
P.O. Box 549
Kekaha, HI 96752

AUG 18 1997 OL...C ZM-35
PI CL✓ MTsuji AT EA AW

BIANNUAL ZONE OF MIXING REPORT FOR OUTFALLS 003 (NOHILI) AND 002 (KAWAIELE)
NPDES Permit No. HI000086 ZM-35
Sample Type = Grab

T = Top
M = Middle
B = Bottom

Sampled by: Marine Research Consultants
4467 Sierra Drive
Honolulu, HI 96816

Sample Date: July 21, 1997; falling tide

Station Sample	Depth	Outfall	Total Nitrogen	Ammonia Nitrogen	Nitrate + Nitrite N	Total Phosphorus	Chlorophyll a	Turbidity	Salinity
Units -->	(feet)		ug/L	ug/L	ug/L	ug/L	ug/L	NTU	ppt
Limits -->			250	9	20	45	1	1	+ or -10%
1-T	3	Control Station	25	<1.4	0.4	14	0.09	0.16	34.8
1-M	45	Control Station	22	<1.4	<0.4	14	0.07	0.1	34.8
1-B	90	Control Station	20	<1.4	0.4	14	0.1	0.08	34.8
2-T	3	Nohili	24	<1.4	<0.4	14	0.09	0.08	34.8
2-M	30	"	25	<1.4	<0.4	15	0.08	0.09	34.8
2-B	60	"	22	<1.4	<0.4	14	0.07	0.08	34.8
3-T	3	"	21	<1.4	<0.4	13	0.07	0.07	34.8
3-M	60	"	20	<1.4	<0.4	14	0.07	0.07	34.8
3-B	120	"	23	<1.4	<0.4	17	0.07	0.07	34.8
4-T	3	"	23	<1.4	13.4	14	0.09	0.27	34.4
4-M	30	"	21	<1.4	1.5	13	0.10	0.08	34.8
4-B	60	"	22	<1.4	1.1	14	0.07	0.08	34.8
5-T	3	Kawaiele	21	<1.4	0.4	12	0.07	0.07	34.8
5-M	30	"	21	<1.4	0.8	12	0.1	0.07	34.8
5-B	60	"	20	<1.4	1.3	13	0.09	0.07	34.8
6-T	3	"	23	<1.4	<0.4	13	0.05	0.08	34.8
6-M	60	"	20	<1.4	0.8	12	0.13	0.08	34.8
6-B	120	"	20	<1.4	0.8	12	0.15	0.09	34.8
7-T	3	"	23	<1.4	1.5	12	0.12	0.13	34.7
7-M	30	"	22	1.4	0.7	13	0.17	0.14	34.8
7-B	60	"	22	1.4	0.8	12	0.18	0.08	34.8
8-T	3	Control Station	22	1.7	<0.4	12	0.12	0.12	34.8
8-M	45	Control Station	20	<1.4	<0.4	12	0.12	0.08	34.8
8-B	90	Control Station	20	1.7	<0.4	13	0.11	0.09	34.8

Signature: Lyle Tabata, Vice President

8/6/97
Date

P.O. B[illegible]
Kekaha, HI 96752

BIANNUAL ZONE OF MIXING REPORT FOR OUTFALLS 003 (NOHILI) AND 002 (KAWAIELE)
NPDES Permit No. HI000086 ZM-35
Sample Type = Grab

T = Top
M = Middle
B = Bottom

Sampled by: Marine Research Consultants
4467 Sierra Drive
Honolulu, HI 96816

Sampling Date: October 20, 1996; rising tide

Station Sample	Depth	Outfall	Total Nitrogen	Ammonia Nitrogen	Nitrate + Nitrite N	Total Phosphorus	Chlorophyll a	Turbidity	Salinity
Units -->	(feet)		ug/L	ug/L	ug/L	ug/L	ug/L	NTU	ppt
Limits -->			250	9	20	45	1	1	+ or -10%
1-T	3	Control Station	64	1.8	1.4	12	0.04	0.07	34.8
1-M	45	Control Station	63	1.4	1.7	14	0.05	0.08	34.8
1-B	90	Control Station	59	1.4	1.4	11	0.05	0.08	34.8
2-T	3	Nohili	55	<1.4	0.7	13	0.07	0.07	34.8
2-M	30	"	58	<1.4	0.7	13	0.07	0.08	34.8
2-B	60	"	57	2.0	0.8	13	0.07	0.06	34.8
3-T	3	"	91	<1.4	0.6	15	0.05	0.07	34.8
3-M	60	"	58	1.5	0.8	12	0.05	0.08	34.8
3-B	120	"	56	1.5	0.6	11	0.05	0.07	34.8
4-T	3	"	63	1.5	1.7	13	0.10	0.08	34.8
4-M	30	"	56	1.5	1.5	12	0.10	0.08	34.8
4-B	60	"	57	1.4	1.5	13	0.09	0.07	34.8
5-T	3	Kawaiele	54	2.0	1.1	11	0.08	0.09	34.8
5-M	30	"	54	<1.4	0.8	12	0.08	0.07	34.8
5-B	60	"	55	1.5	1.0	12	0.07	0.06	34.8
6-T	3	"	54	<1.4	1.3	13	0.08	0.05	34.8
6-M	60	"	56	<1.4	1.1	12	0.09	0.06	34.8
6-B	120	"	55	<1.4	0.8	13	0.08	0.07	34.8
7-T	3	"	55	<1.4	0.7	12	0.13	0.09	34.8
7-M	30	"	57	<1.4	1.1	14	0.12	0.08	34.7
7-B	60	"	55	<1.4	0.8	12	0.11	0.07	34.8
8-T	3	Control Station	58	1.4	<0.4	13	0.10	0.08	34.7
8-M	45	Control Station	55	<1.4	<0.4	12	0.19	0.08	34.8
8-B	90	Control Station	55	<1.4	<0.4	11	0.11	0.08	34.8

Owen S Moe
Signature: Engineering Supervisor

2/3/97
Date

KEKAHA SUGAR COMPANY, LTD.
P.O. BOX 549
KEKAHA, HI 96752

Water Quality Monitoring Report
NPDES Permit No. HI0000086 ZM-35
BIANNUAL REPORT FOR OUTFALL 002 (KAWAIELE)   Tide: Rising

Sampling Frequency = Biannually   T = Top
Sample Type = Grab   M = Middle
B = Bottom

SAMPLING DATE: October 28, 1994

PARAMETERS	UNITS	WATER QUALITY CRITERIA	SAMPLE DATA											
												CONTROL STATION		
			5-T	5-M	5-B	6-T	6-M	6-B	7-T	7-M	7-B	8-T	8-M	8-B
DEPTH	Feet		3	30	60	3	60	120	3	30	60	3	45	90
TOTAL NITROGEN	ug/L	110-150-250 250	91	95	93	86	81	80	80	87	89	93	93	89
AMMONIA NITROGEN	ug/L	2-5-9 9	1.4	0.7	0.84	1.4	2.24	0.14	1.68	1.68	2.38	1.12	0.84	1.4
NITRATE+ NITRITE NITROGEN	ug/L	3.5-10-20 20	1.96	3.36	5.18	2.38	1.68	0.98	0.28	6.02	4.76	3.78	1.68	1.54
TOTAL PHOSPHORUS	ug/L	16-30-45 45	6.82	6.51	7.13	6.82	7.13	7.44	7.44	8.06	7.75	7.13	6.82	6.82
CHLOROPHYLL a	ug/L	[illegible]	0.35	0.38	0.43	0.45	0.31	0.32	0.44	0.61	0.54	0.76	0.40	0.28
TURBIDITY	N.T.U.	[illegible]	0.10	0.09	0.16	0.14	0.08	0.07	0.14	0.22	0.19	0.25	0.11	0.10
SALINITY	ppt	+ OR - 10%	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.7	34.8	34.8

[signature]
SIGNATURE - Executive Vice President & Manager

11-28-94
DATE

BDL = Below Detection Limits

KEKAHA SUGAR COMPANY, LTD.
P.O. BOX 549
KEKAHA, HI 96752

Water Quality Monitoring Report
NPDES Permit No. HI0000086 ZM-35
BIANNUAL REPORT FOR OUTFALL 002 (KAWAIELE) Tide: Rising

Sampling Frequency = Biannually T = Top
Sample Type = Grab M = Middle
B = Bottom

SAMPLING DATE: May 22, 1994

PARAMETERS	UNITS	WATER QUALITY CRITERIA	SAMPLE DATA											
												CONTROL STATION		
			5-T	5-M	5-B	6-T	6-M	6-B	7-T	7-M	7-B	8-T	8-M	8-B
DEPTH	Feet		3	30	60	3	60	120	3	30	60	3	45	90
TOTAL NITROGEN	ug/L	250	74	73	75	80	76	74	74	75	77	74	73	73
AMMONIA NITROGEN	ug/L	9	1.12	0.84	0.56	1.54	0.98	0.42	0.98	0.28	0.98	0.7	0.98	1.26
NITRATE+ NITRITE NITROGEN	ug/L	20	0.98	0.98	0.98	1.26	BDL	0.14	0.98	0.42	0.28	0.42	0.28	0.42
TOTAL PHOSPHORUS	ug/L	45	9.3	9	9.3	9.9	9.9	8.4	9	9.6	9.9	9	8.7	9
CHLOROPHYLL a	ug/L	1	0.27	0.29	0.29	0.31	0.30	0.38	0.32	0.33	0.30	0.34	0.33	0.30
TURBIDITY	N.T.U.	1	0.06	0.06	0.07	0.07	0.06	0.06	0.09	0.07	0.06	0.07	0.05	0.05
SALINITY	ppt	+ OR - 10%	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8

