JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
Director

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Deputy Director

TEL. (808) 270-7745
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COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
AND WASTE MANAGEMENT
ENGINEERING DIVISION
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

RALPH NAGAMINE, L.S., P.E.
Land Use and Codes Administration

RONALD R. RISKA, P.E.
Wastewater Reclamation Division

LLOYD P.C.W. LEE, P.E.
Engineering Division

ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

March 13, 2000

Ms. Genevieve Salmonson, Director
Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu, Hawaii 96813

Dear Ms. Salmonson:

Subject: Final Environmental Assessment (FEA)
South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street
Federal Aid Project No. 3100(11)
Tax Map Keys: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: various
Kihei, Maui, Hawaii

The County of Maui Department of Public Works and Waste Management has reviewed the subject FEA and determined that a Finding of No Significant Impact (FONSI) is appropriate. Please publish notice of availability for this project in the March 23, 2000 OEQC Environmental Notice.

We have enclosed a completed OEQC Publication Form, four copies of the FEA, and the project summary (hard and disk copies).

Please call Joe Krueger of our office at (808) 270-7745 or Rodney Funakoshi of Wilson Okamoto & Associates, Inc. at 946-2277 should you have any questions or require additional information.

Sincerely,

Charles Jencks, Director

Enclosures

cc: Mr. Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

2000-03-23-MA-FEA-

Final Environmental Assessment

South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street

Federal Aid Project No. STP 3100(11)

Prepared For:

County of Maui
Department of Public Works and Waste Management

Prepared By:

Wilson Okamoto & Associates, Inc.

March 2000

Final Environmental Assessment

South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street

Kihei, Maui, Hawaii

Federal Aid Project No. STP-3100(11)

Responsible Officer: _____ **Date** 3-8-00

Charles Jencks, Director
Dept. of Public Works and Waste Management

Prepared For:

County of Maui
Department of Public Works and Waste Management
200 South High Street
Wailuku, Hawaii 96793

Prepared By:

Wilson Okamoto & Associates, Inc.
Engineers and Planners
1907 South Beretania Street
Honolulu, Hawaii 96826

March 2000

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1. INTRODUCTION

This Final Environmental Assessment (EA) was prepared pursuant to Chapter 343, Hawaii Revised Statutes, and Title 11, Chapter 200, Administrative Rules, Department of Health, State of Hawaii. Proposed is an agency action by the County of Maui Department of Public Works and Waste Management (DPWWM) to construct roadway improvements to an approximately 1-mile segment of South Kihei Road from Kulanihakoi Street to Lipoa Street in Kihei on the island of Maui..

PROJECT SUMMARY

Proposing Agency:	County of Maui Department of Public Works and Waste Management (DPWWM)
Accepting Authority:	County of Maui, DPWWM
Project Location:	South Kihei Road between Kulanihakoi Street and Lipoa Street, Kihei, Maui, Hawaii
Tax Map Keys:	(2) 3-9-1: 2, 4, 6, 7, 9, 10, 11, 13, 56, 57, 75, 77, 134, & 151 (2) 3-9-2: 28, 82, 83, 109, 152, &153 (2) 3-9-7: 7, 16, 18, 21, 22, 23, 38, 39, 40, 41, 42, 43, 54, 62, 63 & 64 (2) 3-9-8: 15, 16, 27, 24, & 28 (2) 3-9-22: 3, 4, 20, 21, 22, 29, 38, 39, 40, 57, 58, & 59 (2) 3-9-34: 1, 13, 14, 15, 16, & 27 (2) 3-9-46: 5, 6, 7, 8, 9, & 17 (2) 3-9-52: 16, 17, 18, 19, 20, 21, 22, & 37
Area:	Approximately 7.6 acres
Recorded Fee Owner:	County of Maui (for County road right-of-way)
Existing Use:	5,100-lineal foot, two-lane improved roadway
State Land Use Classification:	Urban
Community Plan Designation:	Single Family, Multi-Family, Hotel, and Commercial
County Zoning Designation:	R-2 Residential, R-3 Residential, A-1 Apartment, A-2 Apartment, H-M Hotel, and B-2 Business
Proposed Action:	Roadway improvements including widening of the right-of-way, addition of a parking lane, bike lanes, sidewalks, gutters, relocation of drainage and wastewater systems, replacement of a 900-foot segment of water line.
Determination:	Finding of No Significant Impact

Parties Consulted During Pre-Assessment:

Federal Agencies:	U.S. Fish and Wildlife Service U.S. Geological Survey U.S. Natural Resource Conservation Service U.S. Army Corps of Engineers
State Agencies:	Department of Land and Natural Resources (DLNR) DLNR, State Historic Preservation Division DLNR, Aquatic Resources DLNR, Division of Forestry and Wildlife Department of Health (DOH) DOH, Clean Water Branch
County Agencies:	Planning Department Board of Water Supply Police Department Fire Department Department of Parks and Recreation – Arborist Committee
Other:	Maui Electric Company Kihei Community Association

2. SETTING AND PROJECT DESCRIPTION

2.1 Project Background And Need

The County of Maui Department of Public Works and Waste Management (DPWWM) is proposing to improve an approximately 5,100-foot portion of South Kihei Road between Kulanihakoi Street and Lipoa Street in Kihei on the Island of Maui.

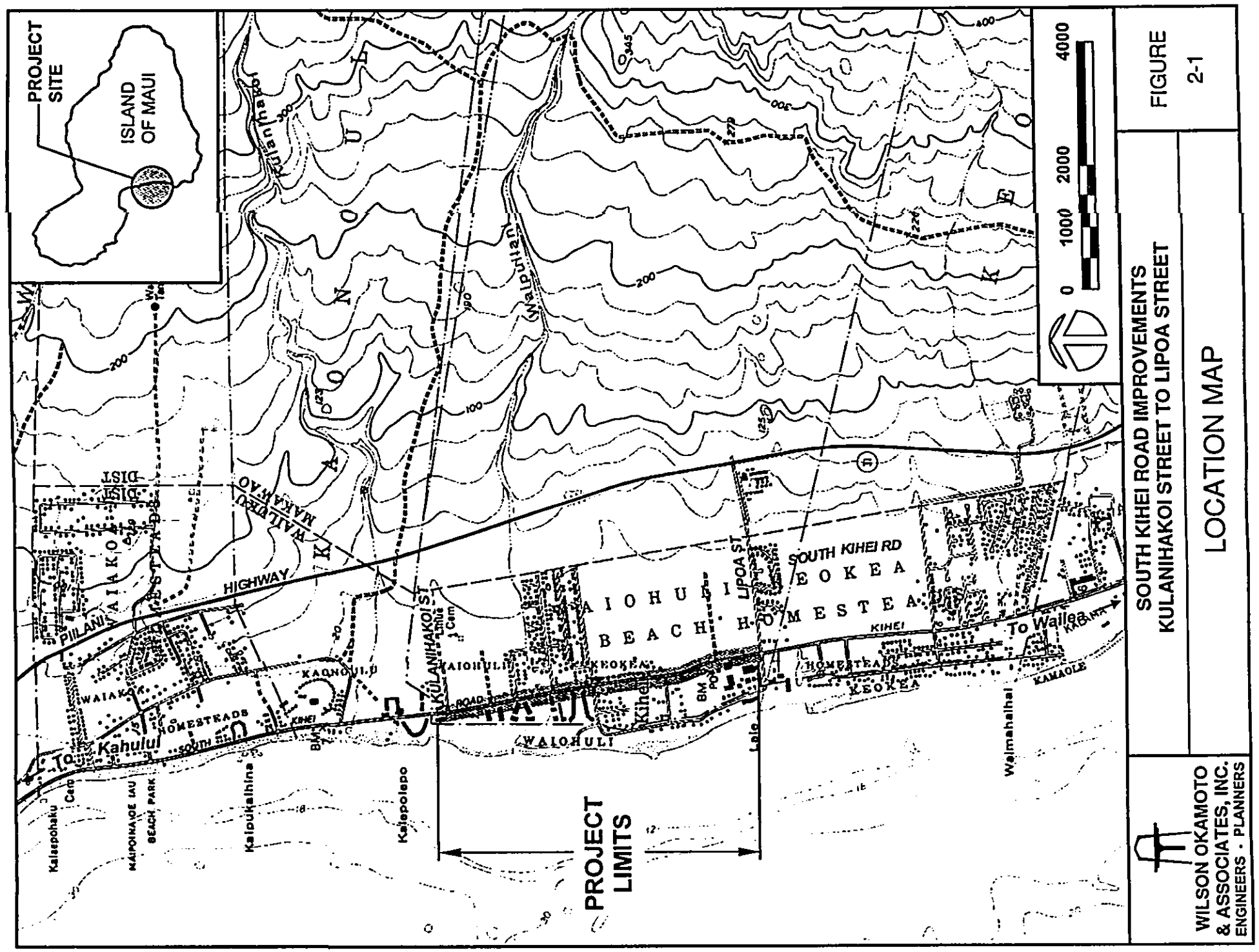
According to the Kihei-Makena Community Plan, inadequate traffic circulation is recognized as one of the most significant problems in the Kihei-Makena region. In 1990, the population of Kihei was 15,365, an increase of more than twice its population in 1980 of 7,263, and almost ten times its population in 1970 of 1,636. While the region experienced significant population growth in the 1980's and 1990's, however, public infrastructure improvements have lagged behind development in the region. As a result, a significant upgrade and expansion of the existing public infrastructure system is necessary. South Kihei Road is the major north-south collector street in the Kihei area. The two-lane road is heavily used and motorists often encounter traffic congestion. The project is proposed to alleviate traffic congestion in this area of Kihei town.

2.2 Project Description

The proposed project encompasses approximately 5,100 lineal feet or 0.95 miles from approximately 170 feet north of Kulanihakoi Street to Lipoa Street (see Figure 2-1, Location Map). Approximately 3,800 feet of the project, from approximately 170 feet north of Kulanihakoi Street to approximately 300 feet south of Nohokai Place, will involve widening of the existing right-of-way, which varies from 50 to 60 feet, to a proposed right-of-way of 60 to 70 feet to provide for 2 travel lanes, bike lanes, a parking lane, turning lanes, sidewalks, and curbs and gutters. The paved roadway will be 40 and 50 feet from curb to curb within the 60 and 70-foot rights-of-way, respectively. The next 1,000 feet to Road "C" will be limited to restriping of the existing roadway. The remaining 300 feet from Road "C" to Lipoa Street will not include improvements or restriping. In addition, at the request of the County of Maui Board of Water Supply, approximately 900 feet of waterline will be replaced from Kauhaa Street to approximately 300 feet south of Nohokai Street (See Figures 2-2 and 2-3, Site Plan and Typical Road Sections, respectively).

The major improvements proposed for the first 3,800-foot segment of the project will include the following:

- Two 12-foot travel lanes;
- Two 5-foot bike lanes;
- Dedicated left-turn lanes at all intersections;
- Dedicated right-turn lanes at selected intersections;
- A parking lane on one side of the road;
- A new culvert crossing at Waipuilani Gulch;
- A new culvert crossing located approximately 240 feet north of Nohokai Street;
- Two 6-foot wide sidewalks; and
- Curbs and gutters on both sides of the road.



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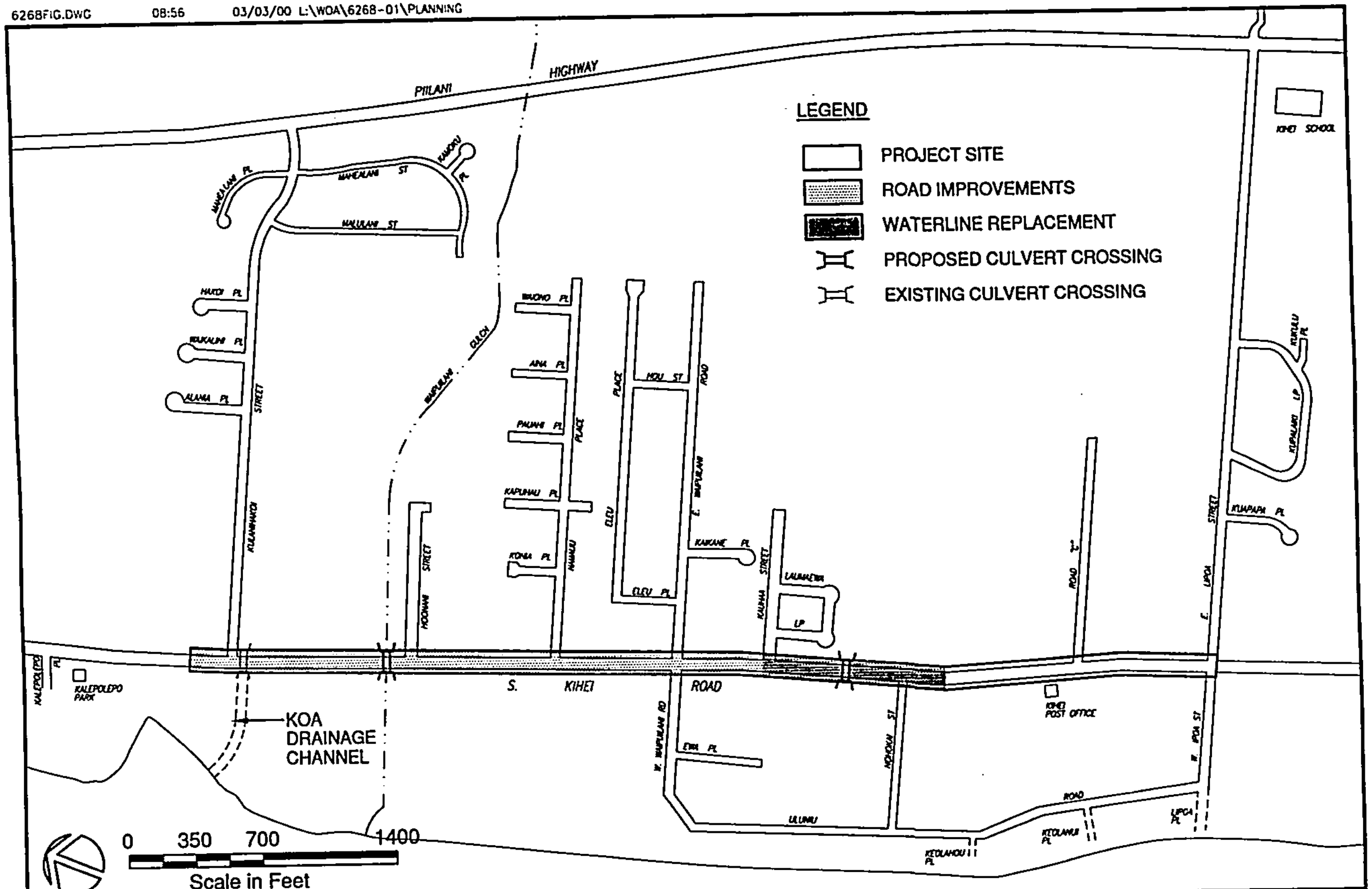

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SOUTH KIHEI ROAD IMPROVEMENTS - KULANIHAKOI STREET TO LIPOA STREET

SITE PLAN

FIGURE 2-2

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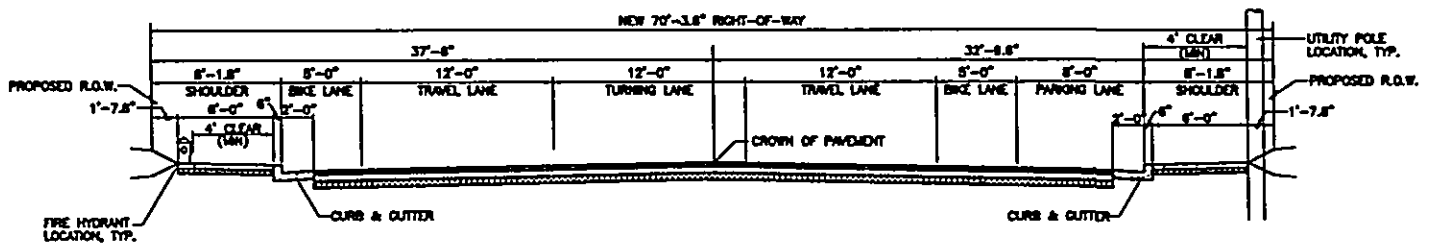

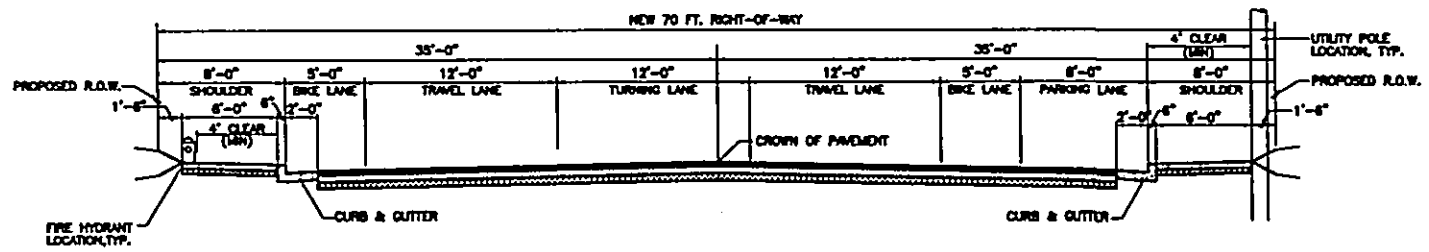

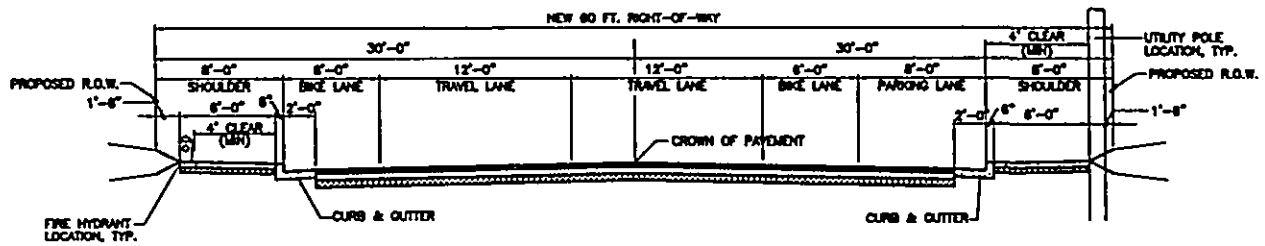

0 6 12 24

Scale in Feet

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SOUTH KIHEI ROAD IMPROVEMENTS - KULANIHAKOI STREET TO LIPOA STREET

TYPICAL ROAD SECTIONS

FIGURE 2-3

Other associated improvements involve new and relocated storm drains and manholes, relocation of driveways, relocation of street lights and overhead utility lines, removal of existing landscaping; and adjustment of sewer manhole covers.

2.2.1 Construction Schedule and Cost

Construction of the proposed project is anticipated to commence in late 2000, with completion estimated by 2002 contingent on land acquisition and contractor selection. The estimated construction cost of the proposed project is $4 million.

2.3 Existing and Surrounding Uses

2.3.1 Existing Uses

The portion of South Kihei Road that comprises the project site is a two-lane improved roadway. Most of the project, from Kulanihakoi Street to Road "C" consists of paved shoulders without curbs or gutters. Sidewalks, curbs and gutters are located only within a few stretches, including approximately 600 feet on the west (northbound) side fronting Kiawe Terrace Apartments near Kulanihakoi Street, approximately 1,000 feet on the east (southbound) side fronting the Luana Kai Condominiums between Hoonani Street and Namauu Place, and approximately 300 feet on the west (northbound) side near Kauhana Street. The remaining 300 feet of the project from Road "C" to Lipoa Street was recently improved and includes sidewalks, curbs and gutters on both sides of the road.

There are three signalized intersections within the project site including one fronting Long Drugs Kihei Center and McDonald's, a second at Road "C", and a third at Lipoa Street. Overhead power and telephone lines are located on the west (northbound) side of the road throughout the length of the project.

Two drainage features traverse the project site. The first feature, Koa Drainage Channel, is a concrete-lined drainage ditch which flows beneath South Kihei Road at Kulanihakoi Street. The crossing is comprised of a triple box concrete culvert with a total width of 24-feet. The second feature, Waipuilani Gulch, is an unlined drainage channel which crosses under South Kihei Road approximately 150 feet north of Hoonani Street.

2.3.2 Surrounding Uses

The town of Kihei is largely characterized by a mix of residential, visitor-related, and commercial developments, with vacant lots interspersed throughout. Uses surrounding the northern portion of the project site, from Kulanihakoi Street to Kauhaa Street include single family residences and several apartment and resort condominium developments such as the Koa Resort, Koa Lagoons, Kiawe Terrace Apartments, Village By The Sea, Luana Kai Condominiums, Maui Schooner Resort, Leinaala, Waipuilani, Maui Sunset, and The Meadowlands. Surrounding uses within the southern portion of the project from Kauhaa Street to Lipoa Street are comprised primarily of commercial and business

uses including Yee's Orchard, Longs Drugs Kihei Center, McDonald's, Azeka Place, Azeka Place II, Star Market, Gas Express, Chevron, Jack In The Box, and Kihei Professional Plaza. The County's Kihei Sewage Pump Station No. 4 and the Kihei Post Office are also located within this portion of the project. Figure 2-4 illustrates the surrounding uses in proximity to the project site.

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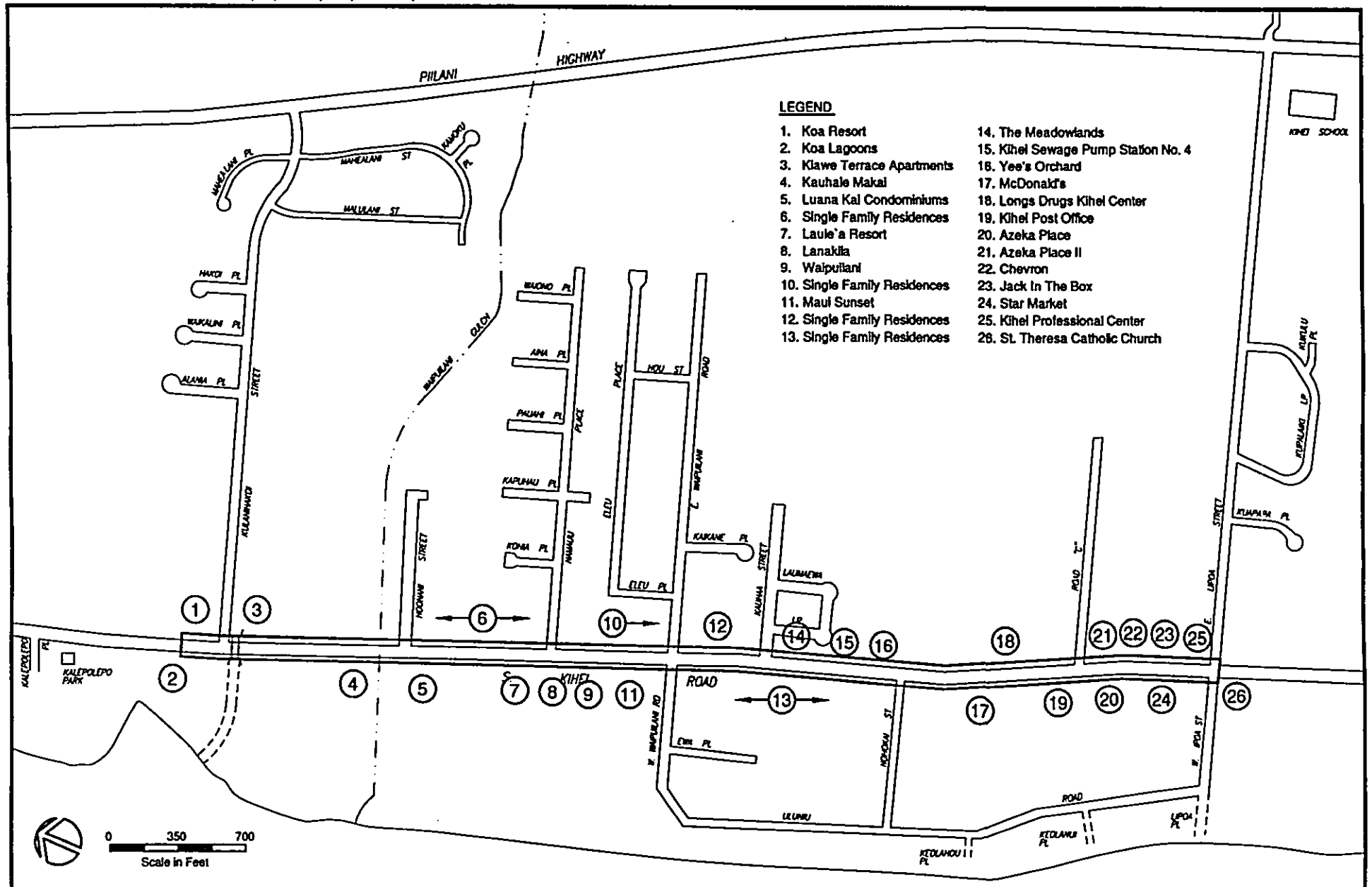

LEGEND

1. Koa Resort
2. Koa Lagoons
3. Klawe Terrace Apartments
4. Kauhale Makai
5. Luana Kai Condominiums
6. Single Family Residences
7. Laule'a Resort
8. Lanakila
9. Walpuilani
10. Single Family Residences
11. Maui Sunset
12. Single Family Residences
13. Single Family Residences
14. The Meadowlands
15. Kihei Sewage Pump Station No. 4
16. Yee's Orchard
17. McDonald's
18. Longs Drugs Kihei Center
19. Kihei Post Office
20. Azeka Place
21. Azeka Place II
22. Chevron
23. Jack In The Box
24. Star Market
25. Kihei Professional Center
26. St. Theresa Catholic Church

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SOUTH KIHEI ROAD IMPROVEMENTS - KULANIHAKOI STREET TO LIPOA STREET

SURROUNDING USES MAP

FIGURE 2-4

3. DESCRIPTION OF THE EXISTING ENVIRONMENT, PROJECT IMPACTS AND MITIGATION MEASURES

3.1 Climate

The Kihei area receives less than 400 millimeters (mm) of rainfall annually (ranging from 5 mm to 50 mm monthly), making it the area with the lowest rainfall on Maui. Most of the rain in this area comes during winter storms. Kihei is part of a broad area of low rainfall extending along the leeward coast of the island from Makena to Kaanapali. The aridity of this area results from the rain-shadow effects of the island's two volcanoes. Typically, Kihei is sunny and dry with an average temperature of 77°F with occasional variations ranging from the low 60s to the high 80s. Winds are predominantly from the north and northeast.

3.2 Geology and Topography

Maui is comprised of two major volcanoes; the older West Maui, and the younger East Maui or Haleakala. The *ahupua`a* of Waiohuli in which the project area lies is located on the western slope of Haleakala. The underlying lava flows are known as the Honomanu Volcanic Series of the Tertiary system. These ancient lavas are exposed in only a few localities including along the north and northeast shore sea cliffs and in Ke`anae Valley.

In the project area, the Honomanu Series lavas are covered by the Kula Volcanic Series of the Pleistocene epoch. Lavas of the Kula Series consist predominantly of `a`a. eruptions were explosive to the extent that many large cinder cones were formed and beds of ash are common. These cones are present mostly on the summit and northern slopes of the mountain but also occur on the western slope in the vicinity of the project area. The Kula flows are relatively thick, averaging from 20 feet near the summit of Haleakala to 50 feet at the coast. Much of the Kihei coastline is comprised of lithified dunes of the Pleistocene epoch. The project area slopes in an east to west direction with an approximate slope of 1 percent to 2 percent. Elevations within the area range from 5 to 9.5 feet above mean sea level (msl).

Impacts

No significant impacts on the geology or topography of the project site are anticipated as a result the proposed project. Construction will require grading and excavation activities for the roadway foundation work. Excavated areas will be paved or otherwise improved in accordance with the roadway improvement plans. To achieve required elevations for the new roadway grading may slightly alter the current topography of the project site.

3.3 Soils

According to the U.S. Department of Agriculture Natural Resources Conservation Service, underlying the project site is the Pulehu-Ewa-Jaucas soil association which is

characterized by deep, nearly level to moderately sloping, well-drained and excessively drained soils. The underlying material is moderately fine-textured to coarse-textured subsoil. The soil occurs on alluvial fans and basins.

There are three specific soil classifications which underlie the project site including alae sandy loam (AaB), dune land (DL) and Jaucas Sand (JcC) (see Figure 3-1).

Alae Sandy Loam, 3 to 7 percent slope (AaB): Consists of excessively drained soils on alluvial fans. These soils developed in volcanic ash and recent alluvium are derived from basic igneous rock. They are nearly level to gentle sloping. Runoff is slow and the erosion hazard is slight.

Dune Land (DL): Consists of hills and ridges of sand-size particles drifted and piled by wind. The hills and ridges are actively shifting or are so recently fixed or stabilized that no soil horizons have developed. The sand is formed mainly by coral and seashells. This type is found on the coastal zones on Maui and Kauai. Elevations range from nearly sea level to 150 feet.

Jaucas Sand, saline, 0 to 12 percent slope (JcC): Consists of poor drainage in depression areas, but excessively drained knolls. Occurs near the ocean in areas where the water table is near the surface and salts have accumulated. In the depressions there is normally a layer of silty alluvial material caused by the high concentration of soluble salts. The water table is normally within a depth of 30 inches. This soil type is highly erodable.

Impacts and Mitigation Measures

Grubbing and grading activities for the proposed project will encompass an area of approximately 7.6 acres. A National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Associated with Construction Activity is required to control storm water discharges from areas of disturbance that are five acres or greater. As such, the proposed project will require a NPDES General Permit. The NPDES requires compliance with a Best Management Practices (BMP) Plan, County Grading Permit, and Erosion Control Plan. All grading work will comply with the requirements of Chapter 20.08 of the Maui County Code and NPDES program administered by the State Department of Health (DOH). Measures proposed in the BMP and Erosion Control Plans will mitigate impacts resulting from grading activities.

A *Preliminary Drainage and Soil Erosion Control Report* was prepared by Wilson Okamoto & Associates, Inc. in January 2000 to assess drainage and erosion control requirements for the proposed project. The plan was prepared based on the requirements of County Ordinance No. 2684, Soil Erosion and Sedimentation Control and includes the following erosion control measures:

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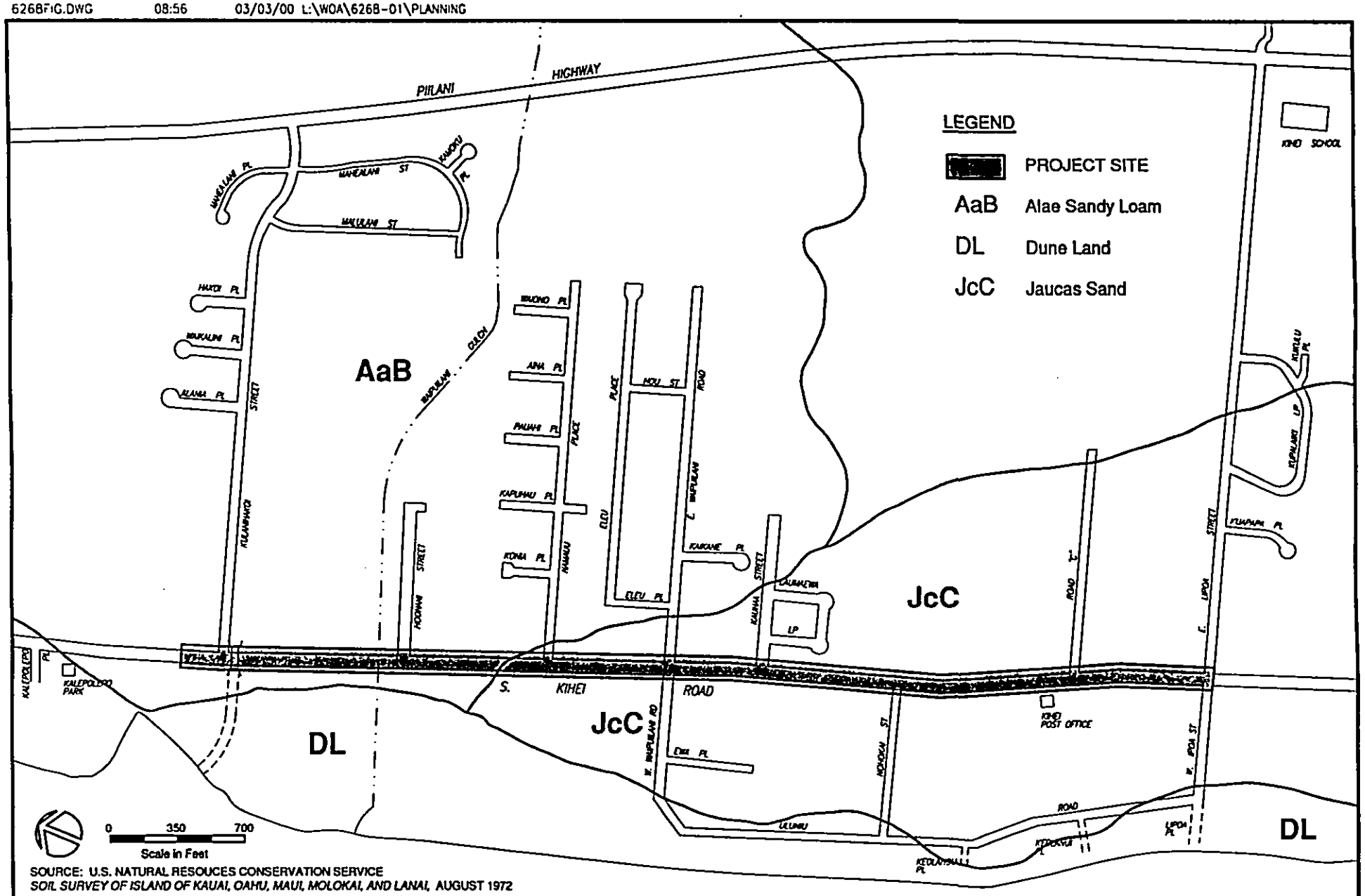

SOURCE: U.S. NATURAL RESOUCES CONSERVATION SERVICE
SOIL SURVEY OF ISLAND OF KAUAI, OAHU, MAUI, MOLOKAI, AND LANAI, AUGUST 1972

WILSON OKAMOTO & ASSOCIATES, INC.
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SOUTH KIHEI ROAD IMPROVEMENTS - KULANIHAKOI STREET TO LIPOA STREET

SOILS MAP

FIGURE 3-1

- Minimizing construction time;
- Retaining existing ground cover as long as possible prior to ground disturbance;
- Constructing drainage control measures as early as possible;
- Using temporary sprinklers in non-active construction areas once the existing groundcover is removed;
- Stationing a water truck on-site during construction to provide immediate sprinkling in active construction areas;
- Using temporary berms and cut-off ditches;
- Watering graded areas after construction activity has stopped for the day and on weekends;
- Sodding and planting areas of cut and fill immediately after grading work is completed; and
- Installing silt screens where appropriate.

3.4 Flora and Fauna Resources

A botanical survey was conducted by Botanical Consultants in October 1999. Native and introduced plant species were recorded within the project site. However, no candidate, proposed, or listed threatened or endangered species were encountered during the survey. A list of plant species which commonly occur within the project site is provided in Table 3-1, while the complete list of plant species is contained in the botanical report included herein as Appendix A.

Table 3-1
Botanical Species Common To The Project Site

Common Name	Scientific Name
Khaki Weed	*Alternanthera pungens* Kunth
Spiny Amaranth	*Amaranthus spinosus* L.
(No common name)	*Calyptocarpus vialis* Less.
Indian Fleabane	*Pluchea indica* (L.) Less.
Seaside Heliotrope	*Heliotropium curassavicum* L.
Australian Saltbush	*Atriplex semibaccata* R. Br.
Croton	*Codiaeum* spp.
Koa Haole	*Leucaena leucocephala* (Lam.) deWit
Kiawe	*Prosopis pallida* Kunth
Hibiscus	*Hibiscus* spp.
Red Hibiscus	*Hibiscus rosa-sinensis* L.
Bougainvillea	*Bougainvillea* spp.

Source: Botanical Consultants, October 1999

According to a February 1991 map prepared by the U.S. Army Corps of Engineers, wetland resources are located in proximity of the project area (see Figure 3-2). However, potential wetland areas were not encountered during field visits conducted by Wilson Okamoto & Associates, Inc. on January 12 and October 6, 1999. In addition, the survey conducted by Botanical Consultants verified that no wetlands or wetland indicators were found within the 70-foot corridor, and concluded that any wetlands previously located between Waipuilani Road and Lipoa Street have since been filled as a result of development within the area.

Faunal species common to the project site are typical of species found in the urbanized Kihei area. Domestic and feral mammals typically found in the area include dogs, cats, rats, mice and *mongoose*. *Exotic* species of birds commonly found in the area include the Northern Cardinal, Common Mynah, Golden Plover, Spotted Dove, House Finch, Gray and Black Francolin, and Blue Heron.

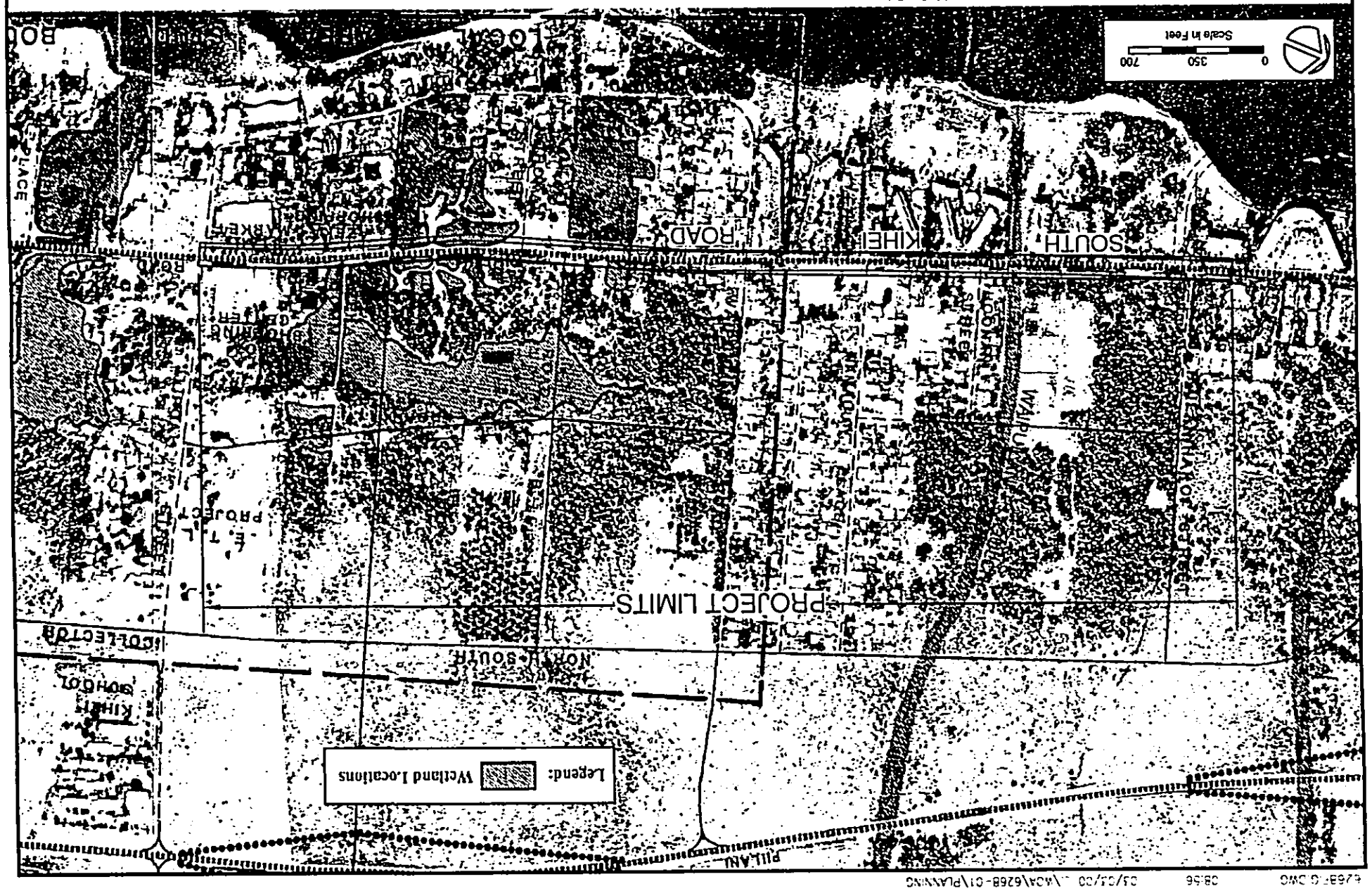
Impacts and Mitigation Measures

While some of the existing vegetation will be removed to accommodate the wider right-of-way, no significant long-term adverse impacts to floral resources are anticipated as a result of the proposed project. Similarly, no significant impacts on faunal species are anticipated. To the extent possible, native plants will be considered and used in landscaping plans. In addition, as much as practicable, trees will be replanted within the new road right-of-way, and root barriers will be implemented to prevent damage to the new sidewalks. In addition, the DPWWM is considering transplanting trees at various county parks. In particular, the South Maui Parks Division of the Department of Parks and Recreation has indicated a need for shade trees at the old Kalama Park located approximately 1 mile south of Lipoa Street. The disposition and treatment of any transplanted trees will be coordinated with the County arborist.

3.5 Surface Water

Two drainage features traverse the project site as indicated on in Figure 3-3. The first feature is Koa Drainage Channel, which originates from about 760 feet above msl. The ditch crosses Piilani Highway via a culvert located about 200 feet south of Kulanihakoi Street. The culvert flows underground along Kulanihakoi Street and daylights on the makai side of South Kihei Road and at Kalepolepo Beach. The second feature, Waipuilani Gulch, is an unlined drainage channel which crosses Piilani Highway approximately 1,200 feet south of Kulanihakoi Street. The gulch crosses South Kihei Road via a culvert located approximately 150 feet north of Hoonani Street and subsequently discharges approximately 800 feet makai of South Kihei Road.

During field visits conducted on January 12 and October 7, 1999, standing water was present at the Koa Drainage Channel, whereas conditions at the Waipuilani Gulch were dry. Both features are indicated on the U.S.G.S. quadrangle



SOURCE: U.S. DEPARTMENT OF THE ARMY CORPS OF ENGINEERS, FEBRUARY 1991

WILSON OKAMOTO & ASSOCIATES, INC. ENGINEERS • PLANNERS	SOUTH KIHEI ROAD IMPROVEMENTS - KULANIHAKOI STREET TO LIPOA STREET WETLANDS MAP	FIGURE 3-2

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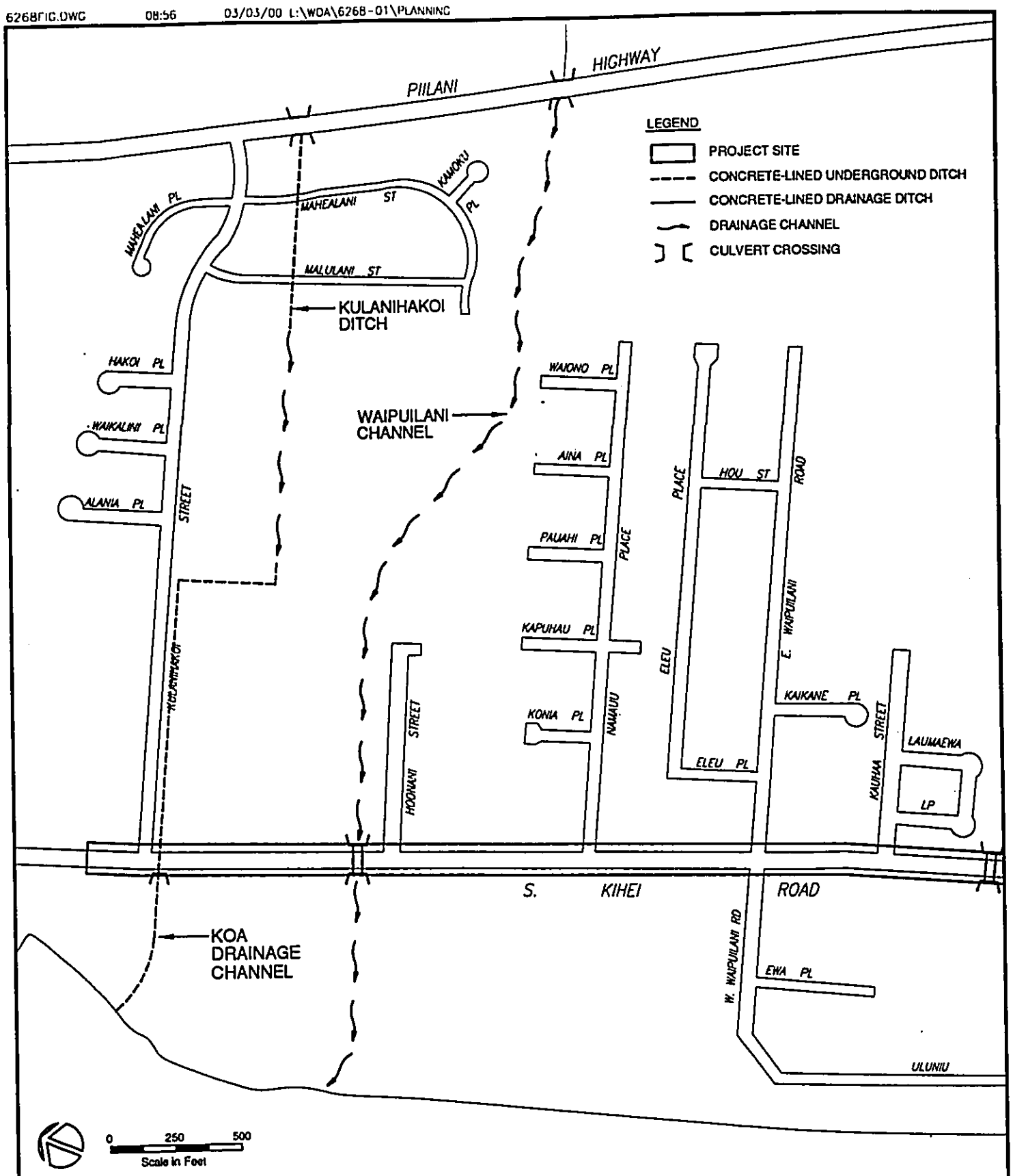

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SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET

DRAINAGE FEATURES

FIGURE 3-3

maps as intermittent, although neither is listed in the *Hawaii Stream Assessment,* compiled by the State Department of Land and Natural Resources.

Impacts and Mitigation Measures

No significant long-term impacts are anticipated to either drainage feature. With regard to the Waipuilani Gulch, however, a new culvert crossing at South Kihei Road is proposed to provide adequate capacity of drainage flows beneath South Kihei Road. In addition, provisions for a future culvert crossing will be constructed approximately 240 feet north of Nohokai Street.

During the short-term, construction in and around the drainage features temporary impacts may occur. A *Preliminary Drainage and Soil Erosion Control Report* was prepared by Wilson Okamoto & Associates, Inc. in January 2000 to assess requirements for drainage improvement in the project site and evaluate the project's hydraulic impact to flood-prone areas. The report was based on recommendations of the *Drainage Master Plan for Kihei, Maui, Hawaii* prepared by Norman Saito Engineering Consultants, Inc. for the County of Maui in August 1997.

Figure 3-4 illustrates the project site in proximity to the drainage districts as defined in drainage master plan. As shown on the map, the project site lies within four drainage districts, including Kulanihakoi District Basin 3 (Kulanihakoi 3), Waipuilani District, Keokea District Basin 1 (Keokea 1), and Keokea District Basin 2 (Keokea 2). Also indicated on the map is the County drainage improvement project approved under SMA permit SM1-990016 (referred to as the Kihei School Off-Site Drainage Improvements), the County's retention basin located near the intersection of Lipoa Street and North-South Collector Road, and the northern portion of the land use petition area described in LUC Docket No. A82-536.