A.T. Reid
SIGNATURE - Executive Vice President

6-08-94
DATE

BDL = Below Detection Limits

P.[illegible]
KEKAHA, HI 96752

Water Quality Monitoring Report
NPDES Permit No. HI0000086 ZM-35
BIANNUAL REPORT FOR OUTFALL 002 (KAWAIELE) Tide: Low
Sampling Frequency = Biannually
Sample Type = Grab

T = Top
M = Middle
B = Bottom

SAMPLING DATE June 29, 1993

PARAMETERS	UNIT	WATER QUALITY CRITERIA	SAMPLE DATA											
												CONTROL STATION		
			5-T	5-M	5-B	6-T	6-M	6-B	7-T	7-M	7-B	8-T	8-M	8-B
DEPTH	Feet		3	30	60	3	60	120	3	30	60	3	45	90
TOTAL NITROGEN	ug/L	250	260	230	190	290	210	170	210	190	170	290	140	160
AMMONIA NITROGEN	ug/L	9	60	90	60	50	60	40	40	70	60	50	30	30
NITRATE+ NITRITE NITROGEN	ug/L	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
TOTAL PHOSPHORUS	ug/L	45	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
CHLOROPHYLL a	ug/L	1	0.05	0.06	0.05	0.06	0.05	0.06	0.04	0.04	0.05	0.15	0.14	0.14
TURBIDITY	N.T.U.	1	0.15	0.15	0.15	0.20	0.15	0.10	0.15	0.10	0.10	0.35	0.20	0.15
SALINITY	ppt	+ OR - 10%	33.1	33.0	33.0	33.1	33.0	33.0	32.9	32.7	32.9	33.0	33.0	33.0

[signature] 8-23-93
SIGNATURE - VICE PRES. & GENERAL MANAGER DATE

KEKAHA SUGAR COMPANY, LTD.
P.O. BOX 549
KEKAHA, HI 96752

Water Quality Monitoring Report
NPDES Permit No. HI0000086 ZM-35
BIANNUAL REPORT FOR OUTFALL 002 (KAWAIELE)

Tide: Low

Sampling Frequency = Biannually
Sample Type = Grab

T = Top
M = Middle
B = Bottom

SAMPLING DATE: June 25, 1992

PARAMETERS	UNITS	WATER QUALITY CRITERIA	SAMPLE DATA									CONTROL STATION		
			5-T	5-M	5-B	6-T	6-M	6-B	7-T	7-M	7-B	8-T	8-M	8-B
DEPTH	Feet		3	30	60	3	60	120	3	30	60	3	45	90
TOTAL NITROGEN	ug/L	250	290	300	210	280	130	200	160	200	180	460	180	110
AMMONIA NITROGEN	ug/L	9	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
NITRATE+ NITRITE NITROGEN	ug/L	20	<10	<10	<10	10	<10	<10	<10	10	10	20	<10	<10
TOTAL PHOSPHORUS	ug/L	45	<10	10	10	<10	<10	30	<10	<10	<10	<10	<10	10
CHLOROPHYLL a	ug/L	1	0.13	0.15	0.11	0.10	0.12	0.12	0.12	0.12	0.14	0.06	0.06	0.07
TURBIDITY	N.T.U.	1	0.20	0.20	0.20	0.20	0.17	0.20	0.20	0.20	0.25	0.25	0.15	0.20
SALINITY	ppt	+ OR - 10%	34.7	34.7	34.7	34.7	34.6	34.6	34.7	34.6	34.7	34.7	34.8	34.5

[signature]
SIGNATURE - VICE PRES. & MANAGER

8/28/92
DATE

KEKAHA SUGAR COMPANY, LTD.
P.O. BOX 549
KEKAHA, HI 96752

Water Quality Monitoring Report
NPDES Permit No. HI0000086 ZM-35
BIANNUAL REPORT FOR OUTFALL 002 (KAWAIELE)
Sampling Frequency = Biannually
Sample Type = Grab

T = Top
M = Middle
B = Bottom

* Samples were spoiled at Hawaiian Air freight office.
Will be rescheduled and taken again.

SAMPLING DATE: January 3, 1992

PARAMETERS	UNITS	WATER QUALITY CRITERIA	SAMPLE DATA											
												CONTROL STATION		
			5-T	5-M	5-B	6-T	6-M	6-B	7-T	7-M	7-B	8-T	8-M	8-B
DEPTH	Meters		1	9	18	1	18	36	1	9	18	1	14	29
TOTAL NITROGEN	ug/L	250	80	100	80	80	330	290	190	180	150	180	110	180
AMMONIA NITROGEN	ug/L	9	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
NITRATE+ NITRITE NITROGEN	ug/L	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
TOTAL PHOSPHORUS	ug/L	45	<10	10	<10	<10	10	10	10	<10	<10	<10	<10	10
CHLOROPHYLL a	ug/L	1	*	*	*	*	*	*	*	*	*	*	*	*
TURBIDITY	N.T.U.	1	0.25	0.30	0.25	0.45	0.45	0.30	0.25	0.20	0.20	0.25	0.20	0.40
SALINITY	ppt	+ OR - 10%	34.7	34.8	34.7	34.5	34.8	34.6	34.8	34.9	34.7	34.5	34.6	34.5

SIGNATURE - VICE PRES. & MANAGER

1/28/92
DATE

KEKAHA SUGAR COMPANY, LTD.

P.O. BOX 549
KEKAHA, HI 96752

Water Quality Monitoring Report
NPDES Permit No. HI0000086 ZM-35
BIANNUAL REPORT FOR OUTFALL 002 (KAWAIELE)
Sampling Frequency = Biannually
Sample Type = Grab

T = Top
M = Middle
B = Bottom

SAMPLING DATE: December 17, 1990

PARAMETERS	UNITS	WATER QUALITY CRITERIA	SAMPLE DATA											
												CONTROL STATION		
			5-T	5-M	5-B	6-T	6-M	6-B	7-T	7-M	7-B	8-T	8-M	8-B
DEPTH	Meters		1	9	18	1	17	34	1	9	18	1	18	36
TOTAL NITROGEN	ug/L	250	70	130	110	100	110	160	80	80	110	100	90	80
AMMONIA NITROGEN	ug/L	9	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
NITRATE+ NITRITE NITROGEN	ug/L	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
TO L PHOSPHORUS	ug/L	45	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
CHLOROPHYLL a	ug/L	1	0.17	0.13	0.18	0.23	0.10	0.13	0.45	0.46	0.58	0.13	0.10	0.13
TURBIDITY	N.T.U.	1	0.25	0.30	0.30	0.30	0.30	0.30	0.60	0.55	0.50	0.25	0.20	0.30
SALINITY	ppt	+ OR - 10%	34.9	34.9	35.0	35.0	35.0	35.0	34.7	34.8	34.7	34.9	34.9	34.9

SIGNATURE - VICE PRES. & MANAGER

1/28/91
DATE

KEKAHA SUGAR COMPANY, LTD.

P.O. BOX 549
KEKAHA, HI 96752

Water Quality Monitoring Report
NPDES Permit No. HI0000086, ZM-35
BIANNUAL REPORT FOR OUTFALL 002 (KAWAIELE)
Sampling Frequency = Biannually
Sample Type = Grab

T = Top
M = Middle
B = Bottom

SAMPLING DATE: July 8, 1991

PARAMETERS	UNITS	WATER QUALITY CRITERIA	SAMPLE DATA											
												CONTROL STATION		
			5-T	5-M	5-B	6-T	6-M	6-B	7-T	7-M	7-B	8-T	8-M	8-B
DEPTH	Meters		1	9	18	1	18	36	1	9	18	1	15	30
TOTAL NITROGEN	ug/L	250	170	60	160	80	110	80	160	190	80	40	60	30
AMMONIA NITROGEN	ug/L	9	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
NITRATE+ NITRITE NITROGEN	ug/L	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
TOTAL PHOSPHORUS	ug/L	45	<10	<10	20	<10	<10	30	<10	<10	<10	10	<10	<10
CHLOROPHYLL a	ug/L	1	0.30	0.21	0.21	0.06	0.06	0.02	0.06	0.06	0.07	0.05	0.06	0.06
TURBIDITY	N.T.U.	1	0.30	0.30	0.30	0.15	0.15	0.20	0.20	0.15	0.15	0.15	0.25	0.15
SALINITY	ppt	+ OR - 10%	35.8	35.9	36.0	35.9	35.8	35.9	35.8	35.9	35.8	35.9	35.8	35.9