The recommendations from the master plan are in various stages of implementation. In the Kulanihakoi 3 District, the existing box culvert at the North-South Collector Road and storm drain system for the residential development makai of Piilani Highway were recommended to be maintained. In the Waipuilani District, flows from the Waipuilani Gulch are recommended for diversion to the Kulanihakoi Gulch. Design plans for this diversion are anticipated by the summer of 2001, with construction to commence shortly thereafter. The culvert modification, which is part of the proposed South Kihei Road improvements, has been designed to accommodate drainage flows following the diversion. In the Keokea 1 District, the master plan recommends that drainage flows cross beneath South Kihei Road and discharge into the wetland area located makai of the road. Provisions for a culvert crossing at South Kihei Road approximately 240 feet north of Nohokai Street have been included as part of the proposed roadway improvements. Upstream and downstream channel improvements for the culvert are not included as part of the project, and will be designed at a later time. No specific recommendations were provided for the Keokea 2 District. A drainage

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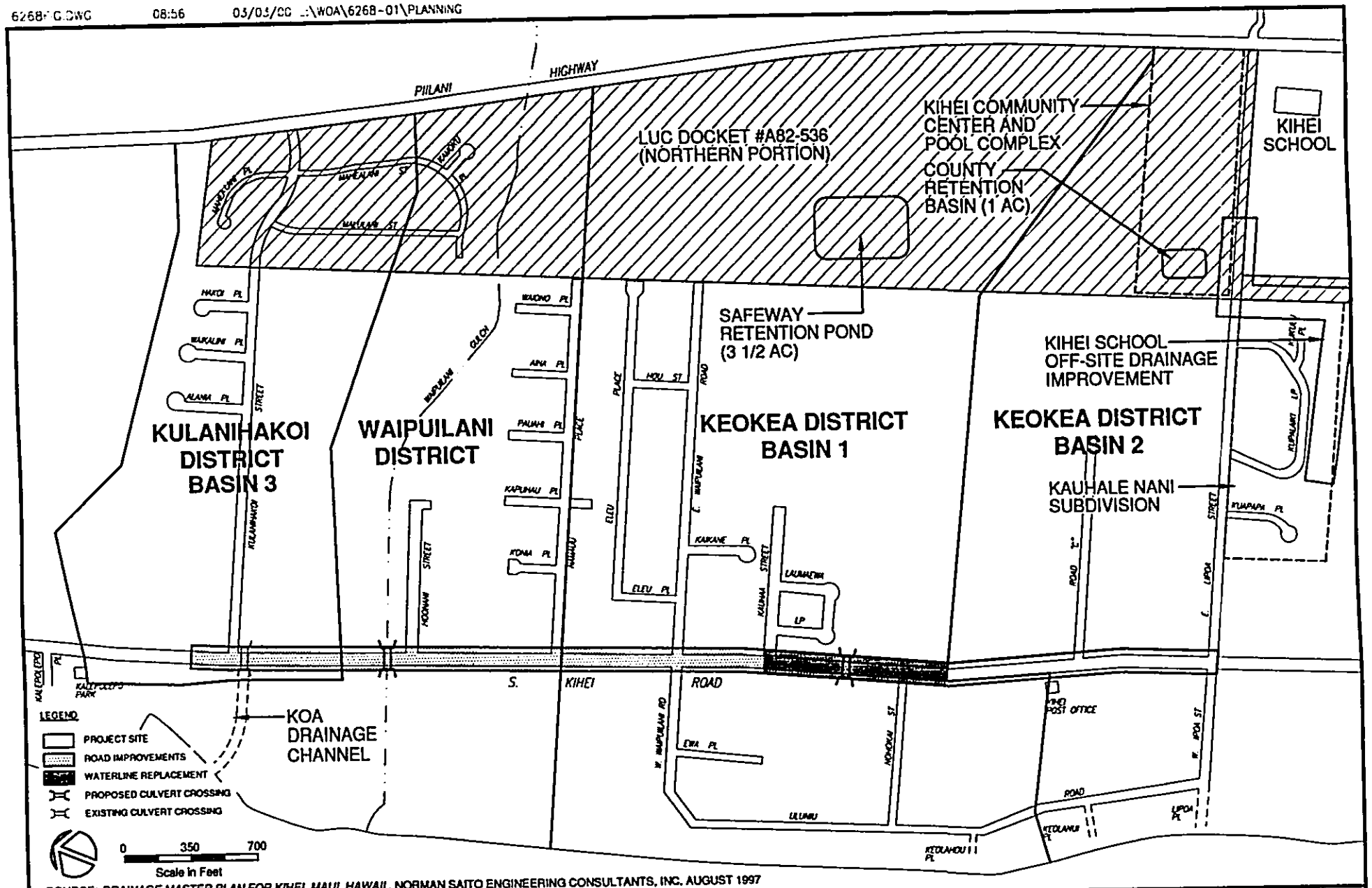

SOURCE: *DRAINAGE MASTER PLAN FOR KIHEI, MAUI, HAWAII*. NORMAN SAITO ENGINEERING CONSULTANTS, INC. AUGUST 1997

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ENGINEERS • PLANNERS

SOUTH KIHEI ROAD IMPROVEMENTS - KULANIHAKOI STREET TO LIPOA STREET

DRAINAGE DISTRICT MAP

FIGURE 3-4

plan developed by the County (and referred to in the master plan), however, called for a retention pond makai of the Kihei Community Center and Pool Complex. In 1998, the Department constructed a one-acre retention pond to address this issue.

The drainage improvements incorporated in the South Kihei Road project are consistent with the drainage master plan within the Kulanihakoi 3, Waipuilani and Keokea 1 Districts. No improvements are proposed for the portion of South Kihei Road that lies within the Keokea 2 District.

A BMP Plan will be prepared to mitigate impacts associated with construction activity, in or around the drainage features. The BMP Plan will include the following general mitigation measures:

- Clearing and grading activities will be limited to the immediate project site;
- Proper grading techniques will be implemented to control runoff into drainage features;
- Sediment basins, temporary diversion dikes and silt fences will be used to prevent runoff from entering drainage features; and
- Sand bags will be placed at all catch basins and drain inlets along the project site to prevent sediment from entering the storm drainage system.

3.6 Flood Hazard

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) Community Panel Number 150003 0265 C (revised September 6, 1989), the project site lies within Zones AH, A3, and A4 flood designations. Zone AH includes areas prone to the 100-year shallow flood where depths are between one and three feet. No flood hazard factors are determined. Zones A3 and A4 include areas within the 100-year flood, where based flood elevations and flood hazard factors are determined. (see Figure 3-5).

Impacts and Mitigation Measures

The project is subject to the policies and requirements of Executive Order (EO) 11988 on Floodplain Management set forth by FEMA on May 24, 1977. The EO requires that agencies "avoid to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid the direct or indirect support of floodplain development whenever there is a practicable alternative." The EO applies to construction of all Federal or Federally-aided buildings, structures, roads, or facilities which encroach upon or affect the base floodplain. Affected areas include all floodplain locations which are, as a minimum, subject to inundation by a flood with a one- percent chance of occurring in any year (i.e. "100-year or base flood"). The EO requires that agencies avoid the base floodplain unless it is the only practicable alternative, or adjust to the base floodplain. If the base floodplain cannot be avoided, the respective agency should adjust to it in order to: "(1) reduce the hazard and the

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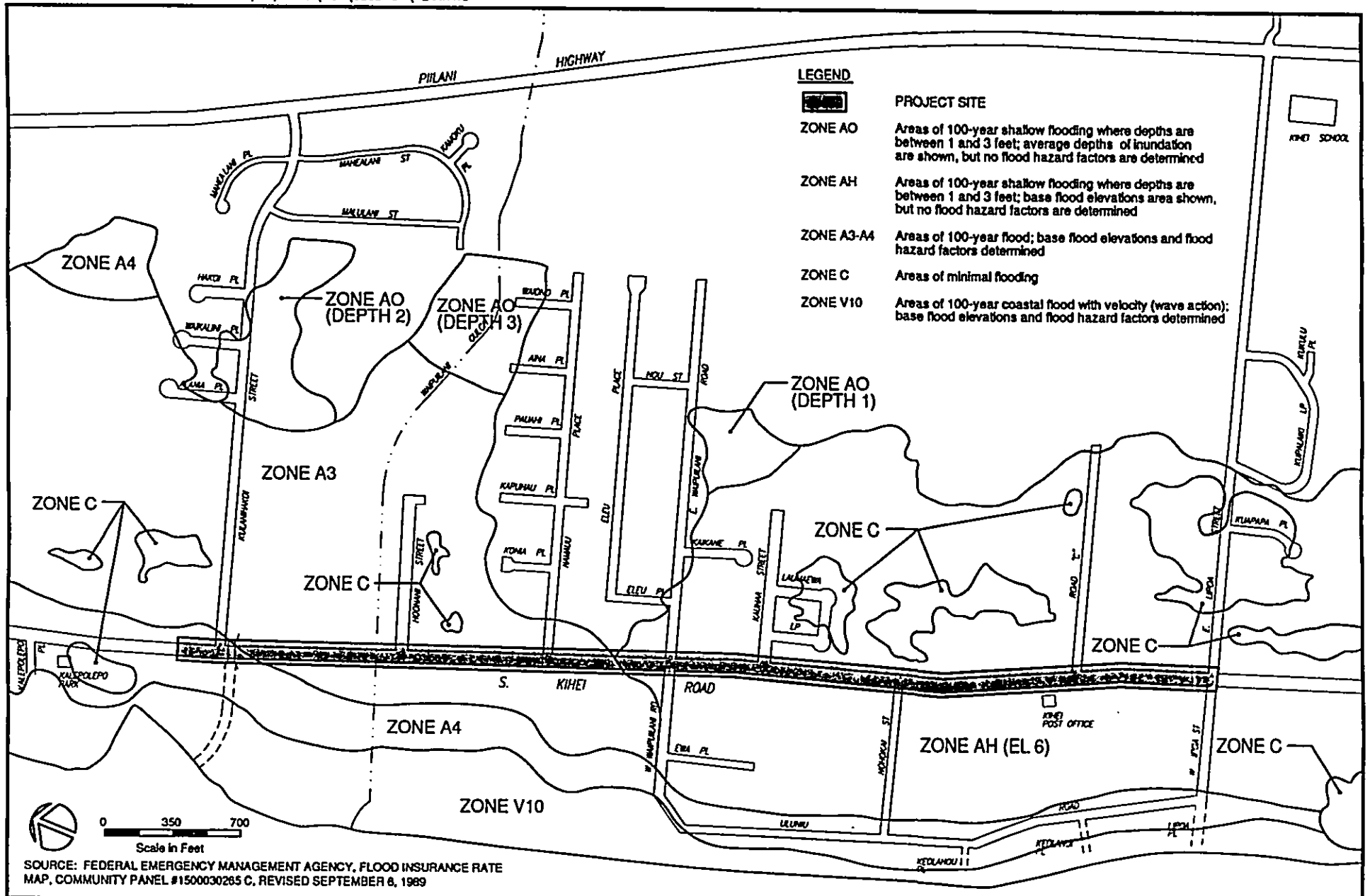

SOURCE: FEDERAL EMERGENCY MANAGEMENT AGENCY, FLOOD INSURANCE RATE MAP, COMMUNITY PANEL #1500030265 C, REVISED SEPTEMBER 6, 1989

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SOUTH KIHEI ROAD IMPROVEMENTS - KULANIHAKOI STREET TO LIPOA STREET

FLOOD INSURANCE RATE MAP

FIGURE 3-5

risk of flood loss; (2) minimize the impact of floods on human safety, health, and welfare; and, (3) restore and preserve the natural and beneficial floodplain values."

The project is also subject to the provisions of Chapter 19.62 of the Maui County Code regarding flood hazard areas. Pursuant to section 19.62.050 of the Code, the project will require a Special Flood Hazard Area Development Permit due to its location within Zone AH, A3 and A4 flood designations. The permit is administered by the County of Maui Planning Department (Staff communication with Planning Department, October 25, 1999).

A *Preliminary Drainage and Soil Erosion Control Report* was prepared for the proposed project by Wilson Okamoto & Associates, Inc. in January 2000 to assess requirements for drainage improvement in the project site and evaluate the project's hydraulic impact to flood-prone areas. The proposed drainage improvements, including the replacement of the Waipuilani Gulch culvert, new culvert located approximately 240 feet north of Nohokai Street, drainlines, and curbs and gutters will be designed to accommodate on- and off-site runoff.

3.7 Air Quality

There are no point source airborne emissions in the immediate vicinity of the project site. The air quality of the Kihei area is considered good with the exception of emissions from automobiles traveling the region's roadway.

Currently, there are two DOH air monitoring stations on the island of Maui from which air quality data is available. One station, formerly located at 140 Uwapo Road in Kihei, located approximately 1-½ miles north of Kulanihakoi Street and the other is in Paia. Results are available only for particulate matter which is 10 microns or less in diameter (PM_{10}). Since the two stations began operation in June and August of 1996, respectively, PM_{10} levels were well below the 50 micrograms per cubic meter ($\mu g/m^3$) annual and 150 $\mu g/m^3$ 24-hour State and Federal ambient air quality standards (AAQS).

In February 1999, the former station at Uwapo Road was closed and a new Kihei station became operational at Hale Piilani Park on Kaialohia Street, approximately 3 miles south of Lipoa Street. The new station monitors for PM_{10} and particulate matter which is 2.5 microns or less in diameter ($PM_{2.5}$). Data from the new Kihei station, however, will not be available until the latter part of 2000.

Impacts and Mitigation Measures

The proposed project will have short-term construction-related impacts on air quality, including the generation of dust and emissions from construction vehicles, equipment, and commuting construction workers. The construction contractor is responsible for complying with State DOH Administrative Rules, Title 11, Chapter 60-11.1 regarding "Air Pollution Control", specifically Section 11-60.1-33 regarding fugitive dust and the prohibition of visible dust emissions at property boundaries.

Mitigation measures to address short-term impacts include:

- Minimizing the movement of construction vehicles during peak traffic periods; and,
- Controlling the generation of fugitive dust through frequent watering of unpaved roads and areas of exposed soil and planting landscaping as soon as possible on completed areas.

In the long term, it is not anticipated that traffic associated with the proposed project will adversely affect air quality, since no significant increase in traffic attributable to the project is projected.

3.8 Noise

Surrounding ambient noise levels in the Kihei region are characteristic of its urban setting. Ambient noise levels in the vicinity of the project site are attributed to natural conditions, such as wind and ocean surf, as well as vehicular traffic along South Kihei Road.

Impacts and Mitigation Measures

Noise from construction activities will likely be unavoidable during the construction period. Unavoidable construction noise impacts will be mitigated to some degree by the contractor's compliance with provisions of the State DOH Administrative Rules, Title 11, Chapter 46, "Community Noise Control" regulations. These rules require a noise permit if the noise levels from construction activities are expected to exceed the allowable levels stated in the Chapter 46 rules. It shall be the contractor's responsibility to minimize noise by properly maintaining noise mufflers and other noise-attenuating equipment, and to maintain noise levels within regulatory limits. Also, the guidelines for the hours of heavy equipment operation and noise curfew times as set forth by the DOH noise control rules will be adhered to. During construction, the specific location where construction activity will be occurring will change such that the actual length of exposure to construction noise from any particular receptor location will likely be less than the total construction time for the project.

In the long term, no significant noise impacts from the operation of the proposed project are anticipated.

3.9 Archaeological Resources

An archaeological assessment was conducted by Cultural Surveys Hawaii in November 1999. Excerpts from the accompanying report are provided in this section, while the report in its entirety is included herein as Appendix B.

No evidence of pre-contact cultural or agricultural activity within the project was determined. A major Hawaiian community, probably from pre-contact times, was

present at Kalepolepo just to the north of the project. The community likely prospered between 1820 and the mid 1870's as a result of the demands of whalers and gold miners for agricultural goods, although this did not appear to affect the project area.

The presence of 4 fishponds along the coast in the project area indicates permanent Hawaiian coastal settlement at Waiohuli and Keokea, although the archaeological evidence suggests that permanent habitation in these *ahupua`a* was overwhelmingly in upland areas above the 2,000-foot elevation. The four fishponds are not located in the immediate vicinity of the project site, but rather along the shoreline, several hundred feet away (see Figure 3-6). The fishpond located nearest to the project site is referred to variably as Ko`ie`ie Loko`ia, Kaonoulu-kai, or Kalepolepo (State Site #50-50-09-1288) and is located approximately 400 feet northwest of the project site. The fishpond is currently being restored by the Hawaiian Islands Humpback Whale National Marine Sanctuary Library and Museum. The remaining three, Waiohulikai (State Site No. 50-50-09-1704), Keokea-kai (State Site No. 50-50-09-1738), and an unnamed pond (no site number assigned), appear to have been severely damaged by high surf and tsunami.

Field reconnaissance and observations of soil borings gave no indication of archaeological resources under or adjacent to the project site. The absence of cultural use within the project area is suggested to be due to its low elevation above the water table, propensity to flood, low rainfall, and poor soils.

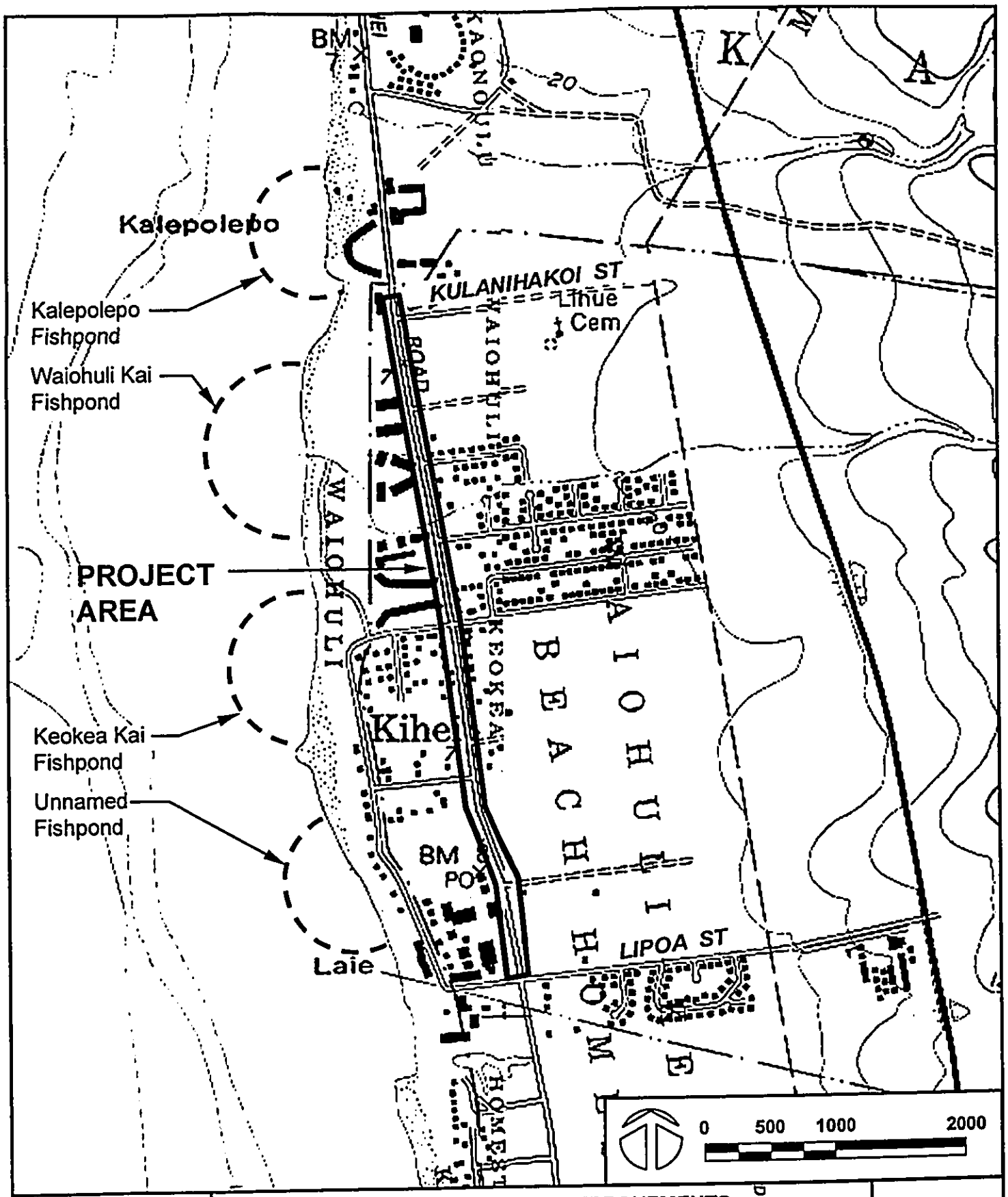
Impacts Mitigation Measures

Based on the absence of any archaeological resources, full-time monitoring is not indicated for the proposed project. Should any archaeological resources including human burials be encountered during construction, all work in the immediate vicinity will cease and the State Historic Preservation Division will be contacted.

With regard to the four fishponds located makai of the project site, while the proposed project is not anticipated to significantly impact these resources, erosion control measures will be implemented to mitigate possible impacts to nearshore waters during construction of the project. Such measures will include the use of temporary berms, early construction of drainage control features, use of temporary sprinklers in non-active construction areas where ground cover is removed, and use of silt screens where appropriate.

3.10 Community Setting

The town of Kihei is largely characterized by a mix of residential, visitor-related, and commercial developments, with vacant lots interspersed throughout. Uses surrounding the northern portion of the project site, from Kulanihakoi Street to Kauhaa Street include single family residences and several apartment and resort condominium developments. Surrounding uses within the southern portion of the project from Kauhaa Street to Lipoa Street are comprised primarily of commercial uses



WILSON OKAMOTO & ASSOCIATES, INC. ENGINEERS - PLANNERS	SOUTH KIHEI ROAD IMPROVEMENTS KULANIHAKOI STREET TO LIPOA STREET	FIGURE 3-6
	LOCATION OF FISHPONDS	

Impacts and Mitigation Measures

The proposed project will require the acquisition of small portions of adjacent private properties along the route to accommodate the new road right-of-way. Based on preliminary design plans, a range of approximately 32 to 4,460 square feet of land will need to be acquired from 49 private parcels along the roadway frontage for the road widening project. This amounts to a total of 40,540 square feet, or 0.93 acres of land distributed among 49 private parcels. Table 3-2 summarizes a preliminary list of parcels adjacent to the proposed project that will be affected by the land acquisition. Also listed are the estimated areas of acquisition for each plat that will be required to accommodate the new right-of-way. As design plans for the proposed project evolve, the County of Maui DPWWM will consult with landowners and leasees of the affected parcels with regard to the acquisition.

Table 3-2
Affected Parcels
(By Tax Map Key)

Zone-Section-Plat	Parcels	Area To Be Acquired (sq. ft.)
3-9-1	2, 4, 6, 7, 9,10, 13, 56, 57, 75, 77, and 151	17,113
3-9-7	7, 16, 18, 21, 22, 23, 38, 39, 40, 41, 42, 43, 54, 62, 63 and 64	11,471
3-9-8	16	1,107
3-9-22	3, 4, 20, 21, 22, 29, 38, 39, and 40	3,348
3-9-34	1, 13, 14, 15, and 27	1,065
3-9-46	5, 6, 7, 8, 9, and 17	6,436
Total Estimated Area To Be Acquired		**40,540**

3.10.1 Population

The population of the Kihei-Makena region has increased dramatically in the last two decades. Population gains were pronounced during the 1970's as the visitor industry developed rapidly, resulting in a significant influx of new residents to the area. In 1990, the population of Kihei was 15,365, an increase of more than twice its population in 1980 of 7,263, and almost ten times its population in 1970 of 1,636. The resident population of the area is projected to be 20,092 and 24,846 for the years 2000 and 2010, respectively. (Community Resources, Inc., January 1994).

Impacts

Short-term impacts to the community associated with construction activities may occur as a result of the proposed project. Motorists, pedestrians, and bicyclists traveling in and around the immediate construction area may experience minor

inconveniences and delays in travel time. In the long-term,motorists, pedestrians, and bicyclists will experience greater operational efficiency while traveling through the area as the new roadway will improve local traffic access and circulation, and relieve congestion. The project, in alleviating existing traffic congestion in this area of Kihei town, may impact the population of the Kihei-Makena region. However, the new roadway will be maintained as a two-lane road such that there will not be an increase in operational capacity.

3.10.2 Economy

The economy of Maui County is heavily dependent upon the visitor industry. Annual visitor arrivals to the island over the last several years have increased from a low of 2.26 million in 1993 to 2.35 million in 1998 (County of Maui Office of Economic Development, 1999). The dependency on the visitor industry is particularly evident in the Kihei-Makena region, which is one of the State's major resort destination areas. Notably, the presence of hotels such as the Four Seasons, Grand Wailea, Outrigger Wailea and Kea Lani has influenced the region's significance as a resort destination. Support for the visitor industry is found in Kihei where numerous commercial centers, including Azeka Place, Azeka Place II, and Longs Drugs Kihei Center have been developed.

Impacts

During the short-term construction period, the project will support construction and construction-related employment. Short-term, construction-related impacts to area businesses, residents, and visitors may occur as a result of the proposed project. Motorists, pedestrians, and bicyclists traveling in and around the immediate construction area may experience minor inconveniences and delays in travel time. While access to driveways will be maintained to the extent possible, businesses may experience minor disruptions in the flow of customers due to the temporary construction activities. Advanced notification will be sent to all residents and businesses in the project area. A traffic control plan will be prepared and submitted to the DPWWM for approval. Any road closures or detours, if deemed necessary, will be coordinated with area residents and businesses, the Fire Prevention Bureau of the County Department of Fire Control, and the County Police Department. In the long-term, implementation of the proposed project will improve the movement of goods and services to the from the Kihei area, thereby positively affecting the economic viability of the region.

3.10.3 Police, Fire and Ambulance Service

The Maui Police Department (MPD) consists of five patrol divisions which provide police services through its Hana, Lahaina, Lanai, Molokai, and Wailuku districts. The District 1 station located at 55 Mahalani Street in Wailuku provides patrol services to the Kihei, Upcountry, Wailuku, and Kahului areas. There are three eight-hour shifts per day; each shift is generally staffed by 13 officers. A new Kihei substation will be located within the

Kihei Town Center approximately one mile south of Lipoa Street on South Kihei Road. The new substation, referred to as the District 6 station, is tentatively scheduled to open in late 1999. (Staff communication with MPD, October 25, 1999).

Fire prevention and protection services are provided to the Kihei region by the Maui Fire Department's (MFD) Kihei station located at 11 Waimahaihai Street, approximately one mile south of Lipoa Street. The station is equipped with one engine (a 750-gallon pumper), and is staffed by a captain, driver/engineer, and four firefighters. (Staff communication with MFD, October 25, 1999).