[signature]
SIGNATURE - VICE PRES. & MANAGER

8/5/91
DATE

Appendix 9

Correspondence

DANIEL K. INOUYE
HAWAII

APPROPRIATIONS
Subcommittee on Defense

COMMERCE, SCIENCE, AND TRANSPORTATION
Subcommittee on Surface Transportation
and Merchant Marine

COMMITTEE ON INDIAN AFFAIRS

DEMOCRATIC STEERING COMMITTEE

COMMITTEE ON RULES AND ADMINISTRATION

JOINT COMMITTEE ON PRINTING

United States Senate

SUITE 722, HART SENATE OFFICE BUILDING
WASHINGTON, DC 20510-1102
(202) 224-3934
FAX (202) 224-6747

PRINCE KUHIO FEDERAL BUILDING
ROOM 7325, 300 ALA MOANA BOULEVARD
HONOLULU, HI 96850-4975
(808) 541-2542
FAX (808) 541-2549

101 AUPUNI STREET, NO. 205
HILO, HI 96720
(808) 935-0844
FAX (808) 961-5163

September 17, 1997

Mr. Ernest Dias
Senior Vice President
General Manager for Operations
CEA TECH USA, Inc.
7 Waterfront Plaza, Suite 400
500 Ala Moana Blvd.
Honolulu, Hawaii 96813

Dear Ernie:

I enjoyed very much the opportunity to spend a few moments with you and your crew to survey the area, learn of your plans, and to taste some delicious shrimp in Kekaha.

I am very interested in seeing the technologies developed with federal research monies transferred to the private sector into commercially viable enterprises. As such, I hope that your request for additional state lands is moving through the process to allow you to pursue your plans. If I can assist you, please do not hesitate to let me know.

Once again, thank you very much for your hospitality. Good luck and best wishes.

Aloha,

DANIEL K. INOUYE
United States Senator

DKI:jsd

nw

Maryanne W. Kusaka
Mayor

Wallace G. Rezentes, Sr.
Administrative Assistant

OFFICE OF THE MAYOR

January 13, 1998

Mr. Samuel S. Lee
Kaua'i District Land Agent
Department of Land & Natural Resources
3060 Eiwa Street, Room 306
Lihu'e, Hawai'i 96766

Dear Mr. Lee:

It is with great pleasure that I submit this letter of support for Ceatech USA, Inc. This company, located in Kekaha, on the westside of Kaua'i is considered one of the state's premier aquaculture developments.

This project is well suited for Kaua'i and its acquisition of additional land for expansion will increase production and sorely needed agriculture employment.

All considerations toward the Ceatech Project is sincerely appreciated.

With warmest aloha,

Maryanne W. Kusaka

Maryanne W. Kusaka

MWK/kt

Mo'ikeha Building • 4444 Rice Street, Suite 235, Lihu'e, Kaua'i, Hawai'i 96766
Phone (808) 241-6300 • Fax (808) 241-6877

WEST KAUA'I
SECOND ANNUAL COMMUNITY PLANNING MEETING
NOVEMBER 6, 1997
AGENDA

- CALL TO ORDER
- INTRODUCTION
- OVERVIEW - WEST KAUA'I BUSINESS & PROFESSIONAL ASSOCIATION
- OVERVIEW - WEST KAUA'I COMMUNITY DEVELOPMENT CORPORATION
- KAUA'I ECONOMIC REVITALIZATION CONFERENCE
- KAUA'I 2000 SURVEY RESULTS
- PROGRAM PRESENTATIONS
    - KVMH - NEW DOCTORS / WELLNESS PROGRAM
    - KAUA'I COUNTY GENERAL PLAN
    - KEDB - WAIMEA TECHNO CENTER UPDATE
    - WKB&P - WAIMEA THEATER PROJECT UPDATE
    - CEATECH - KEKAHA SHRIMP PROJECT
    - KRCC - KAUA'I REGENCY CARE CENTER
    - KVB - KAUA'I VISITOR BUREAU
    - PMRF - PACIFIC MISSILE RANGE FACILITY
    - KBAC - KAUAI BUSINESS ASSISTANCE CORPORATION
    - GIRC&D - GARDEN ISLAND RESOURCE CONSERVATION & DEVELOPMENT
    - PCNC - PARENT COMMUNITY NETWORK CENTER
    - TARO CONFERENCE REPORT
    - KIKIAOLA FOUNDATION
    - KOKEE MUSEUM
    - KEKAHA COMMUNITY
    - WAIMEA COMMUNITY
    - WAIMEA INFRASTRUCTURE
    - CHURCH PROGRAMS
    - COMMUNITY EVENTS
        - CHRISTMAS IN WAIMEA
        - WAIMEA TOWN CELEBRATION
        - FLAVORS OF WEST KAUA'I
    - OTHER PROJECTS / PROGRAMS
- WEST KAUA'I CDC FUTURE PLANS / COMMITTEES
- BREAKOUT SESSIONS
- COMMITTEE SIGN-UP SHEETS
- ADJOURN

MONTHLY MEETING NOTICE - WEST KAUAI SWCD

DATE: Tuesday, November 18, 1997
TIME: 2:30 PM
LOCATION: National Tropical Botanical Gardens Education Center, Lawai, Kauai

AGENDA

I. CALL TO ORDER: - Owen

II. REVIEW/ACCEPT MINUTES: Of 09/23/97 Regular Meeting.

III. TREASURER'S REPORT: - Keith

IV. CORRESPONDENCE: - Board

V. STANDING COMMITTEE REPORTS:
   A. GARDEN ISLAND RC&D - Owen
   B. REVIEW COOPERATOR AGREEMENTS & CONSERVATION PLANS - Ron
   C. LAND USE CHANGES - Adam/Peter
   D. CONSERVATION COMPLIANCE - Owen/Ron
   E. EDUCATION PROGRAMS - Owen/Ron
   F. FLOOD CONTROL PROJECTS - Owen

VI. OLD BUSINESS:
   A. FARM BILL-1996, General Update & "EQIP" - Ron
   B. A&B/McBryde AG-Park, Planning Assistance - Ron/Jon
   C. Kekaha DOA AG-Park, Planning Assistance - Ron/Jon
   D. LWG-Local Working Group, for 1996 Farm Bill - Owen/Ron

VII. NEW BUSINESS:
   A. NRCS Report - Ron
   B. AGENCY REQUEST(s) for REVIEW - Owen
   C. NRCS GRANT AGREEMENT, District Employee.

VIII. OTHER BUSINESS:
   A. Concerns/Needs/Planning - Board

IX. ANNOUNCEMENTS:
   A. As Appropriate - Board

X. SET NEXT MEETING'S AGENDA:

XI. ADJOURNMENT:

(UNIX Filecode: /usr/schlegel/word/wkagenda.dcx)

REGULAR MONTHLY MEETING MINUTES - WEST KAUAI SWCD

October 21, 1997

The meeting was called to order at 2:30 p.m. at the National Tropical Botanical Gardens, Harrison Chandler Education Center, Kalaheo, Kauai.

PRESENT: **Directors:** Owen Moe, Keith Smith, and Antone Silva.
Associate Directors: Peter Tausend.
Others: Ron Peyton, NRCS.Paul Bienfang and Roland Sagum, CEATECH USA.

MINUTES: The September 23, 1997 Minutes were reviewed & accepted.

TREASURER'S REPORT:

State Funds:

Balance as of September 23, 1997	+$4720.06
Receipts:	.00
Disbursements: Koloa Post Master	-$ 64.00
Owen Moe HAC Mtg.	-$ 90.00
Atone Silva - Mileage	-$ 11.46
Denise Baptiste - Mileage	-$ 74.82
EKSWCD - Aloha Night	-$ 100.00
Balance as of October 21, 1997	+$4379.78

District Funds:

Balance as of September 23, 1997	+$1759.07
Interest, September 30, 1997	+$ 7.35
Balance as of October 21, 1997	+$1766.42

CORRESPONDENCE:

A. Correspondence was received from the Planning Commission.

STANDING COMMITTEE REPORTS:

A. Garden Island RC&D:
Forestry activities were reviewed.

B. Review Cooperator Agreements & Conservation Plans:
Dwight Akitas's plan involving EQUIP were reviewed and signed.
Future plans with Pioneer's highly erodible lands were discussed.

C. Land Use Changes:
The agenda for the meeting on the 23rd was briefly discussed.

D. Conservation Compliance:
Dwayne Shimigawa has ceased grading, discussion followed.

E. Educational Program:
The land judging contest will be Thursday.

F. Flood Control: - None.

OLD BUSINESS:

A. Farm Bill-1996, EQUIP, Update.
A thank you for involvement was receive from the secretary of EQUIP.
Sign up for Conservation Reserve Programs will be from October to mid November for people interested in turning previously cropped ag lands into grass cover or trees.

B. A&B/McBryde AG-Park: Planning Assistance.
The Ag Park map was reviewed.

C. Kekaha DOA AG-Park: Planning Assistance.
Paul Bienfang and Roland Sagum of CEATECH USA gave a report on shrimp farming operations and their plans for Kekaha Ag Park, much discussion followed.

D. LWG-Local Working Group: For the 1996 Farm Bill:
A newspaper reported that the County Journal plan is on hold. Discussed RC&D Ag meeting and LWG involvement.

NEW BUSINESS:

A. NRCS Report:
Jon is on vacation for a month. The year end reports are still being worked on. The guidelines for the Wildlife Habitat Improvement programs are complete, projects involving NTGB re-vegatation and enhancement of Lawai stream and the fish pond were discussed. Ron is planning on attending the Taro Conference this Friday and a Water Quality Conference on November 20 & 21. Ron will be holding a soils talk at the NTGB November 7.

B. Agency Requests: For Review. - None.

C. NRCS Grant Agreement, District Employee.
Ron received information from NACD on procedures and processes to assist with the development of the District Employee position and some planning followed.

OTHER BUSINESS:

A. Concerns/Needs/Planning:
Discussion on the importance of the grading ordinance guidelines established in 1990 and the need to adhere to these guidelines.

ANNOUNCEMENTS:

NEXT MEETING:

WHEN: Tuesday, November 17, 1997, 2:30 PM.
WHERE: National Tropical Botanical Garden Educational Center

THERE BEING NO FURTHER BUSINESS, THE MEETING WAS ADJOURNED.

Respectfully submitted,
Liz Schlegel for Keith Smith

(UNIX Filecode: /usr/schlegel/word/wkmin415.dcx)

Owen S. Moe
P.O.Box 656
Kekaha, HI 96752

January 12, 1998

Mr. Michael Laureta
State of Hawaii
Department of Land and Natural Resources
Land Division
3060 Eiwa Street, Rm #306
Lihue, HI 96766

SUBJECT: CEATECH USA Shrimp Plantation at Kekaha Project

Dear Mike:

Economic oppurtunities are hard to come by on the westside of Kauai and with the downsizing of sugar are sorely needed to improve the the employment situation. This letter is written in support of the shrimp plantation project being developed at Kekaha by CEATECH USA, Inc.

Aquaculture has been studied for over twenty years on the westside of Kauai and the Kekaha area has been found to be one of the best locations in the world for aquaculture production. This should be taken advantage of to create job oppurtunities for the people of Kauai.

I want to encourage the Department of Land and Natural Resources to continue it's support of the shrimp project and give it a high priority so it can begin production as soon as possible and start contributing to the economic revitalization of Kauai.

Thank you for help and support of this economic development effort.

Sincerely,

Owen S Moe

Owen S. Moe

KAUAI HEDGE & GROUND COVERS

"Hedge & Ground Cover Specialist"

P.O. Box 1221
Kalaheo, HI 96741

Telephone
(808) 332-9493

January 12, 1998

Mr. Mike Loreta
State Department of Land
and Natural Resources
3060 Eiwa Street
Lihue, Kauai, Hawaii
96766

Re: Development for CEATECH USA Shrimp Plantation
at Kekaha, Kauai, Hawaii.

Aloha Mr. Loreta,

I have had a chance to review the Development Plan for CEATECH USA Shrimp Plantation at Kekaha, Kauai and I feel this project is a very worthwhile project which could help improve our poor economy. I have also reviewed the area where the proposed Project Site is to be located and feel it is the most suitable area on our island for a project with so much potential for growth and not cause a concern for the public or our environment.

I feel this project will definitely invigorate employment for west Kauai residents especially with Kekaha Sugar Plantation slowly becoming part of the list of Hawaii's Sugar Plantations Of The Past. I feel we should encourage and give way for CEATECH USA Shrimp Plantation to establish its industry on Kauai and not somewhere else because I would like to see the people of Kauai benefit from all the opportunities which an industry like this could provide.

I appreciate you taking the time to review my concerns for this project and I hope you would support it as well.

Mahalo Nui Loa,

Lawrence Tachibana

01/15/1998 13:20 8085371307 CEATECH USA, INC. PAGE 01

West Kaua'i Main Street

January 17, 1998

Mr. Roland Sagum
Applied Planning Services
3116 Hoolako, Bay F
Lihue, HI 96766

RE: Support for CEATECH Hawaii, Inc.

Mr. Sagum,

The West Kaua'i Main Street Program is pleased to hear that CEATECH Hawaii, Inc. is expediting plans for the expansion of its current operation in Kekaha The expansion will enable CEATECH to increase its market share while providing job opportunities for West Kaua'i residents.

With the demise of the sugar industry, the economic climate of the Westside of Kaua'i is questionable. The expansion of the shrimp farm will certainly help fill the void.

Please call on us if we can be of any assistance.

Sincerely,

Calvin H. Shirai
Project Manager

P.O. box 903, Waimea, Hawai'i 96796 phone 808/337-9957 fax 808/338-1746

ALEXANDER & BALDWIN, INC.

MEREDITH J. CHING
Vice President

November 12, 1997

Mr. Roland Sagum
Applied Planning Services
P.O. Box 1724
Lihue, Kauai, Hawaii 96766

Dear Roland:

Thank you for describing the aquaculture project of CEATECH USA, Inc.

Additional business activity and the creation of new export markets for farmed aquaculture products form Kauai will improve economic conditions for the entire community.

This diversified agriculture project appears to be compatible with rural character and land use of the area. The new employment and economic development should make a lasting contribution to the island.

We welcome CEATECH USA Inc. to the business community of Kauai.

Sincerely,

Meredith J. Ching

Meredith J. Ching

822 BISHOP STREET • P.O. BOX 3440 • HONOLULU, HAWAII 96801 • TELEPHONE (808) 525-6669 • FAX (808) 525-6677

[illegible]
LIHUE, HI 96766

KAUA'I PAGING & COMMUNICATIONS

P.O. Box 3422, Lihue, Hawaii 96766

(808) 246-2544
FAX: 246-2569

January 8, 1998

CEATECH USA, Inc.
7 Waterfront Plaza, Suite 400
500 Ala Moana Blvd.
Honolulu, Hawaii 96813
Attn: Paul Bienfang, Ph.D

Dear Mr. Bienfang,

It was a pleasure to meet and talk with you when you visited my office. I wish the best in your endeavour to market your products and service. I also applaud the recent successful steps that CEATECH USA has taken to be a self-supporting business entity that is a resource to the economy of Kauai.

On January 7, 1998 one of your associates visited our Rotary club and gave a presentation that was very informative of the efforts of your business. Mr. Landis Ignacio presented a well prepared speech that eloquently covered the challenges of the operation.

CEATECH USA has the support of RAYCOMM INC dba Kaua'i Paging & Communications for your efforts in becoming an asset tö Kauai's struggling economy. Thankyou for your time and company's efforts to educate other businesses of your mission.

Sincerely,

Raymond W. Paler

Raymond W. Paler
President
RAYCOMM INC dba
Kaua'i Paging & communications

Russell Kyono, Realtor
P.O. Box 948
Lawai, Hawaii 96765

January 5, 1998

CEATECH USA, INC.
7 Waterfront Plaza, Suite 400
500 Ala Moana Blvd.
Honolulu, HI 96813

Dear CEATECH USA, Inc.,

I have read your development plan for a shrimp plantation at Kekaha here on the island of Kauai. I commend you for taking an interest in the economic recovery of our island; and for the opportunities you promise to offer to our unemployed population through your endeavors.

As an island resident, I appreciate that you have taken the concerns of the local community, especially effects on the environment, into consideration in planning your Kekaha farm. I trust that your interest in these concerns is sincere and that it will persist in the future.

I wish you success as you venture into this industry.

Sincerely,

Russell Kyono (R)(GRI)

United States Department of Agriculture
Farm Service Agency
Kauai County FSA Office
4334 Rice Street , Suite 103
Lihue, Hawaii 96766

December 11, 1997

Mr. Ronald Sagum
Applied Planning Services
P. O. Box 1724
Lihue, HI 96766

Subject: CEATECH USA, Inc. The Shrimp Company that is a great leap forward for our Island.

Dear Ronald:

As the County Executive Director for the Kauai County Farm Service Agency, I am the manager for the Federal Government that implements a variety of programs to the local farmers and ranchers. Programs that include Environmental Conservation programs, Crop Loss programs, Family Farmer Loan programs, to Emergency Farm programs and other farm/ranch oriented programs.

This FSA office has been in contact with the people of CEATECH USA, Inc. for several reasons. One is to prepare them for assistance in time of a natural disaster, two to assist them (cost-share) to apply conservation measures for the benefits of all, and to monitor them to be in compliance with the conservation problems that may occur with farming agricultural lands. In terms of being in compliance, they remain eligible for FSA's programs (crop loss/conservation and others).