Emergency ambulance service for the County of Maui is provided by American Medical Response (AMR). There are eight units located on the island of Maui. The Kihei unit is a 24-hour emergency unit, and is located at 131 South Kihei Road, near the Kihei Youth Center approximately one mile north of Kulanihakoi Street. The Kihei unit is staffed by six crew members. Each 24- or 48-hour shift is staffed by one paramedic and one emergency medical technician. (Staff communication with AMR, October 25, 1999).

Impacts

Short-term impacts associated with construction activities may occur on police, fire, and emergency services as a result of the proposed project. Vehicles traveling in and around the immediate construction area may experience minor inconveniences and delays in travel time. Long-term impacts to police, fire and emergency services are not anticipated as a result of the proposed project.

3.10.4 Medical Facilities

Maui Memorial Hospital, the only major medical facility on the island, services the Kihei area. Acute, general and emergency care services are provided by the hospital located at 221 Mahalani Street in Wailuku. Several Kihei clinics, as well as dental and medical offices provide local health care services for the Kihei area.

Impacts

Short-term impacts associated with construction activities may occur on medical and dental facilities as a result of the proposed project. Motorists traveling to and from clinics and local medical and dental offices, particularly in and around the immediate construction area may experience minor inconveniences and delays in travel time. Long-term impacts to medical services and facilities are not anticipated as a result of the project.

3.10.5 Schools

The State of Hawaii Department of Education (DOE) operates three schools in the Kihei area: a) Kihei Elementary School, located at 250 East Lipoa Street, includes an enrollment of 733 students in grades K through 5; b) Kamali'i Elementary School, located at 180 Kealii Alanui Street, includes an enrollment of 834 student in grades K through 5; and c) Lokelani Intermediate School, located at 250A East Lipoa Street,

includes an enrollment of 662 students in grades 6 through 8. The nearest high school, Maui High School, is located in Kahului. Its enrollment includes 1,675 students in grades 9 through 12. (Staff communication with DOE, October 25, 1999).

Impacts

Short-term impacts associated with construction activities may occur as a result of the proposed project. Motorists traveling to and from schools, particularly those located in and around the immediate construction areas, may experience minor inconveniences and delays in travel time. Long-term impacts to area schools are not anticipated as a result of the project.

3.10.6 Recreational Resources

Diverse recreational resources are available in the Kihei area, including 11 public parks. Most park resources are beach related. Shoreline recreation opportunities include swimming, fishing, snorkeling and windsurfing. In addition, recreational opportunities are available in the Wailea-Makena area, including several championship golf courses and tennis courts. There are no shoreline parks within or adjacent to the proposed roadway right-of-way. Kalepolepo Beach Park is located makai of the project site just north of Kulanihakoi Street. In addition, a beach reserve owned by the State is located along the shoreline and extends approximately 1.2 miles from Kulanihakoi Street to Kapu Street, situated about 0.2 miles south of Lipoa Street.

Impacts

Short-term impacts associated with construction activities may occur as a result of the proposed project. Users of recreational facilities in proximity to the construction area may experience minor inconveniences and delays in travel time. A traffic control plan will be prepared for the project to ensure that access to shoreline areas will be maintained. Long-term impacts to recreational resources are not anticipated as a result of the project. The proposed project will not affect any shoreline parks.

3.10.7 Solid Waste

The County of Maui provides residential solid waste collection service on a weekly basis, while commercial waste is collected by private collections companies. The waste that is collected is disposed at the County's 55-acre Central Maui landfill, located four miles southeast of the Kahului Airport.

Impacts and Mitigation Measures

A solid waste management plan will be developed in coordination with the Solid Waste Division of the DPWWM for the disposal of cleared and grubbed material from the site during construction. The completed project is not considered a direct solid waste generator.

3.11 Infrastructure

3.11.1 Roadway System

The existing development pattern and roadway system in Kihei focuses on South Kihei Road as the primary arterial. Motorists traveling along South Kihei Road regularly encounter heavy traffic conditions. In certain areas, traffic volume on South Kihei Road is occasionally heavier than Piilani Highway, located approximately a half mile to the east. From a roadway system perspective, there are insufficient connector roads between Piilani Highway and South Kihei Road to collect and distribute traffic to and from Piilani Highway. This condition, coupled with the limited traffic capacity of these connector roads and the difficulty experienced while turning onto a high-speed roadway, has resulted in a greater volume of motorists using South Kihei Road in lieu of the higher capacity Piilani Highway.

Numerous driveways and long cul-de-sacs access South Kihei Road and further increase traffic congestion on this roadway. Consequently, South Kihei Road continues to support local as well as through traffic.

Impacts and Mitigation Measures

During the short-term construction period, construction activities will likely result in local traffic delays and increased congestion. A traffic control plan will be prepared and submitted to the DPWWM for approval. Any road closures or detours, if deemed necessary, will be coordinated with the Fire Prevention Bureau of the County Department of Fire Control and the County Police Department.

In the long-term, the proposed project will improve traffic conditions along South Kihei Road, particularly at or near intersections where dedicated left and right turn lanes are proposed. Motorists will be able to negotiate turns without impairing the movement of cars queued behind them, thus improving the overall efficiency of travel along this stretch of South Kihei Road.

3.11.2 Water System

The Kihei area is served by the Central Maui Water System, which also supplies the communities of Waihee, Waiehu, Wailuku, Kahului, Paia, Maalaea, and Makena. The Iao Aquifer, located in the vicinity of Iao and Waiehu Streams, is the primary water source to the Central Maui Water System. Water from the Iao Aquifer is conveyed to the Kihei-Makena region via two transmission mains including an 18-inch and a 36-inch main. The transmission and distribution system within the project site and along collector roads within the project vicinity includes: a) 6- and 12-inch transmission lines located within South Kihei Road between Kulanihakoi Street and Lipoa Street; b) 12-inch lines within Waipuilani Road and Lipoa Street; c) 6-inch lines within Kauhaa Street, Nohokai Street, and Road "C".

Impacts and Mitigation Measures

Approximately 900 feet of a 6-inch waterline will be replaced with a 12-inch line from Kauhaa Street to approximately 300 feet south of Nohokai Street. During the short-term construction phase, temporary disruptions to the water system may occur as the connection to the new line is implemented. The DPWWM will coordinate design plans and construction activities with the Maui Board of Water Supply to minimize possible disruptions to water services. In the long-term, the upgrade to the water system will improve the operational efficiency of water services to the project vicinity.

3.11.3 Drainage System

There are two drainage features which traverse the project. The first, a concrete-lined drainage ditch, flows beneath South Kihei Road at Kulanihakoi Street. The crossing is comprised of a triple box concrete culvert with a total width of 24-feet. Each cell within the culvert is 7 feet wide. The second feature, an unlined drainage channel, crosses under South Kihei Road at Waipuilani Gulch, located approximately 150 feet north of Hoonani Street. The crossing is comprised of a 10-foot concrete culvert. During field visits conducted on January 12 and October 7, 1999, standing water was present at the Kulanihakoi Street drainage ditch, whereas conditions at the Waipuilani Gulch were dry.

Impacts and Mitigation Measures

A new culvert crossing is proposed at the Waipuilani Gulch to provide adequate flow capacity beneath South Kihei Road. During the short-term, construction in and around the gulch may result in temporary impacts. Construction-related impacts may also occur on the drainage ditch located at Kulanihakoi Street. In addition, the project will include new and relocated storm drains and manholes. A BMP Plan will be prepared to mitigate impacts associated with construction activity, in or around the drainage features. No long-term adverse impacts to either drainage feature are anticipated. A *Preliminary Drainage and Soil Erosion Control Report* was prepared by Wilson Okamoto & Associates, Inc. in January 2000 to assess requirements for drainage improvement in the project site and evaluate the project's hydraulic impact to flood-prone areas. The proposed drainage improvements including the replacement of the Waipuilani Gulch culvert, new culvert located approximately 240 feet north of Nohokai Street, drainlines, and curbs and gutters will accommodate on- and off-site runoff.

3.11.4 Wastewater System

Wastewater from the project vicinity is collected by the County's system of transmission mains and pump stations and conveyed to the Kihei Wastewater Reclamation Facility (KWRF). The KWRF is located on approximately 1 mile southeast of the project site on Piilani Highway south of the Silversword Golf Course, approximately ½-mile east of the project site. Its service area extends from Kihei to the Makena Surf Hotel, with the exception of a few private developments served by small package treatment plants. The plant is an R-1 reclamation facility with a capacity of 8 million gallons per day (mgd)

and an average daily flow of 4 mg, of which approximately 2 mgd is reused and 2 mgd is disposed of into on-site injection wells. Users of the reclaimed water include the Silversword Golf Course, Dekalb Seed Corn, Kalama Park, Kihei Fire Station, Kihei library, Kihei Community Center, and the Kihei Elementary School. The Kihei Wastewater Pump Station, located between Kauhaa and Nohokai Streets, is one of 10 pump stations which collect and convey wastewater to the KWRF. (Staff communication with County of Maui DPWWM, November 12, 1999).

Impacts and Mitigation Measures

With the exception of minor adjustments to sewer manhole covers, no modifications to the wastewater system is proposed. Thus, no significant short- or long-term impacts are anticipated on the wastewater collection or treatment system as a result of the project.

3.11.5 Electrical and Communication Systems

Power and telephone services in the Kihei region are provided by Maui Electric Company, Ltd. and GTE Hawaiian Tel, respectively.

Impacts and Mitigation Measures

No significant impacts are anticipated on the existing electrical and communication systems along the proposed project site. As needed, the systems in the immediate project vicinity, including overhead utility poles, will be relocated to accommodate the new road right-of-way. In a letter dated October 29, 1999, MECO expressed concern regarding the acquisition of required easements and permitting. Any necessary regulatory requirements and utility relocation activities will be coordinated with the respective utility companies to minimize any potential conflicts with service to the adjacent areas.

4. RELATIONSHIP TO PLANS, POLICIES, AND CONTROLS

4.1 State Land Use Districts

The Hawaii Land Use Law in Chapter 205, Hawaii Revised Statues, classifies all land in the state into four land use districts: Urban, Agricultural, Conservation, and Rural. The project site lies within the Urban District. The propósed project involves modification of an existing roadway which is consistent with the Urban District designation.

4.2 County of Maui General Plan

The General Plan for the County of Maui (adopted 1991) was amended by the Maui County Council in 1993. The Plan is a narrative document which sets forth strategies to shape the County's physical, social and economic environments. These strategies are expressed as statements of objectives and policies which are used by the County in decision-making and in developing and implementing plans and programs. The Maui County Charter, in expressing the intent of the General Plan, provides that:

> *The purpose of preparing a general plan is to recognize and state the major problems and opportunities concerning the needs and the development of the county and the social, economic and environmental effects of such development to set forth the desired sequence, patterns and characteristics of future development.*

Furthermore,

> *It shall contain statements of the general, social, economic, environmental and design objectives to be achieved for the general welfare and prosperity of the county through government action, county, state or federal.*

The proposed project is consistent with the following objectives and policies of the General Plan:

IV. TRANSPORTATION

A. Transportation

Objective 1: *To support an advanced and environmentally sensitive transportation system which will enable people and goods to move safely, efficiently and economically.*

> ***Policy F:*** *Support the development of a county-wide network of bikeways and pedestrian paths*
>
> **Comment:** Five-foot bike lanes and six-foot wide sidewalks are proposed for both north and south-bound directions. Both components

will facilitate these environmentally sensitive alternative modes of travel through the Kihei area.

Objective 2: To develop a program for anticipating and enlarging the local street and highway systems in a timely response to planned growth.

Policy b: *Ensure that transportation facilities are anticipated and programmed for construction in order to support planned growth*

Comment: The resident population of the Kihei region has increased dramatically since the 1970's, particularly in response to the rapid development of the visitor industry. Infrastructure needs have lagged behind the growth in population and, as a result, traffic congestion in Kihei has become increasingly evident. The proposed project will improve traffic circulation, enhance accessibility, and reduce congestion.

B. Water

Objective 1: *To provide an adequate supply of potable and irrigation water to meet the needs of Maui County's residents.*

Policy a: *Support the improvement of water transmission systems to those areas which historically experience critical water supply problems provided the improvements are consistent with the water priorities and the County's Water Use Development Plan provisions for the applicable community plan area; and*

Policy b: *Develop improved systems to provide better fire protection.*

Comment: The proposed improvements to South Kihei Road will include the replacement of an existing 6-inch waterline with a new 12-inch waterline. The approximately 900 feet of new waterline will be installed from Kauhaa Street to approximately 300 feet south of Nohokai Street. The new waterline will improve the overall efficiency of the potable water system in the Kihei area, including fire protection capabilities.

4.3 Kihei – Makena Community Plan

The Kihei-Makena Community Plan reflects current and anticipated conditions in the region, and advances planning goals, objectives, policies, and implementation considerations to guide decision-making in the region through the year 2010. The Kihei-Makena Community Plan provides specific recommendations to address the goals, objectives, and policies contained in the General Plan, while recognizing the values and attributes of the Kihei-Makena area. The Kihei-Makena Community Plan

was adopted by Ordinance No 1490 in 1985 and amended in March 1998 via Ordinance No. 2641.

The proposed project is consistent with the Kihei-Makena Community Plan goals, objectives, policies and implementing actions as follows:

PHYSICAL AND SOCIAL INFRASTRUCTURE

Goal
Provision of facility systems, public services and capital improvement projects in an efficient, reliable, cost effective, and environmentally sensitive manner which accommodates the needs of the Kihei-Makena community, and fully support present and planned land uses, especially in the case of project district impacts.

Transportation

Objectives and Policies:

a. *Develop and implement a well-planned road and public transportation system to allow residents and visitors to move safely, effectively and comfortably within the region. Roadway improvements should be planned, designed, and constructed as prioritized under the Implementing Actions section below, and as generally described in the Kihei Traffic Master Plan.*

g. *Plan, design, and construct a pedestrian and bikeway network throughout the Kihei-Makena region which considers the utilization of existing stream beds, drainageways, wetlands and public rights-of-way.*

Comment: The proposed project includes provisions for dedicated left-turn lanes at all intersections and dedicated right-turn lanes at selected intersections. Such provisions will improve the safety and overall efficiency of travel along this stretch of South Kihei Road. In addition, the proposed project will provide for five-foot bike lanes, and six-foot sidewalks along both north and south-bound directions. The sidewalks and bike lanes will facilitate usage by pedestrians and bicycles through this area of Kihei.

4.3.1 Kihei Traffic Master Plan

The Kihei Traffic Master Plan was prepared for the County of Maui DPWWM by Austin, Tsutsumi & Associates, Inc. in October 1989. Its purpose was to meet the objectives set forth in the Kihei-Makena Community Plan in terms of providing a long-range roadway master plan for the region. The study focused on major arterial roadways as well as the collector road system in the Kihei area.

The Master Plan provides for the following recommendations with respect to the treatment of South Kihei Road:

- On-street parking on South Kihei Road should be phased out and replaced with off-street parking facilities;
- South Kihei Road should be widened to a four-lane roadway; and
- All major and minor east-west connector road intersections on South Kihei Road should be signalized.

The proposed project will enable conversion of South Kihei Road to a 4-lane roadway if this is required in the future. In addition, South Kihei Road is currently signalized at its intersections with Road "C" and Lipoa Street.

4.3.2 Kihei-Makena Community Plan Map

The proposed project traverses lands designated by the Kihei-Makena Community Plan land use map as Single Family, Multi-Family, Hotel, and Commercial (see Figure 4-1).

4.4 County of Maui Zoning

The proposed project traverses lands designated by the County zoning map as Single Family, Multi-Family, Hotel, and Commercial Residential, Apartment, Hotel, and B-2 Community Business (see Figure 4-2). The proposed project is a permitted use within the aforementioned zoning designations.

4.5 County of Maui Special Management Area

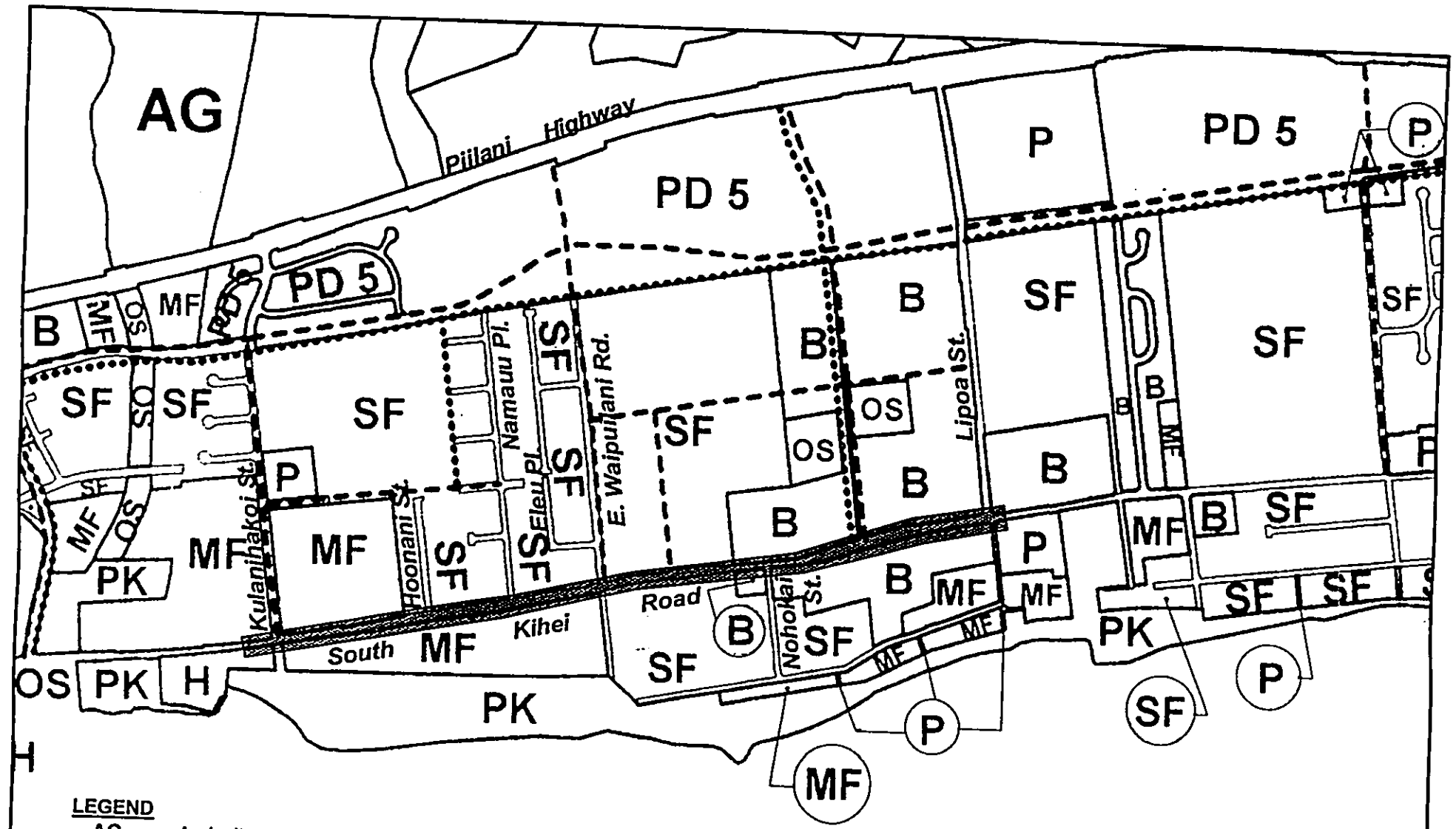
The proposed project is located within the County of Maui's Special Management Area (SMA) (see Figure 4-3). Pursuant to Chapter 205A, Hawaii Revised Statutes, and the Rules and Regulations of the Maui Planning commission, projects located within the SMA area are subject to SMA permit requirements and evaluated with respect to SMA objectives, policies and guidelines. A SMA permit application, submitted in January 2000, is currently under review by the County of Maui Planning Department. The following addresses the project's relationship to applicable coastal zone management considerations, as set forth in Chapter 205A and the Rules and Regulations of the Maui Planning Commission:

Recreational Resources

Objective: Provide coastal recreational opportunities accessible to the public.

Policy B: Provide adequate, accessible, and diverse recreational opportunities in the coastal zone management area.

Comment: The proposed project represents a continuation of an existing use and will not have an adverse affect upon coastal or inland



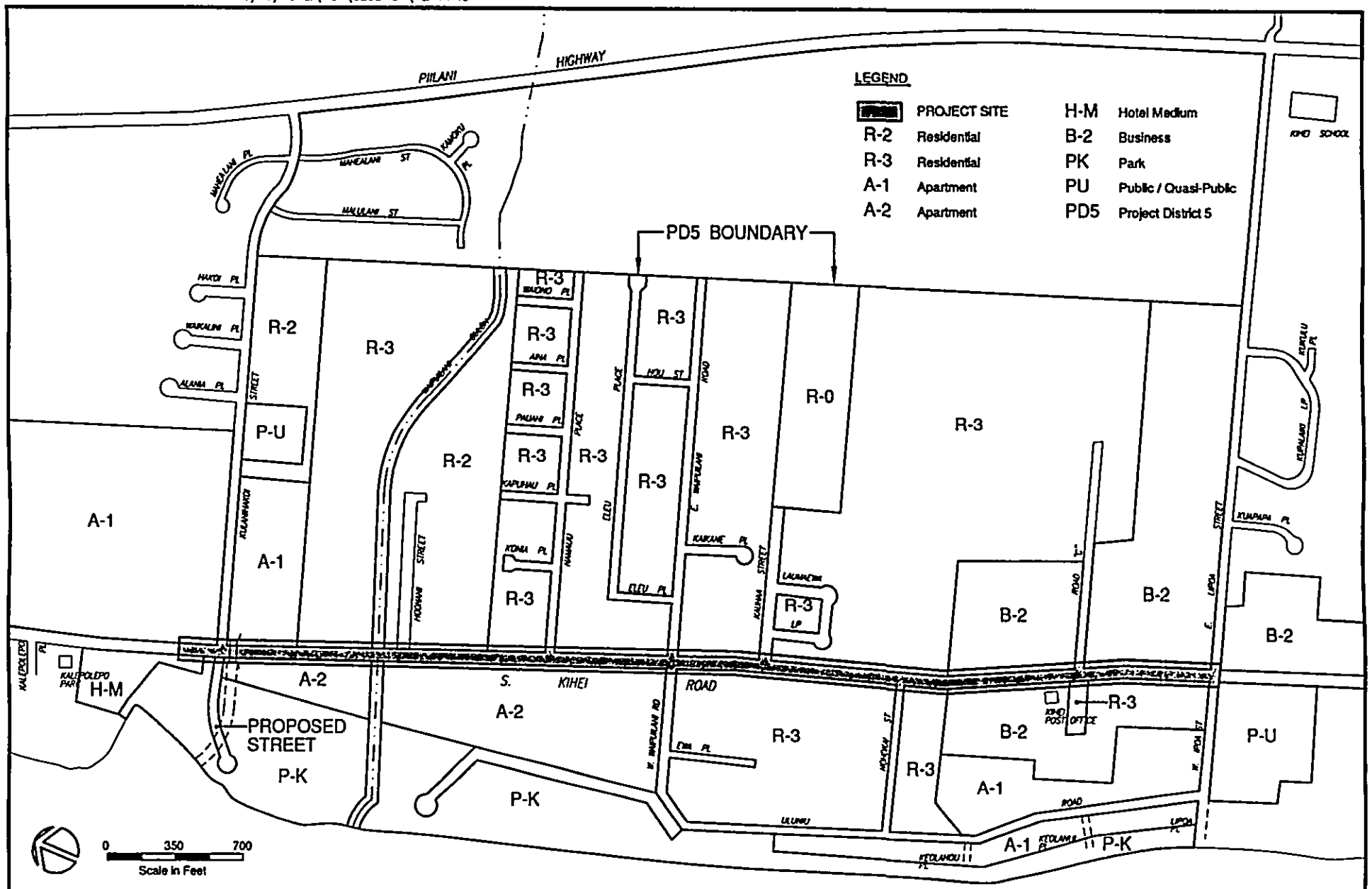
WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS - PLANNERS