In reviewing the progress of CEATECH USA, Inc. where they were, the present, and their projections. They are a great sight for Kauai's agricultural community for several reasons: They have a great staff (industry experience) to insure a great product for whichever market they venture into (success). Majority of the staff came from the westside, have family history there (pride). They present themselves to be environmentally sensitive in preparing for their presence on the westside of Kauai (responsible). They are currently in conservation compliance on the land where they are located.

As the CED for Kauai County it is great to see a business that attempts to balance both Environmental and Economic situations. As an individual, I wish them all the success to longevity and prosperity for everyone who is involved and around them.

Sincerely,

Robert S. Ishikawa, CED

rsi

Unity House, Inc.
"Serving Hawaii's Working People"
Anthony Rutledge, President

2 September, 1997

Mr. Ernie Dias
CEATECH USA, Inc.
7 Waterfront Plaza, Suite 400
500 Ala Moana Blvd.
Honolulu, HI 96813

Dear Ernie:

Unity House is excited about investing in an industry which could have a major impact on the economics of Kauai County and the State of Hawaii, and after careful consideration, was pleased to make a $500,000 investment in CEATECH USA, Inc.

Your updates have been helpful in monitoring progress. We are pleased to see that your perseverance has brought the land and permit issues to near completion. Unity House is confident that the management of CEATECH has the scientific and business expertise to achieve the projections presented to us in January and later restated in CEATECH's Private Placement Memorandum, dated 1 May, 1997.

As previously mentioned Unity House will continue to offer it's support and assistance whenever appropriate, to CEATECH in the accomplishment of your goals.

Unity House is looking forward to your success and supportive of your venture.

Very truly yours,

Anthony Rutledge, President
Unity House, Inc.

Unity House, Inc., a Hawaii Non-Profit Corporation for the benefit of Hawaii's Working People
444 Hobron Lane • PH-4B • Honolulu, Hawaii 96815 • (808) 945-0050 • FAX: (808) 944-0056

USDA United States Department of Agriculture

Cooperative State Research, Education, and Extension Service

Washington, DC 20250

September 8, 1997

Paul Bienfang, Ph.D.
Senior Vice President
CEATECH USA, Inc.
7 Waterfront Plaza, Suite 400
500 Ala Moana Blvd.
Honolulu, HI 96813

Dear Dr. Bienfang:

I appreciate you providing me with the background information on the CEATECH initiative. Since 1985 the U.S. government, through the USDA Shrimp Farming Consortium, has made a significant investment in development of appropriate technology to support the progressive and sustainable development of a domestic shrimp farming industry. Throughout the implementation of this program, I have always stressed the need to optimize the commercialization of the technologies developed by the Consortium. As shrimp farming technology continues to evolve at a rapid rate, there is a need for continued investment in technology development and the commercialization of this technology through both the public and private sector

Globally there is a major paradigm shift underway in shrimp farming systems technology. Environmentally sustainable integrated systems utilizing high health genetically improved stocks will be the key to commercially viable shrimp farming in the future. The CEATECH initiative as outlined is consistent with this concept and is technologically sound. CEATECH should be well positioned in terms of human capital having personnel that have been intimately involved in cutting edge technology development while working within the Consortium through the Oceanic Institute.

Paul, I wish you and your colleagues success as you move forward with this innovative initiative at CEATECH. I have enjoyed working with you and a number of your CEATECH associates in the past, and look forward to hearing from you as this initiative moves forward.

Sincerely,

Meryl C Broussard

MERYL BROUSSARD
National Program Leader, Aquaculture
CSREES, USDA

SENT BY:UH SSRI ; 1-12-98 ;11:10AM ; UH SOCIAL SCIENCE→ 6083320331;# 1

MICHAEL P. HAMNETT, PhD
Economic Development and Management Specialist
47-655 Hui Kelu Street, No. 5
Kaneohe, Hawaii 96744
Phone: (808) 239-6213 Fax: (808) 239-5120

December 15, 1997

Mr. Michael Wilson
Chairman
Board of Land and Natural Resources
c/o Kauai Land Division District Office
3060 Wiwa Street, Suite 306
Lihue, Kauai 96766

Attention: Mr. Michael Lauretta

Dear Mr. Wilson,

I am writing in support of CEATEC USA's aquaculture development venture in the Kekaha area of Kauai. For almost a year now, I have served on the technical advisory committee for the development of the CEATEC shrimp farm and believe it will be of considerable benefit to the west side of Kauai. As you are very aware, Kauai county is still suffering from the economic disaster created by Hurricane Iniki. This has been compounded by the general down-turn in the state's economy. The CEATEC venture will provide desperately needed jobs, help ease the inevitable the transition from sugar to other crops, and maintain the rural character of the area.

I have reviewed CEATEC's anti-degradation analysis and business plan. CEATEC has developed a pond management system that minimizes the amount of waste generated. Moreover, a great deal of care has gone into selecting a site with a suitable nearshore environment to avoid the degradation of coastal resources. Indeed, the area selected is perhaps one of the most suitable areas for saltwater shrimp farming in the state. It has a history of ocean discharge into a high energy environment that has been monitored for many years. The combined discharge from the existing sugar operation and the proposed CEATEC facility is well below the maximum permitted in the existing zone of mixing.

CEATEC is also committed to the development of more effective waste water treatment technology. The staff continue to monitor developments in this area and will, in the course of developing and operating the farm vigorously pursue ways to further reduce the suspended solids and nutrients contain in the effluent.

I have been very impressed with the professionalism of the principles and staff of CEATEC. I have not been directly involved in the development of an aquaculture commercial venture but have interacted with people in the business since the early 1980s. I have found those associated with CEATEC very knowledgeable about the technical aspects of shrimp production and farm management and with business investment and development. They have assembled a very impressive team, developed a sound waste management plan, and are giving the kind of careful attention to the development of the Kekaha farm that will be required to make it an environmental and economic success.

If you have any questions about this matter, do not hesitate to contact me.

Sincerely yours,

Michael P. Hamnett

Michael P. Hamnett

To. The Department Of Natural Resources
Lands Division
3060 Eiwa Street
Lihue Kauai, HI 96766

Attn.: Mr. Mike Laureta

Mr. Laureta , I have had the opportunity to look over the proposed plans for the CEATECH USA Project in the kekaha/mana area. I feel the project is well thought out and environmentally friendly

Bringing such a project to the west side is a plus for the community. It is an opportunity for employment that is much needed on the island. As well as a boost for our lagging economy. It is a great opportunity for our future , which is our young people ,as it would provide jobs for them.

As a resident of the kekaha area for some 33 year's I highly recommend this project .

Thank you

Mr. Chad Machado
Owner : THE IRON HUT GYM & FITNESS
P.O. Box 441
Kekaha,HI.96752

Post-it® Fax Note 7671 Date 12/1 # of pages 12

To	ROLAND	From	MIKE
Co./Dept.		Co.	KDLO
Phone #		Phone #	
Fax #	2460479	Fax #	

DOCUMENT CAPTURED AS RECEIVED

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

STATE OF ....
DEPARTMENT OF LAND AND NATURAL RESOURCES
AQUACULTURE DEVELOPMENT PROGRAM
1177 ALAKEA STREET, ROOM 400
HONOLULU, HAWAII 96813
E-mail: aquacult@aloha.com
PHONE. (808) 587-0030
FAX (808) 587-0033

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
LAND DIVISION
STATE PARKS

RECEIVED
NOV 24 1997
By.____________

November 21, 1997

MEMORANDUM

TO: Sam Lee, Kauai Land Agent
Kauai Land Division District Office

FROM John Corbin, Manager
Aquaculture Development Program

SUBJECT: Technical and Feasibility Assessment of the CEATECH USA Development Plans For Shrimp Mariculture in Kekaha, Hawaii

This responds to your request for our assessment of the CEATECH USA Shrimp Plantation Project. You are interested particularly in assessments of the project's technical and economic feasibility

BACKGROUND

CEATECH management staff has met with us six times in the last six months and we have visited the project site, except for the State lands being requested CEATECH provided their confidential development plan, which includes a financial analysis, and your staff provided a copy of the Environmental Assessment (EA) for the State lands I understand an EA already exists for the State Agricultural Park site. Details of the business plan, beyond that found in the development plan, were discussed with us in a meeting at the Company's Honolulu office and over the phone.

The Company considers some of the information they shared with us strategic and confidential, meaning its for potential investors. As such, in these areas we will offer some general observations based on detailed discussions. Overall our review is based on our technical understanding of the production system, the published scientific and market literature and broad aquabusiness development experience, particularly with marine shrimp. Should DLNR staff or Board Members require more specifics regarding any sensitive areas, we recommend you approach the Company directly

ASSESSMENT

When the Aquaculture Development Program (ADP) reviews a project/business plan, we mainly focus on four areas: a) qualifications of the personnel, b) production technology assumptions, c) cost/price assumptions, and d) market assumptions. In general, our experience with reviewing business plans is that company's do a good job on the costs, but can mis-forcast and be overly optimistic with unit yield, unit price and market demand. Based on the information we have to date, we offer the following comments on the CEATECH Project.