SOUTH KIHEI ROAD IMPROVEMENTS - KULANIHAKOI STREET TO LIPOA STREET

KIHEI-MAKENA COMMUNITY PLAN MAP

FIGURE 4-1

6268FIG.DWG 08:56 03/03/00 L:\WOA\6268-01\PLANNING



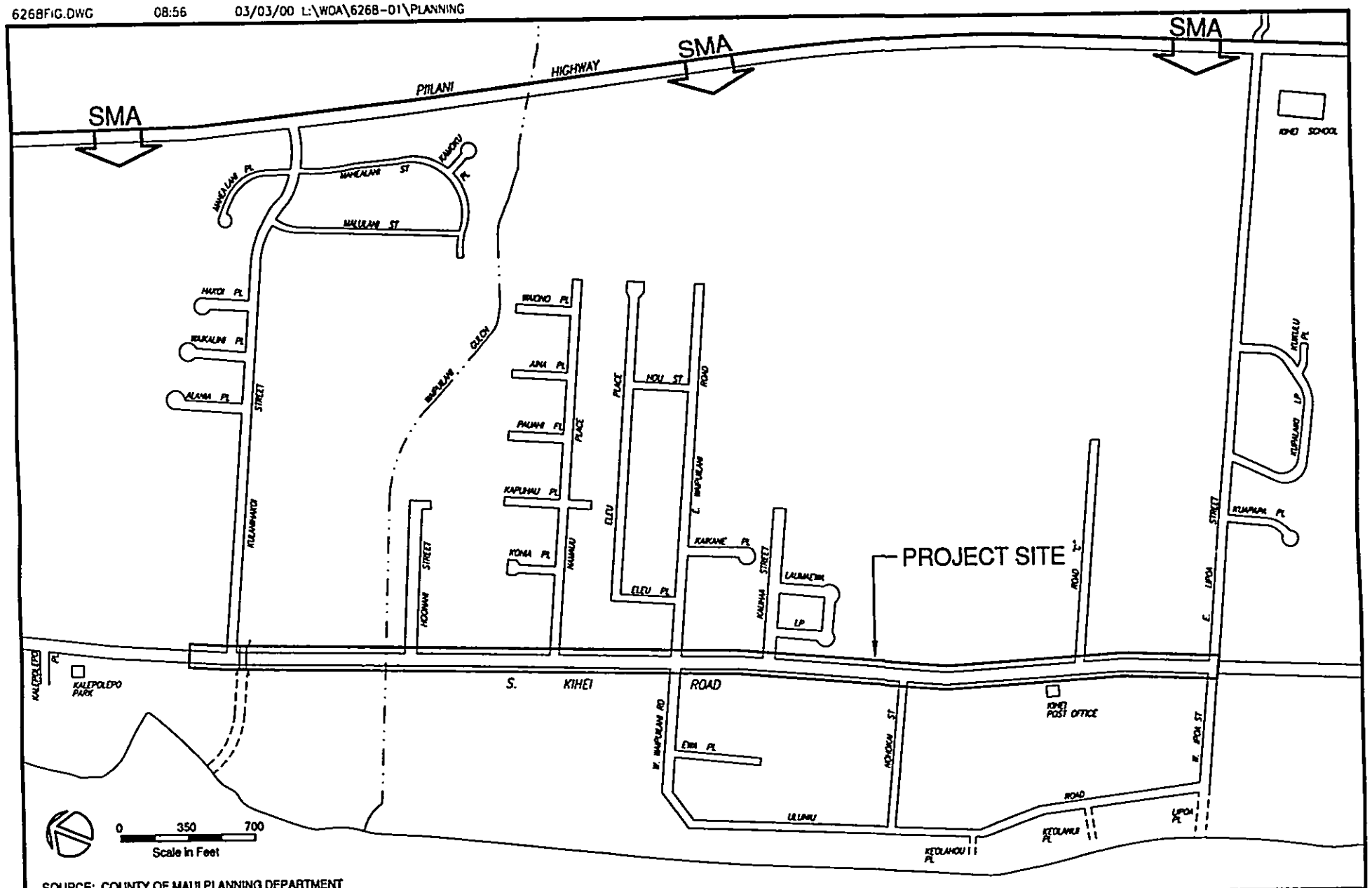
WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS • PLANNERS

SOUTH KIHEI ROAD IMPROVEMENTS - KULANIHAKOI STREET TO LIPOA STREET

ZONING MAP

FIGURE 4-2

6268FIG.DWG 08:56 03/03/00 L:\WOA\6268-01\PLANNING



SOURCE: COUNTY OF MAUI PLANNING DEPARTMENT

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS • PLANNERS

SOUTH KIHEI ROAD IMPROVEMENTS - KULANIHAKOI STREET TO LIPOA STREET

SPECIAL MANAGEMENT AREA (SMA) BOUNDARY MAP

FIGURE 4-3

recreation resources. The nearest shoreline park, Kalepolepo Beach Park, is located makai of the project site north of Kulanihakoi Street. Accessibility to recreational resources may be improved, however, as result of the project.

Historic Resources

Objective: Protect, preserve, and, where desirable, restore those natural and manmade historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture.

Policy A: Identify and analyze archaeological resources;

Policy B: Maximize information retention through preservation of remains and artifacts or salvage operations; and

Policy C: Support state goals for protection, restoration, interpretation and display of historic resources.

Comment: According to the archaeological assessment conducted by Cultural Surveys Hawaii in November 1999, no evidence of pre-contact cultural or agricultural activity within the project was determined. Based on the absence of any archaeological resources, full-time monitoring is not indicated for the proposed project. Should any archaeological resources including human burials be encountered during construction, all work in the immediate vicinity will cease and the State Historic Preservation Division will be contacted.

Scenic and Open Space Resources

Objective: Protect, preserve, and where desirable, restore or improve the quality of coastal scenic and open space resources.

Policy C: Ensure that new developments are compatible with their visual environment by designing and locating such developments to minimize the alteration of natural landforms and existing public views to and along the shoreline.

Comment: The proposed project will not impact coastal scenic and open space resources, nor will it affect public views toward and along the shoreline. The project site is not considered part of a scenic view corridor.

Coastal Ecosystems

Objective: Protect valuable coastal ecosystems from disruption and minimize adverse impacts on all coastal ecosystems.

Policy C: Minimize disruption or degradation of coastal water ecosystems by effective regulation of stream diversions, channelization, and similar land and water uses, recognizing competing water needs.

Comment: The proposed project will require a culvert crossing at Waipuilani Gulch. Construction activities in and around the new culvert structure as well as the existing triple box culvert located at Kulanihakoi Street may result in short-term localized erosion and turbidity impacts in the gulch. A BMP Plan will be prepared and submitted to the Department of Health for review and approval to mitigate impacts associated with construction activity, in or around the drainage features. No significant long-term impacts are anticipated to either drainage feature.

Economic Uses

Objective: Provide public or private facilities and improvements important to the State's economy in suitable locations.

Policy B: Ensure that coastal dependent development such as harbors and ports, and coastal related development, such as visitor facilities, and energy-generating facilities are located, designed and constructed to minimize adverse social, visual and environmental impacts in the coastal zone management area.

Comment: The proposed project will improve the movement of goods and services to the from the Kihei area, thereby positively affecting the economic viability of the region. Implementation of the project will also facilitate the planned development of the area. In this regard, the proposed project is significant in maintaining and enhancing the region's long-term economic stability.

Coastal Hazards

Objective: Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, subsidence, and pollution.

Policy C: Ensure that developments comply with requirements of the Federal Flood Insurance Program.

Comment: The proposed project will require a Special Flood Hazard Area Development Permit due to its location within Zone AH and A3 flood designations. A *Preliminary Drainage and Soil Erosion Control Report* was prepared by Wilson Okamoto & Associates, Inc. in January 2000 to assess requirements for drainage improvement in the project site and evaluate the project's hydraulic impact to flood-prone areas. The proposed drainage improvements including the replacement of the Waipuilani Gulch culvert, new culvert located approximately 240 feet north of Nohokai Street, drainlines, and curbs and gutters will be designed to accommodate on- and off-site runoff.

Managing Development

Objective: Improve the development review process, communication, and public participation in the management of coastal resources and hazards.

Policy B: Facilitate timely processing of applications for development permits and resolve overlapping of conflicting permit requirements.

Comment: In compliance with the Special Management Area Rules and Regulation of the County of Maui, required documentation will be filed with the County Planning Department and will be subject to a public hearing and decision by the Maui Planning Commission. The project will comply with all applicable environmental permit requirements specifically those administered by the Department of Land and Natural Resources, Army Corps of Engineers, Department of Health, and Office of Planning.

Public Participation

Objective: Stimulate public awareness, education, and participation in coastal management.

Policy B: Disseminate information on coastal management issues by means of educational materials, published reports, staff contact, and public workshops for persons and organizations concerned with coastal-related issues, developments, and government activities.

Comment: The public was afforded an opportunity to review and comment on this EA pursuant to the requirements of Chapter 343 Hawaii Revised Statutes and Section 11-200 of Title 11 Department of Health Administrative Rules. Additionally, the Department plans to conduct a public informational meeting to apprise the community and discuss any concerns regarding the project. Further, a public hearing required in

conjunction with the Special Management Area permit process, which was recently initiated, will provide additional opportunity for public input.

Beach Protection

Objective: Protect beaches for public use and recreation.

Comment: The project is not anticipated to adversely impact any beaches or shoreline resources. The roadway is not located adjacent to the shoreline or along any public beaches or beach parks.

As discussed in Section 3.3, a *Preliminary Drainage and Soil Erosion Control Report* was prepared by Wilson Okamoto & Associates, Inc. in January 2000 to assess drainage and erosion control requirements for the proposed project. The plan was prepared based on the requirements of County Ordinance No. 2684, Soil Erosion and Sedimentation Control and includes the following erosion control measures:

- Minimizing construction time;
- Retaining existing ground cover as long as possible prior to ground disturbance;
- Constructing drainage control measures as early as possible;
- Using temporary sprinklers in non-active construction areas once the existing groundcover is removed;
- Stationing a water truck on-site during construction to provide immediate sprinkling in active construction areas;
- Using temporary berms and cut-off ditches;
- Watering graded areas after construction activity has stopped for the day and on weekends;
- Sodding and planting areas of cut and fill immediately after grading work is completed; and
- Installing silt screens where appropriate.

5. ALTERNATIVES TO THE PROPOSED ACTION

5.1 No Action Alternative

The no action alternative would involve no further improvement to South Kihei Road. South Kihei Road will continue to be a primary arterial providing access to the Kihei, Wailea, and Makena areas. The high usage of South Kihei Road necessitates implementation of the proposed improvements. Without the improvements, traffic congestion will continue to worsen as the population of Kihei and surrounding areas increases. The proposed action will increase safety for pedestrians and improve facilities for bicyclists.

5.2 Four-lane Roadway

This alternative would provide for four traffic lanes along South Kihei Road. On-street parking would be phased out and replaced with off-street parking facilities, the bike lanes would be eliminated, and all major and minor connector road intersections on South Kihei Road would be signalized. While four travel lanes are currently not required, the proposed action will enable the conversion to four lanes if this becomes necessary in the future.

6. REQUIRED PERMITS AND APPROVALS

The following is a list of permits and approvals which may be required prior to construction of the proposed project:

Federal

- Department of the Army
  - Corps of Engineers Permit
- Federal Emergency Management Agency
  - Compliance with Executive Order 11988, Floodplain Management

State of Hawaii

- Department of Health
  - National Pollutant Discharge Elimination System (NPDES) Permit for Storm Water Discharges Associated with Construction Activity
  - NPDES Permit for Discharges Associated with Construction Dewatering Activities
  - Section 401 Water Quality Certification
  - Noise Variance Permit
  - Permit for Air Emissions
  - State Commission on Persons With Disabilities (Review pursuant to Americans With Disabilities Act Accessibility Guidelines)

- Department of Land and Natural Resources
  - Stream Channel Alteration Permit

- County of Maui

- Planning Department
  - Special Management Area Use Permit
  - Special Flood Hazard Area Development Permit

- Dept. of Public Works and Waste Management
  - Permit to Perform Work Within County Right-Of-Way
  - Grubbing and/or Grading Permits

7. DETERMINATION OF FINDING OF NO SIGNIFICANT IMPACT (FONSI)

The proposed project involves the modification of an approximately 5,100-foot segment of South Kihei Road from Kulanihakoi Street to Lipoa Street. Potential impacts of the proposed project have been evaluated in accordance with the significance criteria of Section 11-200-12 of the Department of Health's Administrative Rules. Discussion of the project's conformance to the criteria is presented as follows:

(1) Involve an irrevocable commitment to loss or destruction of any natural cultural resource;

The proposed action is not anticipated to involve any construction activity that might lead to a loss or destruction of any natural or cultural resource.

(2) Curtail the range of beneficial uses of the environment;

The proposed project will not curtail the beneficial uses of the environment. Use of the project site for the proposed project would be consistent with its current use as a roadway. In addition, the proposed project involves the modification of an existing roadway within an urban area with uses that are consistent with the Maui General Plan and Kihei-Makena Community Plan objectives, as well as Kihei-Makena Community Plan Land Use and County of Maui zoning designations.

(3) Conflict with the state's long-term environmental policies or goals and guidelines as expressed in Chapter 344, HRS, and any revisions thereof and amendments thereto, court decisions, or executive orders;

The proposed project does not conflict with long-term environmental policies, goals, and guidelines of the State of Hawaii. As presented in this EA, the project's potential adverse impacts are associated only with short-term construction-related activities and can be mitigated through adherence to standard construction mitigation practices.

(4) Substantially affect the economic or social welfare of the community or state;

The proposed project would provide short-term economic benefits in the form of construction jobs. The proposed project would positively impact the welfare of the community by providing a modern roadway that will meet current design standards.

(5) Substantially affect public health;

No impacts to the public's health and welfare are anticipated.

(6) Involve substantial secondary impacts, such as population changes or effects on public facilities;

No secondary effects are anticipated with the construction or operation of the proposed project.

(7) Involve a substantial degradation of environmental quality;

Construction activities associated with the proposed project are anticipated to result in relatively insignificant short-term impacts to noise, air quality, and traffic in the immediate project vicinity. With the incorporation of the recommended mitigation measures during the construction period, the project will not result in degradation to the environmental quality.

(8) Individually limited but cumulatively has considerable effect upon the environment or involves a commitment for larger actions;

No cumulative effects are anticipated, inasmuch as the proposed project involves the modification of an existing roadway within an urban area that is consistent with the County land use plans and designations.

(9) Substantially affect a rare, threatened, or endangered species, or its habitat;

There are no known rare, threatened or endangered species of flora or fauna or associated habitat on the project site that could be adversely affected by the construction and operation of the proposed project.

(10) Detrimentally affect air or water quality or ambient noise levels;

Operation of construction equipment would temporarily elevate ambient noise and concentrations of exhaust emission in the immediate vicinity of the project site. Operation of the proposed project will have no significant long-term impact on air or water quality or ambient noise levels in the vicinity.

(11) Affect or is likely to suffer damage by being located in an environmentally sensitive area such as a flood plain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters;

The proposed project will require a Special Flood Hazard Area Development Permit due to its location within Zone AH and A3 flood designations. A *Preliminary Drainage and Soil Erosion Control Report* was prepared by Wilson Okamoto & Associates, Inc. in January 2000 to assess requirements for drainage improvement in the project site and evaluate the project's hydraulic impact to flood-prone areas. The proposed drainage improvements will be designed to accommodate on- and off-site runoff.

(12) Substantially affect scenic vistas and viewplanes identified in county or state plans or studies; or,

Scenic vistas and viewplanes from the project site are not identified in any County or State plans or studies.

(13) Require substantial energy consumption.

Construction and operation of the project will not require substantial increases in energy consumption.

Based on the foregoing discussion, it is concluded that the proposed project will not result in any significant impacts, and a Finding of No Significant Impact determination is appropriate.

8. PARTIES CONSULTED DURING THE PRE-ASSESSMENT PERIOD

The following agencies and organizations were contacted during the preparation of the Draft EA. Of the 9 parties that formally replied during the pre-assessment period, some had no comments while other provided substantive comments as indicated by the ✓ and ✓✓, respectively. All written comments are reproduced herein.

Federal Agencies

✓✓ U.S. Fish and Wildlife Service
U.S. Geological Survey
✓ U.S. Natural Resource Conservation Service
✓✓ U.S. Army Corps of Engineers

State Agencies

✓✓ Department of Business, Economic Development & Tourism
Department of Land and Natural Resources (DLNR)
DLNR, State Historic Preservation Division
DLNR, Aquatic Resources
✓✓ DLNR, Division of Forestry and Wildlife
Department of Health (DOH)
DOH, Clean Water Branch

County of Maui Agencies

Planning Department
Department of Water Supply
✓✓ Police Department
✓✓ Fire Department
✓✓ Department of Parks and Recreation – Arborist Committee

Other

✓✓ Maui Electric Company
Kihei Community Association

USDA

ited States
partment of
riculture

tural
sources
nservation
rvice

O. Box 50004
nolulu, HI
-850

Our People...Our Islands...In Harmony

October 29, 1999

Mr. Rodney Y. Funakoshi, AICP
Project Manager
Wilson Okamoto & Associates, Inc.
1907 South Beretania Street, Suite 400
Honolulu, Hawaii 96826

Dear Mr. Funakoshi:

Subject: Environmental Assessment (EA) - Pre-Assessment Consultation - South Kihei Road Improvements, Kulanihakoi Street to Lipoa Street, Kihei, Maui, Hawaii

We have reviewed the above mentioned document and have no comments to offer at this time.

Thank you for the opportunity to review this document.

Sincerely,

KENNETH M. KANESHIRO
State Conservationist

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO ATTENTION OF

October 29, 1999

Civil Works Technical Branch

Mr. Rodney Y. Funakoshi
Project Manager
Wilson Okamoto and Associates
1907 South Beretania Street
Honolulu, Hawaii 96826

Dear Mr. Funakoshi:

Thank you for the opportunity to review and comment on the Pre-Assessment Consultation for the South Kihei Road Improvements Project, Kihei, Maui. Due to a lack of information, a thorough evaluation could not be made at this time. However, any work performed within the 100-year floodplain will have to adhere to the requirements of the Federal Emergency Management Agency. Additionally, the need for a Department of the Army permit could not be determined based on the information submitted to us. We will need to review future documentation when it becomes available so that specific information can be provided to you.

If you require additional information, please contact Ms. Jessie Dobinchick of my Civil Works Technical Branch staff at (808) 438-8876.

Sincerely,

James K. Hatashima
Acting Chief, Civil Works
Technical Branch

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Pacific Islands Ecoregion
300 Ala Moana Boulevard, Room 3-122
Box 50088
Honolulu, Hawaii 96850

In Reply Refer To: MSR

Rodney Funakoshi
Wilson Okamoto & Associates
1907 S. Beretania St.
Honolulu, HI 96826

Re: Preparation Notice of an Environmental Assessment for the South Kihei Road Improvements Project (Kulanihakoi St. to Lipoa St.), Kihei, Maui, Hawaii.

Dear Mr. Funakoshi:

The U.S. Fish and Wildlife Service (Service) has reviewed the proposed project summary provided with your referenced request for technical assistance. The project applicant is the County of Maui, Department of Public Works and Waste Management. The proposed project involves road widening, drainage, and related improvements to an approximately .95 mile segment of South Kihei Road from Kulanihakoi Street to Lipoa Street in the Kihei District on Maui. The Service offers the following comments for your consideration.

We have reviewed the information provided with your October 18, 1999 letter and data contained in our own files, including maps prepared by the Hawaii Heritage Program of The Nature Conservancy and the Service's National Wetlands Inventory program. To the best of our knowledge, no federally endangered, threatened, or candidate species, significant wetlands, or other federal trust resources occur in the immediate area of the proposed project site. However, the endangered dark-rumped petrel (*Pterodroma phaeopygia sandwichensis)* may occur in the general vicinity of the proposed project site. Circumstantial observations and experimental evidence have shown that artificial lighting can disorient petrels and other seabirds when flying between inland nesting areas and offshore feeding grounds. This disorientation is caused by excessively bright outdoor lighting and can result in seabird collisions with man-made structures such as light poles and wires. Injured seabirds that "fall-out" from collisions are highly vulnerable to predation by dogs, cats, and mongooses.

At a minimum, we recommend that any light poles erected at the project site be limited to a maximum height of 25 feet since lights higher than this are more likely to cause seabird fall-out. All project lighting should be directed downward and be shaded to prevent light from escaping horizontally, and be of as low wattage as possible. It would also help if the lighting is of muted colors instead of bright white. We suggest you contact Fern Duvall with the DOFAW office on Maui for other recommendations [phone: (808) 871-2929].

In general, the Service recommends that the draft Environmental Assessment (EA) address potential impacts from the proposed project on the above species as well as other native Hawaiian plants and animals and their habitats and identify the Best Management Practices that will be incorporated into the project to minimize adverse impacts. For example, we recommend that clearing and grading activities be minimized and limited to the immediate project site and that adequate erosion control measures be incorporated to ensure that project-related sediments are not carried into nearby wetlands or coastal waters by stormwater runoff.

We appreciate the opportunity to provide early technical assistance on the proposed project and look forward to receiving a copy of the draft EA when it is available. If you have questions regarding these comments, please contact Fish and Wildlife Biologist Mike Richardson by telephone at (808) 541341 or by facsimile transmission at (808) 541-3470.

Sincerely,

Robert P. Smith
Pacific Islands Manager

cc: DOFAW, Maui
DOFAW, Honolulu

WILSON
OKAMOTO
& ASSOCIATES, INC.

ENGINEERS
PLANNERS
1907 S. BERETANIA STREET
HONOLULU, HAWAII 96826
PH: (808) 946-2277
FAX: (808) 946-2253

6268-02
November 23, 1999

Mr. Robert P. Smith
Pacific Islands Manager
U.S. Department of the Interior
Fish and Wildlife Service
Pacific Islands Ecoregion
300 Ala Moana Boulevard, Room 3122
Box 50088
Honolulu, Hawaii 96850

Attention: Mr. Mike Richardson

Subject: Environmental Assessment (EA) Pre-Assessment Consultation
South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street
Tax Map Keys: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: various
Kihei, Maui, Hawaii

Dear Mr. Smith:

As a follow-up to your letter dated November 8, 1999 (Ref. MSR) regarding the subject project, we have contacted Dr. Fern Duvall of the Department of Land and Natural Resources, Division of Forestry and Wildlife regarding the potential for seabird fall-out in the vicinity of the project. Dr. Duvall concurred with your recommendations for lighting design and will be transmitting specific information in this regard to our office.

In conjunction with the EA, a botanical survey was conducted which confirmed that, while native and introduced plant species were recorded within the project site, no candidate, proposed, or listed threatened or endangered species were encountered. No significant long-term adverse impacts to floral or faunal resources are anticipated as a result of the proposed project.

A discussion of best management practices to mitigate potential adverse impacts associated with construction runoff, particularly into drainageways located within the project site, will be included in the Draft EA.

Your participation during the pre-assessment consultation phase of the EA process is appreciated.

Sincerely,

Rodney Funakoshi
Project Manager

cc: Mr. Joe Krueger, County of Maui, DPWWM

BENJAMIN J. CAYETANO
GOVERNOR

ESTHER UEDA
EXECUTIVE OFFICER

STATE OF HAWAII
DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM
LAND USE COMMISSION
P.O. Box 2359
Honolulu, HI 96804-2359
Telephone: 808-587-3822
Fax: 808-587-3827

October 19, 1999

Mr. Rodney Funakoshi
Project Manager
Wilson Okamoto & Associates
1907 South Beretania Street, Suite 400
Honolulu, Hawaii 96826

Dear Mr. Funakoshi:

Subject: Environmental Assessment Pre-Assessment Consultation for South Kihei Road Improvements, Kulanihakoi Street to Lipoa Street, Kihei, Maui, TMKs 3-9-1, 2, 7, 8, 22, 34, 46, 52; various

We have reviewed the project summary transmitted by your letter dated October 18, 1999, and confirm that the project site, as represented on the location map, is designated within the State Land Use Urban District.

We have no further comments to offer at this time. We appreciate the opportunity to comment on the subject project.

Should you have any questions, please feel free to call me or Bert Saruwatari of our office at 587-3822.

Sincerely,

ESTHER UEDA
Executive Officer

EU:aa

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF FORESTRY AND WILDLIFE
1151 PUNCHBOWL STREET
HONOLULU, HAWAII 96813

TIMOTHY E. JOHNS
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

JAMES E. KAWELO
DEPUTY

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

October 22, 1999

RECEIVED
OCT 26 1999
WILSON OKAMOTO & ASSOC., INC.

Mr. Rodney Y. Funakoshi, AICP
Wilson Okamoto & Associates, Inc.
1907 South Beretania Street, Suite 400
Honolulu, Hawaii 96826

Dear Mr. Funakoshi:

RE: EA pre- assessment consultation, S. Kihei Road Improvements, Kulanihakoi Street to Lipoa Street TMK: (2) 3-9-1,2,7,8,22,34,46,52: various Kihei, Maui, Hawaii.

We have reviewed the information provided by your October 18, 1999 letter to DLNR, Division of Forestry and Wildlife regarding the subject above. Although the information acknowledge anticipated impacts to wetland resources, we would like further discussion in the draft EA on the efforts to mitigate the potential impacts the project will have on water birds frequenting the area should a field survey confirm that a wetland exists here. Thank you for allowing us to review this project. Should you need further assistance and consultation, please call Mr. Meyer Ueoka, Wildlife Program Manager at our Maui Forestry and Wildlife Branch office at (808) 984-8108.

Sincerely yours,

Michael G. Buck
Administrator

C: Meyer Ueoka, Maui DOFAW

6268-02
October 18, 1999

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS
PLANNERS
1907 S. BERETANIA ST.
SUITE 400
HONOLULU, HI 96826
PH (808)946-2277
FAX (808)946-2253

RECEIVED
'99 OCT 19 P1:05
FORESTRY & WILDLIFE
STATE OF HAWAII

Mr. Michael Buck, Administrator
Division of Forestry and Wildlife
Department of Land and Natural Resources
State of Hawaii
1151 Punchbowl Street
Honolulu, Hawaii 96813

Subject: Environmental Assessment (EA) Pre-Assessment Consultation
South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street
Tax Map Keys: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: various
Kihei, Maui, Hawaii

Dear Mr. Buck:

On behalf of the County of Maui Department of Public Works and Waste Management (DPWWM), Wilson Okamoto & Associates, Inc. is currently preparing the subject EA. Enclosed for your review is a project summary and location map of the proposed project.

In conjunction with the pre-assessment consultation process, we are soliciting any comments or concerns you may have regarding the proposed project. We would appreciate your written comments by Friday, November 5, 1999, submitted to:

Wilson Okamoto & Associates, Inc.
1907 South Beretania Street, Suite 400
Honolulu, Hawaii 96826
Fax: 946-2277
Email: woa@aloha.net
Attention: Rodney Funakoshi, Project Manager

Should you have any questions or require additional information regarding this request, please call Laura Mau or me at 946-2277. Thank you for your consideration in this matter.

Sincerely,

Rodney Y. Funakoshi, AICP
Project Manager

Enclosures

cc: Mr. Joe Krueger, County of Maui, DPWWM

1. Introduction

The County of Maui Department of Public Works and Waste Management (DPWWM) is proposing to improve a portion of South Kihei Road in Kihei on the Island of Maui. The proposed project encompasses approximately 5,100 lineal feet or 0.95 miles from Kulanihakoi Street to Lipoa Street (see Figure 1, Location Map).

2. Project Description

Approximately 3,800 l.f. of the project, from approximately 170 feet north of Kulanihakoi Street to approximately 300 feet south of Nohokai Place, will involve widening of the existing right-of-way, which varies from 50 to 60 feet, to a proposed right-of-way of 60 to 70 feet. Proposed improvements will include the following:

- Two 12-foot travel lanes;
- Two 5-foot bike lanes;
- Dedicated left-turn lanes at all intersections;
- Dedicated right-turn lanes at selected intersections;
- A parking lane on one side of the road;
- Two 6-foot wide sidewalks;
- Curbs and gutters on both sides of the road;
- New and relocated storm drains and manholes;
- Relocation of driveways;
- Relocation of street lights and overhead utility lines;
- Removal of existing landscaping; and
- Adjustment of sewer manhole covers.

The next 1,000 l.f. to Road "C" will be limited to restriping of the existing roadway. The remaining 300 l.f. from Road "C" to Lipoa Street will be improved under separate County of Maui contracts. In addition, at the request of the County of Maui Board of Water Supply, approximately 900 feet of waterline will be replaced from approximately 300 feet south of Nohokai Street to Olowi Street.

3. Land Use Designations

The project site is located within the State Urban District. With regard to County of Maui zoning designations, the project lies within the Residential, Apartment, Hotel, and B-2 Community Business districts. The project is located within the boundaries of the County of Maui Special Management Area (SMA) and, therefore, is subject to the provisions of the SMA Use Permit.

4. Anticipated Impacts

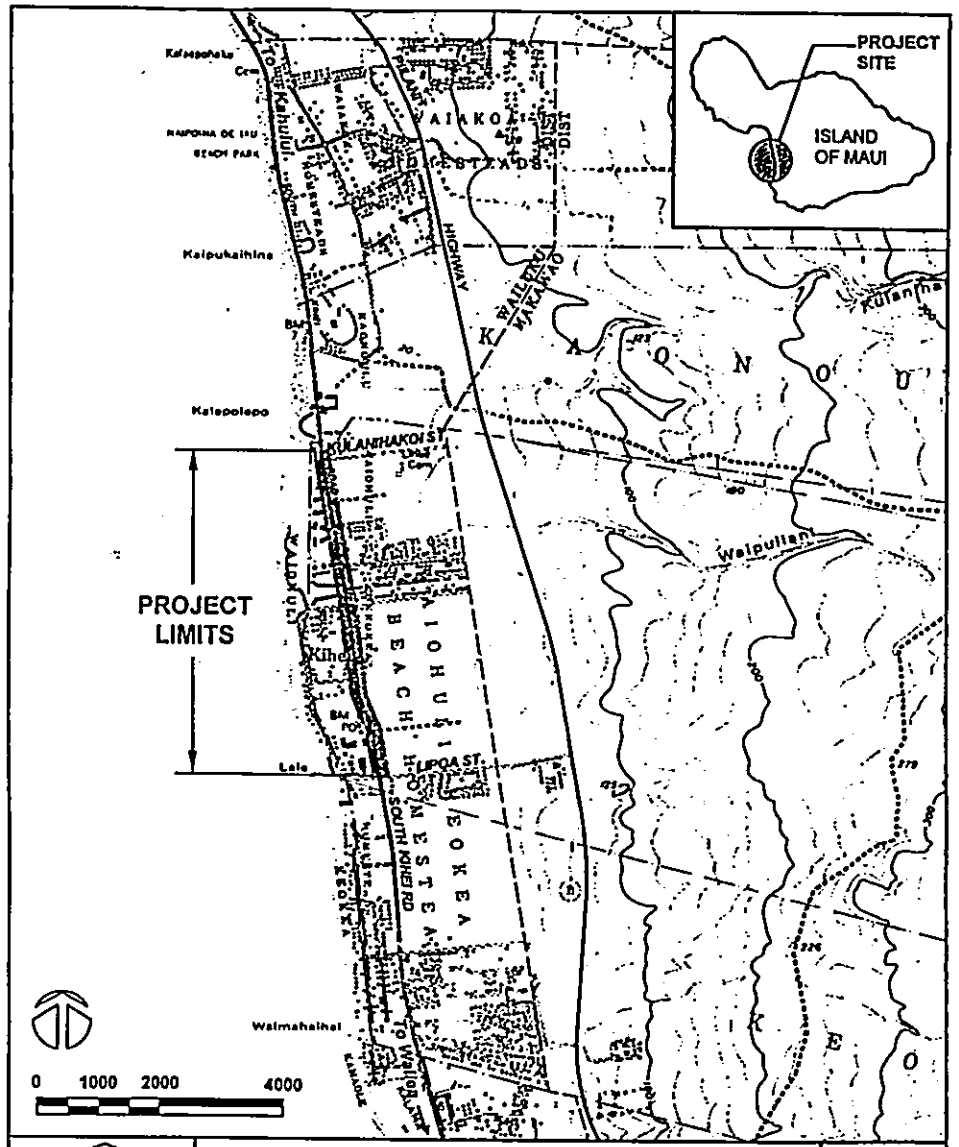
Wetland Resources: According to the U.S. Army Corps of Engineers, wetland resources are located in proximity of the project area as illustrated in the attached map.

However, wetland areas were not encountered during field visits conducted by Wilson Okamoto & Associates, Inc. A botanical survey will be conducted to confirm the presence of wetland areas and to evaluate potential impacts to these areas.

Archaeological Resource: An archaeological reconnaissance survey will be conducted to assess the potential for impacts to these resources.

Land Acquisition: The proposed project will require the acquisition of small portions of adjacent properties along both sides of the route to accommodate the new road right-of-way. Preliminarily, adjacent parcels that may be affected by the acquisition include:

PARCELS TO BE ACQUIRED (By Tax Map Key)	
Zone-Section-Plat	**Parcels**
3-9-1	2, 4, 6, 9,10, 13, 56, 57, 75, 77, and 151
3-9-7	7, 16, 21, 22, 23, 38, 39, 40, 41, 42, 43, 54 and 62
3-9-8	16
3-9-22	3, 4, 20, 21, 22, 29, 38, 39, and 40
3-9-34	1, 13, 14, 15, and 27
3-9-46	5, 6, 7, 8, 9, and 17
3-9-52	37



WILSON OKAMOTO & ASSOCIATES, INC. ENGINEERS - PLANNERS | SOUTH KIHEI ROAD IMPROVEMENTS KULANIHAKOI STREET TO LIPOA STREET | FIGURE 1

LOCATION MAP

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS PLANNERS
1907 S. BERETANIA STREET
HONOLULU, HAWAII 96826
PH: (808) 946-2277
FAX: (808) 946-2253

6268-02
November 23, 1999

Mr. Michael G. Buck, Administrator
State of Hawaii
Department of Land and Natural Resources
Division of Forestry and Wildlife
1151 Punchbowl Street
Honolulu, Hawaii 96813

Subject: Environmental Assessment (EA) Pre-Assessment Consultation
South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street
Tax Map Keys: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: various
Kihei, Maui, Hawaii

Dear Mr. Buck:

Thank you for your letter of October 22, 1999 commenting on the subject project. With regard to your concerns for wetland resources, a botanical survey conducted for the EA revealed that no wetlands or wetland indicators were found within or adjacent to the project site. No waterbirds were observed in the area. The U.S. Fish and Wildlife Service has also confirmed to us that no significant wetlands are located in the immediate area of the project site.

Thank you for your participation during the consultation phase of the EA.

Sincerely,

Rodney Funakoshi
Project Manager

cc: Mr. Joe Krueger, County of Maui, DPWWM

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JAMES "KIMO" APANA
MAYOR

CLAYTON T. ISHIKAWA
CHIEF

FRANK E. FERNANDEZ, JR.
DEPUTY CHIEF

COUNTY OF MAUI
DEPARTMENT OF FIRE CONTROL

200 DAIRY ROAD
KAHULUI, MAUI, HAWAII 96732
(808) 243-7561
FAX (808) 243-7919

October 21, 1999

Mr. Rodney Y. Funakoshi, AICP
Wilson Okamoto & Associates, Inc.
1907 South Beretania Street, Suite 400
Honolulu, HI 96826

RE: Environmental Assessment (EA) Pre-Assessment Consultation
South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street
TMK: 3-9-01, 2, 7, 8, 22, 34, 46, and 52:various
Kihei, Maui, Hawaii

RECEIVED
OCT 28 1999
WILSON OKAMOTO & ASSOC., INC

Dear Mr. Funakoshi,

Thank you for the opportunity to comment on the environmental assessment.

At this time the Department of Fire Control requires that when this project requires any closures and/or detours, that their location and duration be provided, in writing, to the Fire Prevention Bureau.

If you have any questions, direct them in writing to the Fire Prevention Bureau, 21 Kinipopo Street, Wailuku, HI 96793.

Sincerely,

LEONARD F NIEMCZYK
Captain, Fire Prevention Bureau

xc: Plans

HFD/FPB-South Kihei Road Improvements (10.99)

WILSON
OKAMOTO
& ASSOCIATES, INC.

ENGINEERS
PLANNERS
1907 S. BERETANIA STREET
HONOLULU, HAWAII 96826
PH: (808) 946-2277
FAX: (808) 946-2253

6268-02
November 23, 1999

Mr. Leonard F. Niemczyk, Captain
Fire Prevention Bureau
County of Maui
Department of Fire Control
200 Dairy Road
Kahului, Hawaii 96732

Subject: Environmental Assessment (EA) Pre-Assessment Consultation
South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street
Tax Map Keys: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: various
Kihei, Maui, Hawaii

Dear Mr. Niemczyk:

We have received your letter dated October 21, 1999 commenting on the subject project. Any road closures or detours, if deemed necessary, will be coordinated in writing with your office. Thank you for your participation during the consultation phase of the EA.

Sincerely,

Rodney Funakoshi
Project Manager

cc: Mr. Joe Krueger, County of Maui, DPWWM

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POLICE DEPARTMENT
COUNTY OF MAUI

JAMES "KIMO" APANA
MAYOR

55 MAHALANI STREET
WAILUKU, HAWAII 96793
(808) 244-6400
FAX (808) 244-6411

THOMAS M. PHILLIPS
CHIEF OF POLICE

CHARLES H.P. HALL
DEPUTY CHIEF OF POLICE

OUR REFERENCE
YOUR REFERENCE

October 28, 1999

RECEIVED
NOV 02 1999
WILSON OKAMOTO & ASSOC. INC.

Wilson Okamoto & Associates, Inc.
1907 South Beretania Street, Suite 400
Honolulu, Hawaii 96826

Attention: Rodney Funakoshi, Project Manager

Gentlemen:

Subject: Environmental Assessment (EA) Pre-Assessment Consultation
South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street
Tax Map Keys: (2) 3-9-1,2,7,8,22,34,46,52:various
Kihei, Maui, Hawaii

Thank you for your letter of October 18, 1999 regarding the above subject.

We have reviewed the project summary and location map of the proposed project. Enclosed is our questions and concerns. Thank you for the opportunity to comment on the proposed project.

Very truly yours,

AC [signature]

Assistant Chief Robert Tam Ho
for: THOMAS M. PHILLIPS
Chief of Police

Enclosure
c: Mr. Joe Krueger, DPWWM

TO : TOM PHILLIPS, CHIEF OF POLICE, COUNTY OF MAUI

VIA : CHANNELS

FROM : BRADNEY HICKLE, POLICE OFFICER III, KIHEI CPO'S

SUBJECT : ENVIRONMENTAL ASSESSMENT (EA) PRE-ASSESSMENT CONSULTATION/ SOUTH KIHEI ROAD IMPROVEMENTS

10/21/99

Sirs, on 10/21/99 I received a copy of the proposed project submitted by Wilson-Okamoto & Associates, Inc.

As requested and in conjunction with your pre-assessment process, my concerns and comments are as follows.

The primary concerns of the Police Department would be the impact on traffic prior to and during the construction phase of the project. The proposed areas of construction will include the Longs Center, Azeka's I and Azeka's II, Star Market and the Kihei Physicians Group not to mention numerous other business's, condominiums and private residences. This is a highly traveled business district and is sure to have an affect on emergency vehicles and private vehicles which frequent South Kihei road between Kulanihakoi street and Lipoa street.

My questions and concerns at this time are;
1) Has a traffic assessment report been completed within this area? Please submit report.
2) Are road closures anticipated?
3) What are the proposed hours of operation?
4) What are the anticipated dates of the project from the onset until completion?
5) Are there plans to reroute or divert traffic around the construction area?

Valid points addressed by officer Hickle. Answers to the questions raised would be helpful for a good assessment
SGT [signature]
10/2?/99 1049

Respectfully Submitted,

Officer Brad Hickle E-9966
10/21/99 1430 hours

WILSON
OKAMOTO
& ASSOCIATES, INC.

ENGINEERS
PLANNERS

1907 S. BERETANIA STREET
HONOLULU, HAWAII 96826
PH: (808) 946-2277
FAX: (808) 946-2253

6268-02
November 23, 1999

Mr. Thomas M. Phillips, Chief
County of Maui
Police Department
55 Mahalani Street
Wailuku, Hawaii 96793

Subject: Environmental Assessment (EA) Pre-Assessment Consultation
South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street
Tax Map Keys: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: various
Kihei, Maui, Hawaii

Dear Mr. Phillips:

We have received your letter dated October 28, 1999 commenting on the subject project. The following is offered in response to your concerns:

1. A traffic impact assessment was not prepared specifically for the project. A traffic control plan will be prepared and submitted to the Department of Public Works and Waste Management for approval;
2. and 5. Any road closures or detours, if deemed necessary, will be coordinated in writing with your office.
3. Hours of construction will generally be restricted to typical non-peak hours from 8:30 a.m. to 3:30 p.m.
4. Construction activity is expected to start in late 2000 and continue to 2002.

Thank you for your participation during the consultation phase of the EA.

Sincerely,

Rodney Funakoshi
Project Manager

cc: Mr. Joe Krueger, County of Maui, DPWWM

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Maui Electric Company, Ltd. • 210 West Kamehameha Avenue • PO Box 398 • Kahului, Maui, HI 96733-6898 • (808) 871-8461

October 29, 1999

Mr. Rodney Funakoshi
Project Manager
Wilson Okamoto & Associates, Inc.
1907 S. Beretania St., Suite 400
Honolulu, HI 96826

Dear Mr. Funakoshi:

Subject: Environmental Assessment(EA) Pre- Assessment Consultation
South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street

Thank you for the opportunity to review and comment on the subject project.

We request that we be provided electrical, civil and mechanical final design plans for our review and comment, our distribution facilities located in the vicinity of the proposed project area require relocation per statements provided in your project description.

Easements are required and must be obtained before the installation of our facilities. Negotiation and obtaining these required easements will be done by the governmental agency initiating this project. Also, during construction, we must have an archeological person present. Another matter of concern is that permits are required for our Company to do our portion of work. Therefore, this process may affect your project time line and you may need to consider this in your project planning.

If you have any questions or concerns, please call Dan Takahata at 871-2385.

Sincerely,

Edward L. Reinhardt
Manager, Engineering

WILSON
OKAMOTO
& ASSOCIATES, INC.
ENGINEERS
PLANNERS
1907 S. BERETANIA STREET
HONOLULU, HAWAII 96826
PH: (808) 946-2277
FAX: (808) 946-2253

6268-02
November 23, 1999

Mr. Edward L. Reinhardt
Manager, Engineering
Maui Electric Company, Ltd.
210 West Kamehameha Avenue
P.O. Box 398
Kahului, Hawaii 96733-6898

Subject: Environmental Assessment (EA) Pre-Assessment Consultation
South Kihei Road Improvements
Kulanihakoi Street to Lipoa Street
Tax Map Keys: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: various
Kihei, Maui, Hawaii

Dear Mr. Reinhardt:

We have received your letter dated October 29, 1999 commenting on the subject project. All design plans, easement acquisitions, and permitting requirements will be coordinated with your office. Thank you for your participation during the consultation phase of the EA.

Sincerely,

Rodney Funakoshi
Project Manager

cc: Mr. Joe Krueger, County of Maui, DPWWM

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MAUI COUNTY ARBORIST COMMITTEE

275 UHU STREET · KAHULUI · HAWAII 96732 · (808) 243-7325 · FAX (808) 243-7953

November 22, 1999

Mr. Rodney Y. Funakoshi, AICP
Project Manager
Wilson Okamoto & Associates, Inc.
1907 S. Beretania Street
Honolulu, Hawaii 96826

Dear Mr. Funakoshi:

At its November 10, 1999 meeting the Maui County Arborist Committee reviewed your request for input regarding the widening of South Kihei Road. The Committee strongly recommends that trees already growing in the area be kept because they provide much needed shade. Any that are removed should be replaced with specimens that will provide shade as soon as possible. Sidewalks, curbs, etc. should be adequately reinforced to minimize lifting by roots in the future. Oftentimes "hardscapes" are not sufficiently reinforced and result in an engineering failure and not a tree root problem.

Hopefully new trees will be planted along the improved highway. I am enclosing literature we provided the Engineering Standards Committee (Public Works Department) for your review and transmission to whoever designs the road and planting spaces. These novel methods of planting street trees are designed to minimize root/hardscape problems. Using connected underground vaults enable larger shade trees to be planted without impacting sidewalks, curbs, and roads. Connecting tree planting sites with a buried synthetic fabric encourages root growth along these pathways.

We hope the SMA review board and the County of Maui are willing to plant trees with one or several of these different methods. This is an excellent opportunity to achieve shade from larger trees without the damaging effects to hardscapes.

The Maui County Arborist Committee is available to provide support to creative solutions to planting street trees along South Kihei Road, or any other area. If you have any questions, please contact us through Sue Kiang at 243-7325.

I am enclosing a copy of the assessment of the Monkey Pod trees growing along South Kihei Road we sent to Mr. Charles Jencks in February, 1999.

Thank you for including the Arborist Committee in the initial planning stage.

Sincerely,

Ernest H Rezents

ERNEST H. REZENTS
Chairman

Enclosures

1. The Journal of Arboriculture 24(3):May 1998 has many excellent suggestions. Figure 2 on page 124 looks very promising.
2. Principles and Practice of Planting Trees and Shrubs, page 45 has similar inclusions and holds tremendous promise.
3. Arborist News (ISA) is for general information.
4. The Cornell University packet is a source of good information.
5. South Kihei Road Monkey Pod tree Assessment.

c: Ms. Jeannie Pezolli, President
Maui Outdoor Circle (w/o enclosures)
Engineering Standards Committee (w/o enclosures)

c:\arbcom\RFunakoshi(er)

FILE

MAUI COUNTY ARBORIST COMMITTEE

271 UHU STREET · KAHULUI · HAWAII 96732 · (808) 243-7225 · FAX (808) 243-7953

February 23, 1999

Mr. Charles Jencks, Director
County of Maui
Department of Public Works and
Waste Management
200 South High Street
Wailuku, Hawaii 96793

Dear Mr. Jencks:

The Monkey Pod trees growing on South Kihei road in front of Kauhale Makai condominium were discussed at the February 10, 1999 Maui County Arborist Committee meeting. A meeting of the Tree Concerns subcommittee was scheduled on site for February 23rd. The Arborist Committee requested that following this meeting a letter be sent to you with suggestions on how to deal with the root/sidewalk impact.

Because the trees provide a great deal of welcomed shade to an other wise hot area, there is community support for keeping the street trees. The tree concerns subcommittee inspected the trees and sidewalk beginning from the North end at Village by the Sea condominium.

Observations:

Some of the trees have large exposed surface roots and others do not. This may be due to a shallow soil. Some Kihei developers used large rocks as fill and then covered them with soil prior to planting a landscape. We did not excavate to verify what occurred here. Nonetheless this would not solve the present concerns. We learned that the trees are about 20 years old.

1. Monkey Pod #1. Large surface roots. No sidewalk lifting. Recommend that the sidewalk be curved towards the curb to provide the tree with a larger space for trunk and root growth. This method has been observed in mainland communities.

2. Monkey Pod # 2. No sidewalk impact.
3. Monkey Pod # 3. Same as tree number 1.
4. Monkey Pod # 4. No sidewalk impact.
5. Monkey Pod # 5. Same as tree # 1.

Entrance into Luana Kai Condominium.

6. Monkey Pod # 6. There is some sidewalk lifting at the ramp. Some root pruning occurred in the past. Solve by providing more growing space as in tree # 1.
7. Monkey Pod # 7. Provide an enlarged growing space at base of the tree as recommended in tree # 1.
8. Monkey Pod # 8. No sidewalk impact.
9. Monkey Pod # 9. Provide more growing space as recommended in tree # 1.
10. Monkey Pod # 10. Provide more growing space as recommended in tree # 1.
11. Monkey Pod # 11. Roots have impacted with the sidewalk. Provide more growing space as in tree # 1.
12. Monkey Pod # 12. Same as tree # 1.

Entrance to parking lot.

13. Monkey Pod trees # 13, 14, and 15. These three trees have raised the sidewalk the most. Provide more growing space by elevating the sidewalk as discussed below. Sidewalk repair in any other method will probably require root pruning. This is not a recommended practice.

Possible Solutions:

1. Elevating the sidewalk: Move the entire sidewalk towards the curb and elevate it by adding 3-4 inches of soil and 3-4 inches minimum of crushed

blue rock on top of it. Compact the blue rock some. Pour a new sidewalk reinforced with steel. The curb may need to be raised to level the elevated sidewalk with it. A railing could be installed between the sidewalk and the curb instead. Fill between the sidewalk and trees with top soil.

The soil and blue rock will provide more space for expanding roots and the steel will lessen any future lifting by the roots. This technique should provide some years of impact free growth.

2. Provide an enlarged growing space for trees # 1, 3, 5, 6, 7, 9, 10, 11, and 12 by curving the sidewalk towards the curb. The new sidewalk should be steel reinforced and tied into the existing sidewalk sections. For trees number 13, 14, and 15, because the distance is only about 40 feet and each tree is raising the sidewalk it is recommended that a new sidewalk be constructed as proposed in solution # 1.

3. Do number 2 without steel reinforcements or blue rock base. This will fix the problem but not provide long term correction.

Other Suggestions:

1. Do not prune the roots because this practice affects tree stability and opens up sites for root decay.

2. The Arborist Committee has learned of new creative methods for building underground spaces for improved root growth that lessens root/sidewalk and curb impact. We have shared a video from Cornell University with the Planning Department and would like to offer it for your department's review. However, these methods are used prior to planting and not to correct an existing problem.

We are interested in using this technique, or some other one, for street/parking lot tree planting in a private or public project. If you are aware of a project where such an experiment could be conducted, please bring it to our attention. We are interested in changing the way we plant trees to provide better growth and lessen root impact with hardscapes.

We hope these suggestions will help you resolve the Monkey Pod's impact with the sidewalk in Kihei. We all want to keep the trees and yet make the area safer for walkers. Thank you for your assistance on this matter. If you have any questions please contact Sue Kiang at the Volunteer Action Program at 243-7325.

Sincerely,

ERNEST H. REZENTS
Chairman

c: Elaine Malina, Tree Concerns Subcommittee
David Sakoda, County Arborist

c:\arbcom\jencks3(er)

DESIGNING URBAN PAVEMENT SUB-BASES TO SUPPORT TREES

by Palle Kristoffersen

Abstract. In Denmark, poor growth conditions for urban trees have been perceived as a problem since the 1980s. Restricted planting-pit sizes are mainly responsible for this problem. In 1996, a survey found that the average size of municipal planting pits had increased from 0.1 m³ (3.5 ft³) in the late 1960s, to 3.4 m³ (120 ft³) in 1996. To increase the volume of the planting pit, several materials have been introduced to mix with soil to allow root growth under pavements. Three methods are available for installing these materials under pavements. During the last 5 years, more than 800 trees have been planted on more than 30 sites using these materials and installation methods. Every method has advantages and disadvantages. No serious difficulties due to load-bearing capacity or frost heaves have been recorded.