A Qualifications of the Personnel

In most projects targeted for Hawaii, the Aquaculture Development Program (ADP), knows the people either personally or by reputation. Those projects in which we don't know the staff, we can "check out" through our international network of contacts. In the case of CEATECH, most of the key operating personnel have come from the Oceanic Institute (OI), particularly the shrimp research program. We know the people by reputation or have worked with most of them for many years and they are very experienced in the species and technologies being used for the project.

It is a great advantage to the Company to have these former OI individuals on staff because they were instrumental in developing the "cutting-edge", round pond technology being utilized on Kauai, i.e., the technology was developed at OI over the past 10 years using millions of dollars of federal research funds. Since this is the largest scale of application of the technology to date, it is normal that there will be "problems of scaling up" to solve along the way. Having a highly experienced team will make this process go more smoothly. Moreover, the Company also points out that the staff have long-standing family ties to Kauai, which will help with obtaining community support for the project.

CEATECH has chosen to use a five member Technical Advisory Board to supplement their in house expertise, which is an excellent "back stop" approach. Four of the members we know personally and one by international reputation. Their collective credentials are indeed impressive. If utilized effectively, they can provide significant expertise in such critical areas as; production improvement, disease management, sustainable approaches, environmental impacts and community and government relations. All the advisors are internationally known and widely respected in their particular fields. (We can provide more detailed comments on this area if needed).

Finally, it is clear from our various discussions with the Company that, CEATECH principals Al Garcia, CEO and Ron Ilsley, CFO, have extensive backgrounds in starting and financing new company's, including publicly traded companies. Background material provided indicates a remarkable depth of experience in management, operations, finance, and marketing of new businesses and development stage companies. Mr. Ilsley has managed very large companies (in excess of $400 M in sales) and has many years of experience in international banking and finance Mr Garcia, in his long career, has actually distributed and sold fish and appears very familiar with the idiosyncrasies and "close nit" nature of the U S seafood industry and its distribution systems It's rare that a large scale start up company in the aquaculture field has people with this type of strong, big business background in management positions

One problem often seen with start-up aquaculture projects is undercapitalization and this is aggravated when the effort is high tech, with a high initial investment From our discussions, it appears that CEATECH principals are very experienced in the financing area, including attracting risk capital and managing public offerings Given this "track record", raising adequate capital to support the initial project phases should not be a problem assuming adequate performance

B Production Technology

The site chosen by CEATECH is one of the best aquaculture sites in the state for marine shrimp. There is an ideal climate (hot and low rain fall), combined with abundant land and water resources and a favorable regulatory situation There are few sites in Hawaii where this scale of operation, using this intensive rearing technology, could be carried out.

In brief, the Company is using round ponds that were developed at the Oceanic Institute with millions of dollars of federal research funds. CEATECH has acquired the Sunkiss Shrimp Company at Kekaha, which is successfully utilizing the round pond technology on Kauai. With this acquisition it can be said that a pilot demonstration has been successfully carried out at the site and we understand most production parameters used in the business plan have been tested under actual conditions

Specific advantages of round pond technology to grow Penaeus vannemei, the Mexican white shrimp, are many: yields exceeding 40,000 pounds per acre per year (with three crops) are possible based on the scientific literature (compared to 10,000 to 15,000 pounds for conventional semi-intensive earthen ponds), growth of the shrimp is very uniform (harvest sizes vary very little), water quality (e.g., suspended solids) is managed through much of the production cycle by specially designed water circulation and drainage systems, and the individual pond systems are modulated so large-scale layouts of ponds can be economically reproduced (e.g., common drainage), while inherently reducing risk. A three phase system is being utilized, i.e., hatchery, nursery (for small animals) and growout (to grow to market size), and this is typical for the more technically advanced operations in the industry.

The Company projects yields of 40,000 pounds per acre per year based on three crops per year. These values are within the expected performance of round pond technology as published in the literature and have been demonstrated by the Oceanic Institute in Hawaii Further, we were told that Sunkiss Shrimp Company has successfully grown shrimp in its four 1/4 acre round ponds, at growth rates and yields comparable to the scientific literature Company expectations are that 1 acre ponds will perform at approximately four times the results of the 1/4 acre ponds, and we believe from the scientific literature that this is a reasonable assumption with this species and technology.

Disadvantages of round pond technology include; it uses a lot of water relative to other technologies and the effluent can be highly nutrient dense, particularly late in the production cycle when the shrimp are large Source water must be reliable and direct discharge into the ocean is the only reasonable, cost-effective means of disposal

The Kauai site identified by CEATECH provides favorable ways to deal with both these issues. The coastal site is well situated to source large volumes of appropriate salinity (salt content) water as planned by the Company. We understand that preliminary discussions with the State Water Resources Commission indicate there should be no problem in drilling the required number of deep wells for all phases of the project We would expect adequate sea water should be available from deep wells - Phase 1 of 52 ponds requires approximately 25 million gallons a day (MGD) - and there are no competing uses in the area

The sites chosen for this project are particularly favorable for dealing with the effluent issue The regulatory situation has been set by the long-standing sugar plantation land use on the coast A National Pollution Discharge Elimination System (NPDES) permits and Zone of Mixing (ZOM) permits has been granted by the State Department of Health (DOH) to Kekaha Sugar Company (KSP) for direct discharges of 100 MGD for the dry season and 200 MGD for the wet season Reportedly the existing NPDES permit includes permits for six to eight ZOM's - defined as areas where State receiving water standards can be legally exceeded. ZOM's serve the purpose of allowing effluents to be diluted until they reach ambient background concentrations at the edge of the ZOM When the effluent stream moves out of the ZOM area it is at ambient concentrations and undetectable

This approach to waste water disposal is made possible by coastal waters in the area being classified as Class A by DOH, thus allowing direct ocean discharge. CEATECH cites a near-shore oceanographic study that demonstrates the natural current and wave patterns cause an extremely well-mixed environment for dilution, thus minimizing environmental impacts from coastal discharges While we have not reviewed the study, these conclusions are consistent with our understanding of the oceanographic situation, at an exposed ocean coast

Comparatively, the shrimp farm is projected to have roughly half the amount of effluent permitted by the dry season permit limits, when the first two phases are built (104 ponds) Moreover, the concentrations of nutrients and suspended solids in the shrimp pond discharge can be expected to be substantially less than the existing effluent, due in part to the pretreatment procedures (i.e., settling basins) being applied prior to discharge We would anticipate that CEATECH's request for discharge permits for the project should not be an issue, since cane irrigation waste water will probably be reduced in the near future due to the phasing out of sugar

We also note, the Company has given a great deal of consideration in its site planning for the State lands to flooding and drainage issues It has integrated these considerations into its waste water disposal design The Company's strong concern for a sustainable, environmentally compatible project is admirable

Another important technical aspect of this project that should be mentioned is its use of *Specific Pathogen Free (SPF) stock and use of high health (biosecure) management procedures* for the farm. Shrimp virus diseases are devastating shrimp farms in Asia and South America. One approach to managing this situation is to utilize only certified virus-free (SPF) animals on the farm and then closely control access to hatchery and growout facilities CEATECH has two of the foremost experts on the area of shrimp disease in the world on its advisory board and company officials assure us they will be following the latest protocols to maintain the farm virus free - we note, for example, plans call for the hatchery area to be physically separated from growout areas

C. Cost and Price Assumptions

The areas of cost (capital and operating) and price are more difficult to comment on specifically due to the proprietary nature of the detailed information, i.e., at this point it is for disclosure to qualified investors Company officials willingly discussed assumptions and answered specific questions about these specific values, however, permitting some general comparisons with known values from the literature, shrimp farming in general and common sense. Financial statements presented in the development plan included; a balance sheet, sales and cost of sales projections, income statement, stock holder's equity, assets and depreciation, and forcasted cash flow Figures were for 1997 to January 1998, February 1998 to January 1999 and February 1999 to January 2000 or roughly 3 years

Briefly, a review of projected construction costs for unit grow-out pond, i.e., cost per pond, are within the range expected for the type of technology utilized. CEATech should have direct estimates from it's Sunkiss operation. Further, gross cost estimates to upgrade the Sunkiss facility to a large-scale hatchery to supply the Phase I farm appear reasonable.

Other key cost areas include the operating costs of feed, labor and utilities, which are usually the top three costs in an intensive operation like this Unit feed costs for bulk mainland shrimp feed delivered to Kauai are within the range expected, given current prices. Feed composition, specifically protein content, the most expensive component, represents the state of the art thinking in shrimp nutrition Likewise, the feed conversion ratio (feed needed to make one unit of shrimp) used in calculations is consistent with known values from the literature Only a very general statement can be made on the labor requirements as, detailed breakdowns of jobs and salaries were not discussed The ratio of 1 job per 1 acre of production pond is within the range expected for this type of intensive technology. We did not discuss the cost of utilities for the project

The Company discussed the unit price to be charged for its marine shrimp It will be sold in the head-on, fresh-chilled product form. Form, size, and portion control are important considerations in selling shrimp and the company has positioned itself in what might be called the fresh-chilled, head-on niche of the huge national and world shrimp markets Shrimp will be sold at a premium price in comparison to other similar product forms in the size range However, CEATECH believes it can add value to its product by tight quality control, efficient handling and service and branding the product from Hawaii. From our experience, other Hawaii producers have been able to accomplish this by doing an excellent job with these factors

The company also discussed its break-even price with us. We understand this was created from detailed cost estimates for various components of the operation and is probably in the mid-range of what might be expected from this site and technology The projected margin between cost and price is quite significant and gives room to fine-tune the operation, as it scales up We believe the projected break-even cost must reflect the economies of scale that will likely be achieved at full, Phase I size.

It is useful to give the reader an idea of the significant revenue generation potential of intensive round pond technology. A rough average wholesale price in Hawaii for locally produced heads-on, fresh chilled shrimp is $5 00 a lb Each 1 acre round pond could at 40,000 pounds per year generate $200,00 a year in gross revenue, compared to $2000 an acre a year for sugar.

Regarding the specific financial aspects of the development plan we can offer only a few brief comments The $4 M in construction funds needed for this project reflect the capital intensive nature of this technology. Given the experience of the principals in finance and raising risk capital, we would anticipate that with adequate performance, capital to complete all three phases would be available

The Company has executed an Initial Public Offering (IPO) to raise most of the Phase I expansion capital They are seeking a Federal loan guarantee to further strengthen the attractiveness of this investment Principals also discussed several other interesting approaches to securing additional capital with us

Cursory review of the nearly three years of monthly financial numbers indicates allocation and scheduling of expenditures are well thought out Reasonable construction schedules and product cycles appear factored into the calculations. If there is a weakness it is in the timing of the initial start up for Phase I, and the acquisition of land and permits While acquiring acreage in the Department of Agriculture, Agriculture Park should move smoothly ("turn key"), it may prove ambitious to assume that all the necessary Federal, State and County permits and approvals will be received and the State land acquired to meet the timetables and cash flows indicated for Phase I start up and operation. As such, the company may have to adjust its plans accordingly Our experience with some of the regulatory agencies involved, particularly in permitting coastal Hawaiian fishponds, has not been positive

D Market Assumptions

CEATECH has chosen a "main stream" aquaculture product, with global consumption of marine shrimp approaching 3 billion pounds a year Approximately, 30% of world shrimp supplies are aquacultured and this amount in increasing steadily due to increasing demand and limited wild supplies As mentioned in the plan, Americans consume approximately 850 million pounds of shrimp annually, 75% of which is imported *Importantly, CEATECH will have little* domestic aquaculture competition for its premium, fresh-chilled product. Only two states, Texas and South Carolina, engage in shrimp farming

As for the Hawaii market, though no specific figures are available, we consume probably between 5 and 6 million pounds of shrimp a year. Probably 98% of it is imported, mostly in the frozen or processed form. We do have a few small shrimp farmers that have overcome problems with virus disease and are making a go, but these should not be a threat to the Company.

Their business plan calls for the export market for 80% of their product CEATECH has recognized that their production could flood the local market and negatively affect these small operations Furthermore, we understand they have reached out to local farmers and offered to work with them in the joint marketing of products and even provision of SPF seed stock. We consider both of these approaches prudent and responsible and applaud the company for its community concern.

Company officials shared details of the marketing strategy with us. They are positioning their product as a premium, fresh, Hawaii-grown product. We reviewed some of their marketing materials i.e., product name and word mark and logo, and found them to be very well done. The Company is working with a top mainland marketing firm to develop these and other promotional materials to initially target urban centers in the Western U.S and Japan. Clearly, from discussions, the Company has made some excellent contacts to help sell and distribute its product and has carefully budgeted for marketing More importantly, they seem to have a good strategy to differentiate their shrimp from the mainstream "commodity shrimp", which dominates the market.

CEATECH appears to be successfully incorporating the advantages of the round pond technology and its Hawaii location into its marketing plans Disadvantages, however, will have to be managed effectively to succeed Probably, the greatest of these is the remoteness of the location to Honolulu Airport and direct mainland flights We note from the plan, the processed product will be handled twice before it leaves Hawaii for its mainland location, i.e , loaded on a plane on Kauai, unloaded and reloaded on a plane for the West Coast

We discussed this issue with company officials and they are certainly aware of the potential logistic and cost problems. The key to seafood product quality control is maintenance of the necessary "core temperature" for the product through all phases of its distribution CEATECH will be using ice to carry out this function from the pond bank to the processing/packing plant Officials described the use of a newly developed, refrigerated LD3 shipping container for the remainder of the journey to the end customer We were impressed with the reported capabilities of this new container and believe it could keep product spoilage during transport to a minimum

Finally, we believe the overall long-term supply and demand situation for marine shrimp is very favorable for a company that can consistently produce, large volumes of high quality product Consider demand for seafood and particularly marine shrimp can be expected to continue to rise, if not from increases in per capita consumption, then just from increases in the world population. Moreover, continued expansion of urban mega-cities in non-U.S. countries, e g , Bangkok, Seoul, New Deli, Tokyo, can be expected to "pull product" away from the U S market, making domestically produced product more valuable

On the supply side, shrimp supplies can be expected to be erratic in the long term Wild caught marine shrimp supplies are not expected to grow and in fact, due to coastal pollution, poor fisheries management, etc , they may be reduced Aquacultured shrimp supplies, worldwide, can be expected to go through "boom and bust" cycles of supply - continuation of the trends of the last ten years - as third world countries fail to come to grips with virus disease management and poor aquaculture planning.

Equally important, the global trade in marine shrimp can be expected to be significantly impacted by the growing number of controversies over non-tariff import barriers Examples include, new European Union Health Directives and recent actions against some shrimp imports, the Food and Drug Administrations new HACCP requirements, Australia's "Quarantine Regulation" banning certain seafood imports, and U.S. requirements on how imported tuna and wild shrimp must be harvested.

These looming environmental, economic and political issues bode well for a Hawaii company that can guarantee supply of high quality, fresh shrimp to the U S marketplace Notably, other product forms and by-products are being explored

CONCLUSION

In conclusion, we have analyzed the CEATECH shrimp aquaculture project locating on Kauai Conceptually, the project has many favorable characteristics outlined above and few if any significant risk areas that haven't been considered in the development plans We are very supportive of the project as a potentially sustainable, long-term use of State land and ADP stands ready to assist the Company with our various industry support services, e.g , marketing, permit assistance and animal health management As you know, a successful, full scale project would have be a major benefit to the Kauai economy Should you have any questions, please call me at 587-0030

c Dean Uchida, Land Division

BENJAMIN J. CAYETANO
GOVERNOR

GARY GILL
DIRECTOR

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
235 SOUTH BERETANIA STREET
SUITE 702
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November 4, 1997

Mike Laureta
Department of Land & Natural Resources
3060 Eiwa Street #306
Lihue, HI 96766

Dear Mr. Laureta:

Subject: Draft Environmental Assessment (EA) for Ceatech Hawaii Marine Shrimp Farm, Kekaha; TMK 1-2-2: por. 1

We have the following comments to offer:

1. Maps: Many of the maps are quite old and/or unclear. Please provide updated maps for the following:
   - ▸ FIRM map (Exhibit M)
   - ▸ Land Use Commission map (Exhibit L) does not show the portion of the project site which falls in the Conservation District, as mentioned in Secion 4.1, *Zoning*
   - ▸ Site map (Exhibit E); also indicate the project location on the regional map, Exhibit A

2. Kawaiele Sanctuary: Section 1.4.1, *Location*, states that this sanctuary lies to the south of the project site. In the final EA give a full description of the sanctuary and indicate what measures will be taken to protect the sanctuary from both construction and operational impacts, such as runoff, impacts to the underground and surface water systems, and impacts affecting viewplanes of the sanctuary from mauka locations.

3. PMRF Impacts: When the adjacent Pacific Missile Range Facility prepares to launch, will Ceatech have to cease operations temporarily or evacuate the premises, as had happened in the past to the immediate neighbors? Are there any other impacts on Ceatech from PMRF activities?

4. Consultations: In the final EA include copies of any correspondence with consulted agencies, organizations or individuals.

If you have any questions, please call Nancy Heinrich at 586-4185.

Sincerely,

GARY GILL
Director

c: Roland Sagum, Applied Planning Services
Paul Bienfang, Ceatech

University of Hawai'i at Mānoa

Environmental Center
A Unit of Water Resources Research Center
2550 Campus Road • Crawford 317 • Honolulu, Hawai'i 96822
Telephone: (808) 956-7361 • Facsimile: (808) 956-3980

November 24, 1997
EA:00168

Dr. Paul Bienfang
CEATECH USA
7 Waterfront Plaza, #400
500 Ala Moana Boulevard
Honolulu, Hawaii 96813

Dear Dr. Bienfang:

Draft Environmental Assessment (EA)
CEATECH USA
TMK: 1-2-2:por. 1
Waimea, Kauai

The Applicant, CEATECH USA, proposes to acquire approximately 300 acres of State land to construct and operate a marine shrimp farm in Kekaha, Kauai. The proposed action consists of emplacing 104 1-acre lined circular nursery and grow out ponds, a hatchery facility, interior access roads, drainage ditches, brackish groundwater supply wells, waste recovery retention basins, and accessory structures. The proposed CEATECH USA facility will produce 4 million pounds of shrimp annually.