Planting pits for urban trees are surrounded with soil that has been either unintentionally compacted or replaced with compacted road-building materials (Kopinga 1985; Lichter and Lindsey 1994; Randrup 1997). The restricted planting pits allow only limited root growth, and insufficient rooting volumes in urban situations often result in destructive roots. Roots outgrow the planting pits and often spread immediately below the pavement surface, lifting and eventually destroying the pavement. This is a serious and expensive problem that stresses trees (Kopinga 1991, 1992). Sycamore maples (*Acer pseudoplatanus*) grown under stressed conditions exhibit limited height growth, more capital axes, fewer cardinal axes, and twisted and crooked stems (Bonsen 1996). This irregularity of growth causes aesthetic as well as maintenance problems in system plantings in which all trees are important in forming a unified appearance. If system plantings are established in paved, partly paved, and unpaved areas, the chances of obtaining a homogeneous appearance will be reduced further.

The usual method of establishing urban trees in Denmark has been to plant trees in individual planting pits. The size of the planting pit has increased since the 1960s, when it was often less than 0.1 m³ (3.5 ft³). Since then, the average volume of planting pits, as found in 11 Danish municipalities, has increased to 3.4 m³ (120 ft³), ranging from 0.8 to 8.1 m³ (28 to 286 ft³) (Tellmann and Kristoffersen 1996).

Applying one of the predeveloped models to estimate soil volumes for urban trees based on the soil's water-holding capacity shows that a tree with a canopy diameter of 10 m (33 ft) requires a 35 to 40 m² (377 to 431 ft²) planting pit (Lindsey and Bassuk 1992). In urban areas, it is almost impossible to plan unpaved planting beds of this size. Therefore, several methods for integrating the growing media under paved surfaces have been described. These methods consist of a mix of medium-course sand (Couenberg 1994), a load-bearing matrix mixed of stones and soil (Grabosky and Bassuk 1995), and pavements constructed with a span above a growing media, such as top soil (Urban 1989).

In Denmark, pavements are defined to consist of a sub-base and a base, both usually compacted to densities that impede root growth, and of a top layer of bricks, pavers, or asphalt (Patterson 1977; Vejdirektoratet 1984). The sub-base material usually consists of sand or other materials that promote drainage. The base is often made of screened and graded gravel but almost never concrete, as it is in the United States.

Design and Installation Methods

In Denmark, more than 800 trees were integrated into pavements at 30 different sites using a load-bearing matrix or different sand mixes. A number of matrix materials were used, and 3 mixing methods have been developed.

Materials. Stones, ranging from 32 to 150 mm (1 to 6 in.) diameter gravel, granite, lava slags, crushed bricks, and blocks of Leca-concrete have been used as load-bearing matrixes (Table 1). Leca-concrete is made of

Table 1. Materials and mixing methods used as sub-base to support trees.

	Materials					
	Stones (80–150 mm)	Stones/ crushed stones (32–80 mm) (32–45 mm)	Leca-concrete blocks* (100 x 100 mm)	Crushed lava (32–45 mm)	Crushed bricks (25–50 mm)	Sand mix (0.2–0.5 mm)
Installation methods	water mix dry mix	premix water mix	premix	premix water mix dry mix	premix water mix	premix
Growing medium	topsoil	topsoil	topsoil	topsoil	topsoil	humus/ compost
Density of material (g/cm³)	2.7	2.7	1.0	1.8	1.8	2.6
Porosity of material (vol. – %)	0	0	approx. 15	approx. 55	approx. 30	0
Voids in compacted material (vol. – %)	45	45/40	56	38	35	45

*Leca is the Danish commercial name for Light Expanded Clay Aggregates

Leca nuts mixed with cement and formed to blocks. Leca is a commercial name and an acronym for Light Expanded Clay Aggregates. The Leca nuts consist of an inner clinkerized cellular structure with a hard, resistant outside coating. The material porosity is presumed to influence the air and water exchange in the soil mix.

Methods of installation. Soil is used to fill the voids in the load-bearing matrix. Because compacted soil impedes root growth, it is necessary to prevent compaction during the installation process. Three mixing and installation methods have been developed and tested: premixing before installation, water mixing during installation, and dry mixing during installation.

(1) ***Premixing before installation.*** Stones and soil are mixed at a predetermined ratio. Mixing can be done with a front loader, a power shovel, a concrete mixer, or similar equipment. Separation of soil from stones may occur after mixing if the mixture is moved or transported; therefore, remixing before installation may be necessary to restore uniformity. The matrix of stone and soil is compacted after spreading to establish contact between the individual stones, thereby transferring the load of pedestrian and vehicles to the subgrade. When the soil and stone mix is compacted, the stones will be rearranged as the soil fills the voids (Harris 1971). To obtain the proper degree of compaction, the stone-soil mix should be installed in layers of no more than 15 to 20 cm (6 to 8 in.).

The correct mixture of stones and soil (i.e., the point at which the soil is not compacted during the installation) can be determined by measuring the stone weight per cubic unit or by filling a known volume of stones with water and then estimating the volume of the voids. The volume of soil added should be less than this volume. If the applied stone material has 20% voids after compacting, the correct mixing ratio of stone to soil will be 5:1. An incorrect mixing ratio of 4:1 will lead to a filling level of 125%, which means that the soil will be compacted in the voids and the stones will not be touching each other. At a mixing ratio of 6:1, only 80% of the voids would be filled but, considering root growth, this seems to be sufficient and better than overfilling the voids and compacting the soil (Kristoffersen 1998).

(2) ***Water mixing during installation.*** Layers of stones are installed and compacted. Then a layer of screened soil (e.g., sandy loam) is spread on top of the stones and watered into the voids. The stone layer can be up to 25 cm (10 in.) thick when stones of 80 to 150 mm (3 to 6 in.) in diameter are used. When using smaller stones and broken stones, the recommended thickness is 10 to 15 cm (4 to 6 in.).

(3) ***Dry mixing during installation.*** Another method of mixing during installation is installing stones in layers of 15 to 25 cm (6 to 10 in.) and

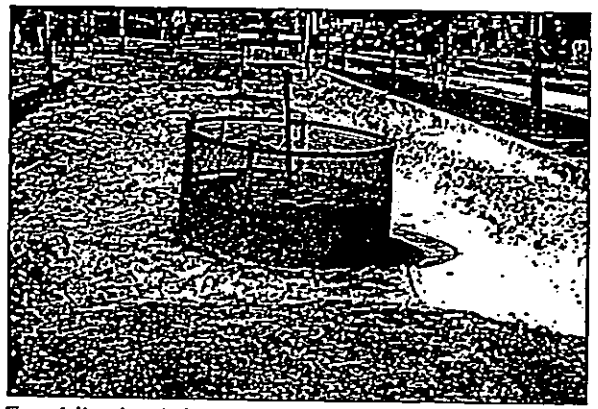

Figure 1. Use of sand mix at The Christians Havns Square, Copenhagen. The material is used in a 3-m wide, 57-m long pit, in which 7 linden trees (*Tilia tomentosa*) were planted. The soil in the planting pits is separated from the sand mix by a wire basket during the installation process.

subsequently filling the voids with dry soil by sweeping and vibration. Both the stones and the soil must be completely dry, and installation must be carried out in dry weather. The dry-mixing method has been used only with stones of 80 to 150 mm (3 to 6 in.) in diameter and is not suitable for use with smaller stones. This method can cause difficulties because most construction work is carried out when rainy weather can occur.

Sand mix. The Dutch experience has shown that uniform graded sand can be used to expand the rooting volume beneath pavements. The sand is mixed with up to 4% or 5% of humus in the form of compost or sphagnum. In Denmark, the sand mix has been used and installed as described by Couenberg (1994) (Figure 1). The intention of using sand mix is to achieve a compaction level of 70% to 80% proctor density (Couenberg 1994). Therefore, penetration resistance is measured to ensure that the degree of compaction does not exceed the critical limit for root growth. This quality check is not practiced in Denmark.

Technical Construction of Planting Site

When topsoil and other materials containing humus are installed under pavements, there is a risk that the obstruction of aeration could cause anaerobic conditions. This risk is increased by insufficiencies in drainage (e.g., if the soil is compacted) (Harris 1992). Sufficient air movement in the soil or sand mix is achieved by installing a layer of stones or broken stones between the root growth area and the pavement above. The aeration layer receives air via pipes or the planting pit (Urban 1989) and should be covered with a suitable geotextile to prevent filling from the layers above (Figure 2). The same type of aeration layer is recommended when raising the grade around existing trees (Harris 1992). Although the effect of an aeration layer has not been documented in the Danish examples, it is considered to have a beneficial effect on the soil and the root growth (Smith 1995). The aeration layer may also be used to irrigate the trees (Urban 1989).

Applications in Denmark

More than 800 trees have been successfully planted since 1991 on more than 30 construction sites in Denmark using these alternative materials and methods.

Table 2 shows that stones or broken stones, in various size classes, are the most commonly used materials for load-bearing matrixes and are used with more than 75% of planted trees. Premixing before installation is the most frequently used installation method. Dry mixing during installation is only occasionally used. Each installation method has advantages and disadvantages (Table 3).

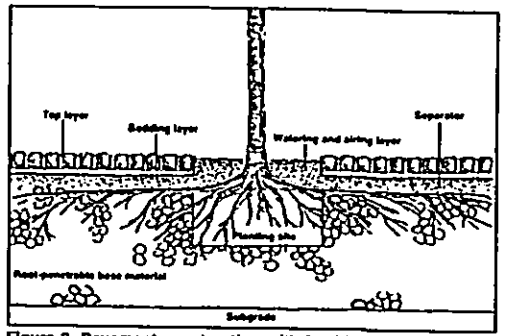

Figure 2. Pavement construction with load-bearing matrix and aeration layer.

The major disadvantages of using the premix of stone and soil is that separation might occur during transportation and installation. A tackifier can help the soil adhere to the stones (Grabosky and Bassuk 1995). The calculation of mixing ratio is also problematic. In a stone and soil mix, a calculated void percentage (e.g., 25%) has often led to a recommended mixing ratio of 3:1. In one case, this ratio led to compaction of the soil in the voids, which caused subsequent settling. The correct mixing ratio should have been 4:1 to secure 25% voids in a stone and soil mix. Dry mixing has been the most effective and practical method. However, the dry mixing method requires dry weather, dry stones, and dry soil.

Measurements of soil densities are included in the original Dutch method, in which sand mix was used (Couenberg 1994). Although the degree of compaction is intended to be optimized for plant growth, there is a risk of subsequent soil compaction of soil and settling of the pavement.

Conclusion

During the last 5 years, soil mixes, sand mixes, and load-bearing stone have been introduced for use in Denmark. Most landscape projects involving trees in paved areas use these new methods. No difficulties with load-bearing capacities, irregularities, or frost-heaving of pavements have been recorded. Compared to normal Danish conditions, the winter of 1995–1996 was long and cold, with continuous frost from the start of November to the middle of March. A top layer of at least 0.5 m (20 in.) was frozen, which influenced all layers of load-bearing mixes installed below pavements. None of the methods applied appear to have higher susceptibility to frost heave than does traditional pavement construction.

To reduce the visual effects of possible irregularities caused by heaves and settlements, landscape architects often changed the pavement on the load-bearing matrix materials so that it differed from the rest of the pavement. As a result, the possible height differences are less conspicuous than would be the case with uniform pavements. In addition, the change in pavement shows where the tree has its roots.

Table 2. Examples of load-bearing matrixes used in Denmark.

	Stones	Lava	Bricks	Leca	Sand	Totals
Premixing	8 locations 256 trees	2 locations 3 trees	6 locations 46 trees	1 location 40 trees	8 locations 114 trees	25 locations 459 trees
Water mixing during installation	5 locations 181 trees	2 locations 12 trees	1 location 3 trees	— —	— —	8 locations 196 trees
Dry mixing during installation	4 locations 141 trees	1 location 22 trees	— —	— —	— —	5 locations 163 trees
Totals	17 locations 578 trees	5 locations 37 trees	7 locations 49 trees	1 location 40 trees	8 locations 114 trees	38 locations 818 trees

Table 3. Comparison of advantages and disadvantages of installation methods.

Mixing method	Advantages	Disadvantages
Premixing	Can be done by machine Risk of soil compaction in voids Can require special mixing equipment	Separation during transportation and installation
Water mixing during installation	Contact between stones is ensured Independent of weather Prevents soil compaction	Can require large volumes of water Most suitable at large aggregate sizes
Dry mixing during installation	Contact between stones is ensured Prevents soil compaction	Dry weather required Requires dry soil
Sand mix	Rational mixing with right equipment Inexpensive ingredients Easy to install	Risk of soil compaction to a degree that impedes root growth The compaction level must be controlled Poor load-bearing capacity

All examples presented in this article were established between 1991 and 1996. None of these trees have been measured for growth rates. Fast and accurate results were obtained by conducting growth experiments with 8 materials and 3 tree species beginning in spring 1994. These results illustrate the growth capacities of the different materials (Kristoffersen 1998).

Acknowledgements. The author wishes to thank the municipalities involved in the planning and the construction of the cases studied. Thanks are also due to Dr. Thomas B. Randrup for valuable discussions in connection with this paper.

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Résumé. Au Danemark, les conditions pauvres de croissance pour les arbres en milieu urbain ont été perçues comme un problème depuis les années '80. Les dimensions restreintes des fosses de plantation sont principalement responsables de ce problème. Une recherche effectuée en 1996 a mis en lumière le fait que les fosses moyennes de plantation en milieu municipal sont passées de 0,1 m ≥ à la fin des années '60 à 3,4 m ≥ en 1996. Pour augmenter le volume de la fosse, plusieurs matériaux ont été introduits en mélange avec le sol afin de permettre aux racines de s'étendre sous le pavage. Trois méthodes sont possibles pour introduire le matériel sous la surface pavée. Au cours des cinq dernières années, plus de 800 arbres ont été plantés dans plus de 30 sites avec ces matériaux et ces méthodes d'insertion. Chacune de ces méthodes a ses avantages et ses inconvénients. Aucun problème sérieux imputable à la capacité de support des matériaux ou au soulèvement par le gel n'a été rapporté.

Zusammenfassung. In Dänemark wird seit den 80ger Jahren das Problem der armseligen Wachstumsbedingungen der Stadtbäume erkannt. 1996 fand eine Studie heraus, das die durchschnittliche Größe die kommunalen Baumscheiben vom 0,1 m² in den späten 60ger bis zu 3,4 m² angestiegen ist. Um das Volumen der Pflanzgruben zu vergrößern, wurden verschiedene Materialien eingeführt, um im Mix mit dem Boden Wurzelwachstum zu ermöglichen. Es sind drei Methoden zur Einbringung von Materialien unter der Bepflasterung durchzusetzen. Während der letzten 5 Jahre wurden mehr als 800 Bäume an mehr als 40 Standorten gepflanzt, die diese Nachteile. Es wurden keine größen Schwierigkeiten wegen der Ladekapazität oder Frostverwerfungen gemeldet.

Watson & Himelick ISA 1997

each other and the soil from sun and winds. Below ground, roots can spread over a larger area. Though not much additional soil is available for each tree, the larger shared root space provides a more consistent environment for the roots. Soil temperature, moisture, and other factors will be less affected by the container walls.

Soil specifications

When soil volume is restricted, soil quality becomes very important. Too often, trees are planted in whatever soil is present when the pits are created. Whether it is new construction or openings cut in existing pavements, the soil is often of very poor quality and should be replaced. Soils for planting pits and planters should contain (measured by weight) less than 27 percent clay, at least 50 percent medium (1 mm) sand, and 5 percent organic matter (20-35 percent organic matter by volume) (Patrick Kelsey and Phillip Craul, personal communications).

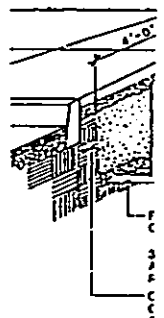
Planting pit design

Traditional planting pits have been openings in the pavement as small as 2 ft (60 cm) square, covered with an open grate. In recent years, the need for larger root spaces has begun to be recognized and better designs have been adopted. A larger pit with a larger grate is a simple way to enlarge the root space, but not always the most effective. Trees need an area of soil that is two ft (60 cm) deep within the dripline of the expected mature size of the tree, or the equivalent in a slightly different shape (50,52).

Many designs provide additional root space underneath the pavement. Planting pits can often be large enough to become shared root spaces, especially for linear plantings along streets. Vaulted systems suspend the pavement above the soil in order to provide an aeration pathway to the soil surface as well as to reduce or prevent compaction of the soil. Drainage and irrigation systems are usually installed as well (Figure 3-9).

Soils designed to support pavement without settling are often called load-bearing soils. To expand planting pits under pavements, the soil must also provide a favorable environment for root growth while supporting the pavement. The first soil of this type was developed in Amsterdam, Netherlands. Amsterdam Tree Soil specifications call for 91-94 percent medium coarse sand, 4-5 percent organic matter, and 2-4 percent clay (by weight). Phosphorous and potassium are added as necessary. The organic matter provides a source of nitrogen (39). The soil mix is carefully compacted to a specific density when installed, and aeration is provided through spaces in the pavers placed over the soil (Figure 3-10). This system has been shown to be effective in providing vigorous trees and stable pavements for many years.

More recently, other load bearing soils have been tested. Usually, large stones are used to create a network of interconnected spaces that can be filled with soil for root growth (43). Testing is still in the early stages in the United States, and engineers must be satisfied with the system before it will be used widely. Similar systems have been used successfully in European countries for several years.



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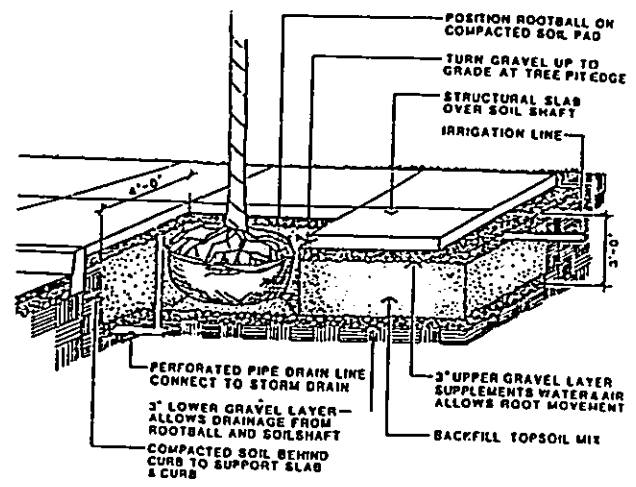


FIGURE 3-9. Vault systems can provide high quality root space underneath pavements. (Drawing courtesy of J. Urban)

Root barriers

When pavements are laid on a compacted soil base, roots often grow between the pavement and the compacted soil. Roots enlarge and can eventually lift the pavement. Barriers are sometimes installed to force roots to grow deeper. Barriers have been constructed from plastic, metal screening, and geotextile impregnated with herbicide. Most are effective at blocking roots between the surface and the bottom of the barrier. When roots grow under the barrier, they often grow back toward the surface, especially in poorly drained soils (42,62). In well-drained and well-aerated soils, the roots may not return to the surface so quickly, or at all (33,34).

Barriers reduce overall root development of trees (33,42,63). On sites with very poor aeration, the roots may not be able to grow deep enough to go under the barrier. The limited root system on one or more sides could result in poor vigor or instability.

When pavements were laid on a 12 in (30 cm) base of coarse brick rubble or gravel, roots did not grow directly under the pavement (51). The rubble was apparently not a suitable environment for root growth without soil in the spaces in between, and the roots grew in the deeper soil underneath the rubble.

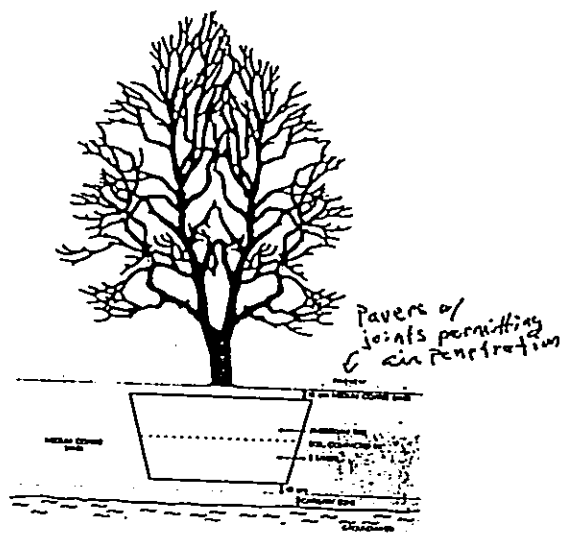
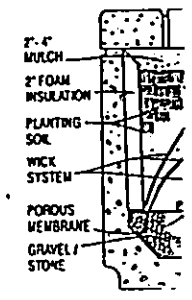


FIGURE 3-10. Underground tree pit design in Amsterdam. The medium coarse sand surrounding the Amsterdam Tree Soil is compacted to >90% Proctor Density. Note that the tree pit is extended underneath the pavement. (Drawing courtesy of E. Couenberg)

Aboveground planter design

In downtown areas, sidewalks and courtyards may be built over basements, underground parking, or subway systems. In situations like these, trees must be planted in aboveground planters. The decision to plant a tree in a planter must include a permanent commitment for intensive maintenance. The limited amount of moisture held in the extremely small soil volume can be depleted very quickly. Frequent, but monitored, irrigation is required. If the drainage system becomes clogged, excess water will cause damage to roots. Extremes in temperature, especially extremely low temperatures in winter, can cause extensive root injury leading to the death of the plant. The use of larger planters helps to reduce these problems

Planting success depends on good root growth. Good root growth depends on a good quality environment. Without adequate site preparation, the plant will not grow vigorously on the new site and reach its full potential in the landscape.



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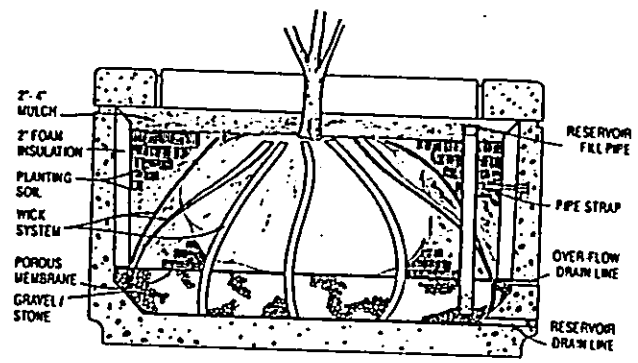

FIGURE 3-11. Planters designed for the City of Milwaukee provide a water reservoir and wicking system to lengthen the irrigation cycle, drainage to prevent waterlogging, and insulation to minimize temperature extremes. (Drawing courtesy of Wausau Tile, Inc.)

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Designing the Right Place for the Right Tree

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The concept of plant the right tree in the right place is well known to tree care professionals. Planting the right tree in the right place ensures that the tree will not outgrow its site and interfere with surrounding utilities or structures and its aesthetic and functional assets perfectly complement the site. Most urban sites do not provide the physical characteristics required to grow desirable species or to allow the tree to reach its desired size and life span.

Cincinnati's Year 2000 Master Plan includes a Central Business District (CBD) street tree plan which establishes a guide for tree planting decisions. By designing development projects to accommodate the right tree, a team of urban foresters, design and construction engineers, and architects can create a streetscape which is low maintenance and conducive to tree growth.

However, good design and construction practices do not eliminate the need for maintenance. Hardware such as grates, guards, and holiday tree lights require proper installation and periodic maintenance—often a confusing, difficult, and expensive procedure.

Introduction

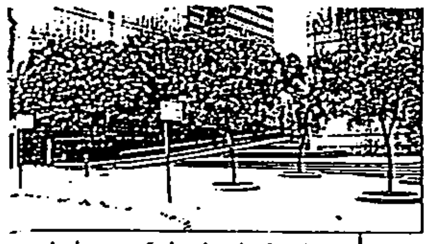
Created in 1986, the Cincinnati Year 2000 Plan was recognized as the blueprint for all street tree planting in the CBD. The plan provided a conceptual base for planting that identified large sections of the CBD based on use and only assigned general characteristics for the trees to be planted. While written with good intention, the plan resulted in disparate clusters of homogeneous tree populations rather than beautiful tree lined streets. The problem was compounded by a streetscape design which specified 4 feet by 4 feet tree wells (tree coffins) covered by a tree grate. The design did not allow for adequate root space and it limited planting options.

The plan was revised in 1993 with the direction to establish a guide for planting decisions. Plan objectives included increasing species diversity, reinforcing major travel corridors, selecting functionally appropriate species, and [illegible]. The research applied specific tree selections to street segments within the CBD. As did the original plan, the revision considered the [illegible] historic districts and the [illegible] between residential, commercial, and office districts. For example, honeylocust *Gleditsia triacanthos* and [illegible] are used in [illegible] districts where [illegible] and [illegible] are [illegible]. Large broadleaf shade trees such as [illegible] are used in residential districts to provide shade and [illegible].