We have reviewed this Draft Environmental Assessment (DEA) with the assistance of Nancy Bushnell, Biological Science, Kauai Community College; Richard Brock, Fishery Specialist, Sea Grant; Philip Loh, Microbiology; John Stimson, Zoology; and Alexandra Gurary, Environmental Center.

General Comments

If successful, aquaculture developments such as have been proposed by CEATECH USA will expand the economic base of the State and will complement the development of diversified agricultural industries. However the magnitude and the scope of the proposed action are such that the project very likely will have significant environmental impacts on the surrounding environment, impacts that may be detrimental or beneficial, but nevertheless significant as defined in HRS 343-2(12). Our reviewers unanimously concluded that the scale of the CEATECH USA project requires a more thorough environmental analysis than is provided in the present DEA. The applicant should prepare an Environmental Impact Statement (EIS) which should include more detailed information about the local and regional environment, and about the operational inputs and effluents of the proposed facility. In particular, the following concerns reflect some of the critical points that should be addressed in an Environmental Impact Statement.

Water requirements

The DEA fails to provide detailed data on sources and quantities of water required to operate the 104 ponds. Our reviewers estimate a range of 35 to 54 million gallons of sea water per day, based on the number of ponds (104), the volume of each pond (1.3 million gallons), and a daily turnover of 25 to 40 % (this estimate does not include the water requirements for the 12 nursery ponds). How will this sea water be obtained? If drawn from the ocean, where will the intakes be located? Will the intakes be at the beach or on the reef? How will these intakes be protected from storms? If taken from ground water wells, where will the well, or wells, be located and what will be the effect on the water table and lens in this area? Are brackish ground waters anoxic, or elevated in sulfides or nitrates? What treatment or aeration facilities are needed to condition the water for aquaculture? What will be the location and the number of pumps needed to provide the necessary quantity of sea water to the ponds? How much electricity will be required to operate these pumps, and is this electricity currently available?

Discharge Water Content and Treatment

The present DEA does not provide sufficient data on contents of the discharge water or its treatment for evaluation of the project's environmental effects. It is certain that the discharged sea water from this facility will be adding dissolved and particulate nutrients (nitrogen and phosphorous) to the waters which flow to the ocean. How will these aquaculture waste products be treated and delivered to the site of disposal? Since aquaculture wastes represent an "enriched medium" conducive to the growth of microbial as well as plant and animal life, what steps will be taken to monitor the changes that will occur?

Solid Waste Disposal

CEATECH USA intends to recover and reuse settled particulates which accumulate on the pond bottom. The project proposes that this solid waste be used as a soil amendment by the Kekaha agricultural community. However, this might not be a realistic proposal due to the high content of salt. What alternative disposal methods have been considered, and what is the expected volume of solid waste requiring disposal? The consequences of the reuse of solid aquaculture waste (sludge) require more detailed evaluation.

The Effects of Discharge on Nearshore Water Quality

The information provided on the oceanography of the receiving water is very general and insufficient to make a proper analysis of possible impacts. Although reference is made (pg. 24-B) to dynamic and hydraulic modeling of shoreline effluent discharges, discussion and presentation of specific algorithms and parameters are not provided. Hence, our reviewers cannot evaluate the appropriateness of the modeling efforts, nor can we assess the validity of the asserted modeling results. Lacking detailed descriptions of the regional physical oceanography and the precise chemistry of effluents, the DEA offers no substantiation for its claim that discharges from the facility will be inconsequential. Therefore, statements such as " The project is not anticipated to adversely affect the water quality in the adjacent ocean ..." (pg. 24-B), and " ...there is no evidence of any negative impact to the water quality, or aquatic flora or fauna from the historical discharges to the area..." (pg. 23-A) are unsubstantiated. These statements do not seem to take into consideration that the project will almost certainly be discharging a more nutrient-rich effluent than is presently discharged, and that it will be a continuous discharge of salt water, not fresh water. Agricultural wastes and effluents, except for the presence of toxic chemicals (which are not as prevalent in the sugar cane industry), are a lot " cleaner" than aquaculture wastes which contain a greater amount of organic wastes. Therefore the statement that "... the quality of the effluent discharge will improve over its current condition..." is unsubstantiated without any supporting documentation.

Miscellaneous Issues

The DEA does not provide a study on precautions or controlled measures that need to be taken to handle changes in avian life and small wild-life populations. Since there will be a greater attraction of avian life both in numbers and possibly different species, there is a potential for transmission of infectious diseases by avian hosts, rodents, and other fauna.

Our reviewers also noted that exclusive use of even the sixth generation of specific pathogen-free high health shrimp does not preclude the presence of other infectious agents. Such SPF animals are only monitored for some eleven infectious agents, and may carry other infectious agents not currently monitored.

One of our reviewers noted the presence of a large population of endangered sea turtles in the proposed discharge area. What will be the effect of effluent rich in organic and inorganic wastes on the coastal environment and subsequently on the turtle colony.

The DEA discusses the site location and Best Management Practices as it relates to the project being located in the flood zone, but there is no discussion of the fact that the project site is within the Tsunami inundation zone.

The DEA does not provide a detailed study on wider impacts of the proposed action on the economy of the island of Kauai. By their own admission CEATECH USA anticipates changes in the economic status of the community (pg. 54-4), but discussion of social and economic impacts in the long term is generally lacking.

The absence of detailed maps made it difficult and sometimes impossible to follow the location of the proposed drainage system, and to evaluate the site location as it related to tsunami and flood hazard zone.

Conclusion

As stated in Section 343-1, Hawaii Revised Statues (HRS), the primary intent of Hawaii's environmental review system is "... to ensure that the environmental concerns are given appropriate consideration in decision making." Of principal interest is the balancing of long-term environmental effects with the economic and technical outcomes likely to result from a proposed action. In order to reliably arrive at an appropriate balance, sufficient information must be available to adequately assess both the presumptive effects and the likely benefits of the proposed action.

This DEA provides only general information concerning elements of both the proposed action and of the environment in which the action is embedded. Our reviewers have consistently noted the insufficiency of detailed data upon which conclusions as to the possible significance of project impacts may reasonably be based. While assertions of inconsequence abound, the burden of proof as to the lack of significance of the environmental effects lies with the applicant, and we find such proof conspicuously lacking.

Dr. Paul Bienfang
November 24, 1997
Page 5

According to HRS 343-5(b) an Environmental Impact Statement is required if "...the proposed action may have a significant effect on the environment..." The present DEA does not provide the necessary detailed data to adequately evaluate the potential impacts of a long term effects on the environment that a project of such magnitude and scope might have. According to Section 11-200-12 of the HAR, the proposed CEATECH USA project is potentially significant on number of counts, thus, an Environmental Impact Statement is needed.

Thank you for the opportunity to comment.

Sincerely,

John T. Harrison
Environmental Coordinator

cc: OEQC
DLNR, Kauai District Land Office
Applied Planning Services
Roger Fujioka
Nancy Bushnell
Richard Brock
Philip Loh
John Stimson
Alexandra Gurary

January 9, 1998

Mr. Mike Laureta
Department of Land & Natrual Resources

Lihue Hawaii, 96766

Subject: Ceatech Project

Dear Mr. Laureta

I have been privileged to know Mr. Sagum for several years in my role as Managing Supervisor and Owner at Fredstan Kaluahine's Towing & Service, I am currently director of business management.

While Mr. Sagum reported to me at Fredstan Kaluahine's Towing & Service, I found his management abilities to be valuable in helping me to establish new Ideas as a leader in these kinds of projects, His concentious effort and corperation in doing professional, high-quality work were appreciated. And we feel that this Ceatech project would be very good for the Island of Kauai and something very much needed.

As a group supervisor, Roland is efficient innovative, and responsive. He motivates his people with challenge and the opportunity for new ideas as well as personal growth.

If you find that Roland's career objectives match these kinds of position project description, I know of no reason you would be disappointed by his recammendation in this Ceatech Project. Please let me know if you require further informantion.

Sincerely,

Fredstn Kaluahine

BAA/fkt

Appendix 10

Consultant List

CONSULTANT LIST

Avery Youn Architects	Architectual & Design
Aqua Engineers	Septic System
Applied Planning Services	Land Use
Wagner Engineering Services	Civil Engineering
J. Douglass Ing	Legal
Bob Matsumoto	Legal
Tom Nance	Wastewater Disposal
Cliff Jamile	Water Quality
Gregg Bonacker	Engineering & Design
Edward K. Noda & Associates	Marine Hydraulics

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