[illegible] the entire [illegible] species were chosen primarily for aesthetic and functional properties plus [illegible] tolerance to [illegible] de-icing [illegible].

A 1993 survey of North American cities indicated that a street tree planted in a downtown area has an average life span of 13 years as compared to 37 years for residential sites (1). The primary reason for poor tree performance in downtown environments is a lack of growing space for root systems. Most researchers agree that in natural settings, tree root systems often spread two to four times the width of the canopy. The standard 4 foot by 4 foot tree well design formerly used in Cincinnati provided only 48 cubic feet of root space; research conducted by Urban and Associates (2) indicates that a 20 foot by 20 foot (1,200 cubic feet) area is necessary to sustain a 25-foot diameter tree. Because Cincinnati's CBD is cramped, trees must compete with sidewalks, parking meters, doorways, and utilities for limited right-of-way space. Large tree wells were almost an impossibility.

To beautify the CBD with large, healthy shade trees, the Park Board's foresters worked closely with City architects and engineers to design adequate space for tree roots in streetscape projects. The design process created five opportunities for expanded root growth areas.



Sophora trees *Sophora japonica*. Trees in background have shared root systems in adequate root space. Trees in foreground are in 5 foot planters. All trees were planted at the same time and receive the same maintenance.

few seasons. In 1995 Cincinnati inventoried all 1,588 tree grates in the City. Of 1,588 grates, 1,282 (80 percent) needed to be replaced or repaired. The City Solicitor's Office determined that because tree grates are part of the walkable sidewalk surface, their maintenance is covered by the City Code governing and funding the sidewalk program in the Public Works Department. The cost of the work was $160,000. There is currently an agreement between Public Works and The Park Board that the street tree program will pay 50 percent of future repair costs.

Tree grates are often necessary to maintain walkable sidewalk surface. In areas with ample sidewalk surface, they should never be used unless maintenance money is set aside in advance and an agency is authorized to maintain them. Tree grate size and type should be standardized to ease replacement of broken units. When new grates are installed, the joint between the two sections should always be parallel to the curb so that if a vehicle leaves the road and runs over the grate, only one half will be broken.

Tree guards have been used in the United States since the late 1890s. In 1903 William F. Fox, Superintendent of the State Forests for the State of New York strongly recommended using tree trunk guards. Fox stated that "the necessity for some such protection is readily apparent on examining trees from the curbstone side, an observing the large number on which the bark has been gnawed by horses" (4). While Mr. Fox's observations were relevant in 190[illegible], today most municipalities have relatively few equine problems. Cincinnati no longer uses tree guards. They are expensive to install, difficult and expensive to maintain, and girdle and kill trees if not removed. If they are used, they should be endowed with a maintenance fund to pay for their removal after a few growing seasons.

Tree lights such as holiday lights are often installed by the abutting property owner. If improperly installed, these lights can injure

Tree grates require constant maintenance. The aperture in this grate is enlarged to accommodate an ever growing tree. Tree grates are inventoried and inspected every five years.

or kill a tree by girdling. The lights can turn a simple pruning job into a tangled mass of frustration for arborists (but not for chippers!)

In Cincinnati, holiday lights must be attached to the tree with screw eyes. Screw eyes are screwed into the trunk at intervals of 4 feet. The electrical wire is then attached to the screws with bands or twist ties. When the wire is above branching height, it is draped throughout the tree.

This attachment method is based on National Arborist Association standards for cabling a tree. Horticulturally, the damage to the tree trunk is minor and the tree can generally compartmentalize the damage. This method is superior to using tape or wire for attachment. Such fasteners can girdle the tree when not removed.

Result

Large shade trees along crowded inner-city streets do not just happen. Opportunities for large trees exist but must be designed and integrated into the surrounding infrastructure. By determining the right tree for a given street, the right planting place can be created. The growth requirements of the right tree must drive the surrounding infrastructure improvements. This concept is accepted in Cincinnati, and all of the methods outlined in this article are used to create viable streetscapes. The overriding factors in determining which method(s) to use are existing infrastructure and costs.

Of the five methods, the parking lot beautification program is the least expensive, most cost effective, and most dramatic. While the parking lot owner may lose a few parking spaces and associated revenue, the trees gain thousands of cubic feet of root area and parking lot users and pedestrians gain beauty and relief from the hot summer sun. Typically the cost to reconfigure and landscape an average lot is less than $10,000.

The cost to create a 4 foot by 4 foot (48 cubic feet) tree well with a tree grate and frame is $1,740 (not including tree costs). An expanded growth vault measuring 6 feet by 12 feet (288 cubic feet) with nearly six times the amount of root space is $2,270, a difference of only $530. If the expanded growth area can be incorporated into an existing basement encroachment, the cost is only $1,800, or $60 more than a standard tree well. It is difficult to determine the cost of the large shared root vaults because they are part of the total infrastructure of the site. It is believed that the shared growth planters provide the best growth opportunity because they allow trees to share root area and root systems.

The structural soil mix is the most useful and the least expensive of the expanded growth area techniques. The mix is easily adaptable to most locations, easy to install, and inexpensive. The mix of local materials tested by City consultants costs only $30 per cubic yard. In many situations, the structural soil mix is less expensive than structural fills used in the past.

Large, healthy trees are important in our cities. Do not settle for "the right tree in the right place." Determine the perfect tree, then design the right place.

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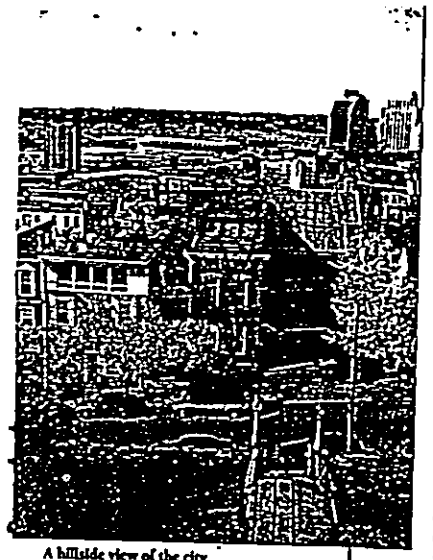


A hillside view of the city.

1. Individual vaults beneath the sidewalk, covered by a structural slab.
2. Shared root space vaults, covered by a structural slab.
3. Basement vaults.
4. Sidewalks built on structural soil.
5. Parking lot beautification.

Vaults in New Streetscapes

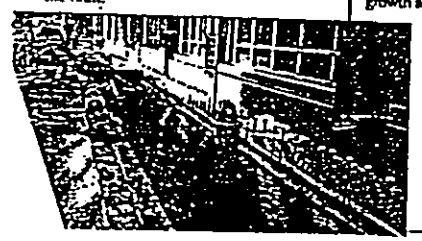
The City of Cincinnati builds tree vaults when new buildings and their corresponding streetscapes are constructed. The vaults have poured concrete or concrete block walls which support a reinforced concrete structural slab. The reinforced concrete slabs are designed to be strong enough to support a fully loaded fire truck. The vault provides adequate root space when filled with planting soil. The Park Board uses a special mix comprised of 60 percent sand, 25 percent topsoil, and 15 percent organic material such as composted leaves.

The size of the vault is determined by the root area required by the tree at maturity as calculated by Urban and Associates (2). Individual vaults, built for one tree, are constructed when trees are spaced more than 40 feet apart or when existing utilities cannot be relocated to accommodate larger vaults. Shared root space vaults, built for more than one tree, are constructed when new buildings and subsequent right-of-way development require extensive excavation and relocation of existing utilities. Shared root space vaults are typically one third to one half of a block long and accommodate four to six trees. These vaults are constructed as part of the utility infrastructure with fire hydrants, pole foundations, and water lines built into the poured concrete vault walls. Capped feeder tubes are inserted through the structural slab to allow for watering and fertilization away from the tree grate.

Shared root system vault. Utilities such as water lines and fire hydrants are built into the vault.

Basement Vaults

Opportunities exist for expanded growth areas in existing streetscapes or areas under renovation. In Cincinnati, many old buildings have basements which extend below the sidewalk and encroach into the public right-of-way. This was a common practice before elevators were invented. It created useable space without adding additional floors with additional steps to climb. Typically these encroachments were used for coal bins and storage. The City eliminates basement encroachments due to safety and liability issues. By walling off the basement at the property line and filling the walled off portion in the right-of-way with a combination of low density fill and a vault filled with soil, an expanded growth area can be created at a nominal cost.



Structural Soil

A structural soil mix is used to create root growth area when there is no opportunity for vaults. This structural planting soil is a 2.7 to 1 by volume ratio mix of stone aggregate to a soil/organic filler. The stone aggregate is capable of supporting a sidewalk while the pores between the aggregate contain the organic filler. Research (3) indicates that the structural mix, even when compacted, retains properties necessary for root growth. This method requires very little disturbance of the surrounding streetscape. The area is excavated to a depth of 30 inches, the soil mix installed and compacted, and new sidewalk poured, leaving a grate covered hole for the tree.

Parking Lot Beautification

Cincinnati's Economic Development Department has an aggressive parking lot beautification/screening program. Under this program, parking lots are re-striped and configured to allow enough space to construct a 10 to 12 foot wide planting bed located just behind the sidewalk off of the public right-of-way. Asphalt and underlying aggregate base are removed, and planting mix is installed. Often the mix is formed into a berm 1 to 3 feet high to provide additional screening of the lot. The CBD Street Tree Plan is used to determine the tree species to be planted so that the parking lot trees match the street trees. The lot owner then assumes responsibility for maintenance.

Creating Problems to Guard Against

Good streetscape design can minimize maintenance. However, maintenance is an essential part of any successful streetscape. The most commonly ignored maintenance items are tree grates and guards. Tree grates have been popular streetscape amenities for decades because they are attractive and increase the amount of walkable sidewalk surface. They are erroneously perceived as low maintenance because they supplant the need for mulch and, when backfilled with gravel, suppress weed growth.

Tree grates are labor intensive and expensive to maintain. They must be periodically reset or replaced when offset or broken. Depending on the size of the center opening, fast growing trees can be girdled after just a

New Video on Structural Soil Available

"Support Your Local Tree - Cornell Structural Soil Mix"

Cost - $20.00

Available from:

Nina Bassuk
20 Plant Science Building
Urban Horticulture Institute
Cornell University
Ithaca, NY 14853
(607) 255-4586
nlb2@cornell.edu

Checks payable to Cornell University

Thank you.

STRUCTURAL SOIL MATERIAL FOR STREET TREE PLANTINGS

PART 1: GENERAL

The object of this document is to initiate discussions between urban foresters, engineers and architects for future project consideration. This material is experimental. It has only been tested on two stone sources and one soil at the time of this writing. There is no data available on long term rooting of trees in compacted profiles of these materials. The longest plant experiment to date lasted two growing seasons. While the material is initially of high bearing strength, there is no data, nor has there been any type of study which can predict the impacts of encouraging tree root proliferation below the pavement structure wearing surface. As experience and further testing of materials continues, a more comprehensive mixing protocol may be developed. Experiments and extensive study of root systems in paved settings will be necessary before any pavement design changes can be recommended to account for the presence of expanding tree roots below paved structures. Organic matter levels in the system have not been tested in any form to date. Mixing technique, placement and compaction are also under study for usage and testing guidelines.

1.01 DESCRIPTION: The work of this section consists of preparing and placing and compacting Structural soil materials on a prepared subgrade.

1.02 SUBMITTALS:

A: Submit soil and stone test analysis reports for the topsoil and the aggregate to be used from an approved soil testing laboratory.

1. The testing laboratories shall have a minimum of 5 years experience with the test protocols of the United States Golf Association - Green Section and the American Association of State Highway and Transportation Officials (AASHTO).

2. Provide a physical analysis of the soil to include the following:

a. Particle size distribution
b. pH
c. Dry bulk density of soil as it is delivered to the mixing plant
d. Specific gravity
e. Percent organic content by weight
f. Nutrient levels including nitrogen, phosphorus, and potassium.

Fine sand	5 - 10%
Very fine sand	10 - 30%
Silt	20 - 40%
Clay	25 - 40%

C. Provide a minimum of three particle size analysis tests from samples obtained randomly throughout the source stock pile of field.

D. The pH value shall be between 6.0 and 7.0.

E. Nutrient levels in pounds per acre:
Nitrogen (standard soil spec levels)
Phosphorus (Bray P1) "
Potassium "

F. Maximum soluble salts "

2.02 STONE

A. Stone meeting the local DOT size designation equivalent to AASHTO size #4 \ ASTM size #4. Preferably a crushed stone.

1. Stone shall be clean and be certified to meet local DOT aggregate soundness requirements for use in road construction.

2. Stone of high angularity will be preferred over washed gravel.

3. Stone dimension aspect ratio should approach 1:1:1 with a maximum of 2:1:1 average length:width:depth.

4. Particle size distribution shall meet the local DOT size designation equivalent to AASHTO size #4 \ ASTM size #4. A single sized stone near one inch will be preferred to a wider size distribution or smaller single sized stone fitting the general size description.

5. Submit at least three, five pound samples of different aggregate sources and the physical analysis from section 1.02-A-3 for review and selection.

2.03 HYDROGEL:

A. Gelscape© as manufactured by Amereq Corp., Congers, NY 10920 or approved equal.

2. Place the stone into the mixing hopper and set into motion.

3. Add the water-hydrogel slurry and allow to uniformly wet the stone.

4. Add the soil and mix (experience and testing will establish some initial guidelines).

5. Deposit the material.

6. Do not over-mix. If the clay begins to pelletize and separate from the stone, discard the batch.

- Remote mixing and storage in a dryer state and hydration after placement is under consideration.
- Pugging technology is also under consideration for large applications. This system would account for soil moisture while mixing and can mix by a pre-programmed metered weight ratio.

PART 3: EXECUTION

3.01 MIX DESIGN

A. Prepare sample structural mixes for testing and approval.

1. Test the topsoil and stone. Submit the test results and the samples, with their respective analyses for approval. Based on the samples and the analysis, the Contracting Officer and the contractor will jointly determine up to three different mix ratios for each Structural Soil Material to be tested for conformance with the requirements of the specifications

2. The contractor shall prepare the samples of the proposed mix ratio options and obtain test results Submit the samples of the mixes with the testing results.

3. Develop a standard moisture-density curve per AASHTO T 99 for each proposed mix.

4. If desired, conduct permeability and California bearing ratio (CBR) tests on compacted samples when compacted to peak density. Soaked CBR should be a minimum of 40 at peak standard density. Permeability expectations have not been developed at time of

yards of material produced. The sample stone-soil ratio will be checked by splitting a known weight of material on a #4 sieve. The percentage of soil should not be greater than 2% from the target ratio. The mean stone-soil ratio for the stock pile will be calculated and included.

NOTE: This takes time, and can be run quickly on low organic mixes by pan frying the mix, weighing, washing off the soil over the sieve, pan frying the stone and calculating soil percentage. "Speedy moisture" kits or microwaves could also be used for slightly longer drying times on organic materials, or oven methods which can take up to two days.

E. In the event that the average stone-soil ratio varies significantly from the approved sample, as determined by the Contracting Officer, make adjustments to the mixing ratios and procedures. Re-mix and re-test any lot of soil that fails to meet the correct analysis after the adjustment has been made.

F. After completion of the mixing and prior to the installation, protect the Structural Soil Material stockpile from rain and mix separation through erosion.

1. Cover the stockpile at all times with tarps or store in a covered structure.

3.03 UNDERGROUND UTILITIES AND SUBSURFACE CONDITIONS:

A. Notify the Contracting Officer of any subsurface conditions which will effect the contractor's ability to complete the work.

B. Locate and confirm the location of all underground utilities prior to the start of any excavation.

C. Repair any underground utilities or foundations damaged by the contractor during the progress of this work. The cost of all repair shall be at the contractor's expense.

3.04 SITE PREPARATION:

A. Excavate to the proposed subgrade to depths as shown on drawings.

B. Confirm that the subgrade is at the proper elevation and compacted as required. Subgrade elevations shall slope parallel to the finished grade and\or toward the subsurface drain lines as shown on the drawings.

URBAN HORTICULTURE INSTITUTE
Cornell University

October 1995

PROGRESS ON THE DEVELOPMENT OF AN URBAN TREE SOIL SPECIFICATION

Jason Grabosky and Nina Bassuk

The objective of this material is to provide a load-bearing pavement base material which will also provide a rooting medium for street trees. The stone-soil mix described below produces an extremely gap-graded material which provides rapid drainage and air movement. The strength of the material is fundamentally that of the stone when the mix is not produced with excessive soil. Defining the point where soil could be considered excessive has not been thoroughly defined for all stone and soil types, but one tested system is described as an example.

The original premise was to form a rigid stone matrix to meet loading requirements for a maintained light traffic pavement (sidewalks and possibly parking areas). Between the stones would be continuous voids which roots could grow through. A soil would be introduced to fill only a portion of those voids. A tackifier was used to "glue" the soil to the stone to prevent aggregate separation during the mixing, placement and compaction of the material.

The material is intended to be used as a pavement base which will also be expected to sustain street trees and their water use demands. For this reason, it is desired to have a deep base profile of 24 to 36 inches. The additional cost is in excavation, but in some construction and infrastructure repair projects, this cost may already be accounted for.

The Materials

The stone tested to date has conformed to NYSDOT §703-02 sizing specifications for a size #2 stone. This corresponds roughly to a material which passes a one inch sieve and is retained on the one-half inch sieve. The preferred aggregate would be a crushed stone (such as NYSDOT §703-0201) which meets local DOT aggregate stability requirements for pavement base materials. More angular aggregates are preferred. The length to width ratio (flakiness index) of the preferred aggregate has not yet been established. A non-limestone based aggregate would likely expand the street tree species selection opportunities since the pH of the final mix would be lower than a limestone-based mixture.

The only hydrogel tested in this system to date is Gelscape® from Amereq Corporation 50 North Harrison Ave. Congers, NY 10920.

The only soil tested to date has been a clay loam (USDA textural triangle classification for a soil with 35% clay, 40% silt, and 25% sand by weight). Soils with high percentages of sand are discouraged to ensure a gap-graded material. A relatively high clay content has been desired in the preliminary studies to maximize the nutrient holding ability of the limited soil reserves in the mix. Based on the research completed to date, any specification would call for a clay loam.

A possible mixing ratio could then be:

Stone:	100	
Soil:	20	UNITS OF WEIGHT
Hydrogel	0.03	
Total Moisture	10	

Installation notes

Two large scale installations have been completed in Ithaca, NY. From these two experiences several observations were made.

- The material can be over-mixed causing the soil to pelletize in the mixing hopper.
- The material can be mixed in seven cubic yard batches in a concrete truck.
- Batching the material is preferable if a staging area is present
- Drainage is essential if excess water is entering the site (such as washing out of trucks and tools as concrete is installed).
- The material should be compacted as any other pavement base material and subjected to the same quality control measures on site.
- The stone to soil dry weight ratio fluctuates as much as 15% within one mixing load. Placement of the material evened this out, but the soil component was observed to fluctuate by 20% within one project of 400+ cubic yards. Minimal quality controls could substantially decrease this variation.
- As a factor of safety, the specified ratio should not be set at the point of failure, but at a point where the variation of the mixing process will not cause potential problems.

Final note

We have produced this "pre-specification" with the idea in mind that discussion between engineers, contractors, landscape architects, and city foresters can begin. As we continue to test these materials, we anticipate a working specification within 18 months.

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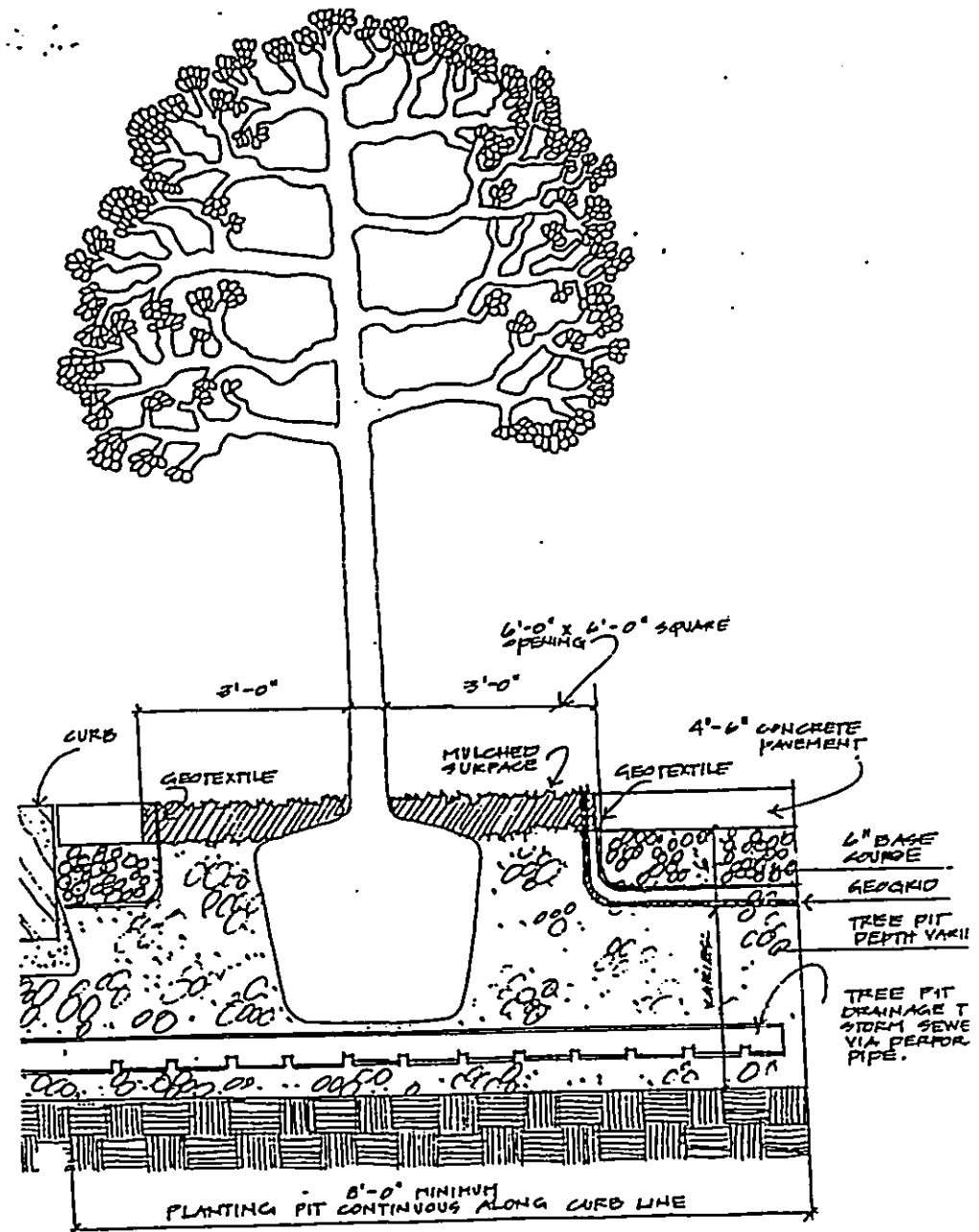


Figure 2: Elevation plan of a proposed structural soil pavement profile using the sub-base as the rooting zone.

SECTION 755

STRUCTURAL SOIL

1.01 GENERAL

The work of this Section consists of all Structural Soil work and related items as indicated on the Drawings or as specified herein and includes, but is not limited to, the following:

A. Structural Soil.

1.02. RELATED WORK SPECIFIED ELSEWHERE

A. The following items of Work are specified and included in other Sections of the specifications:

1. Unclassified Excavation
2. Grading
3. Site Pavements and Curbs
4. Site Improvements
5. Landscape Irrigation
6. Topsoil and Planting Mix
7. Seeding
8. Planting
9. Culvert, Storm Drains and Sewer Pipes

1.03 REFERENCES AND STANDARDS

A. The following references are used herein and shall mean:
1. ASTM: American Society of Testing Materials.
2. USDA: United States Department of Agriculture.
3 AASHTO: American Association of State Highway and Transportation Officials.
4. Standard Specifications: *Regional or Municipal Standard Specifications Documentation for the location of proposed usage*
5. AOAC: Association of Official Agricultural Chemists

compliance with ASTM D422 after destruction of organic matter by hydrogen peroxide.

3. Submit a chemical analysis, performed in accordance with current AOAC Standards, including the following:

a. pH and Buffer pH.
b. Percent organic matter as determined by the loss of ignition of oven dried samples. Test samples shall be oven dried to a constant weight at a temperature of 230 degrees F, plus or minus 9 degrees.
c. Analysis for nutrient levels by parts per million including nitrate nitrogen, ammonium nitrogen, phosphorus, potassium, magnesium, manganese, iron, zinc, calcium and extractable aluminum. Nutrient test shall include the testing laboratory recommendations for supplemental additions to the soil as calculated by the amount of material to be added per volume of soil for the type of plants to be grown in the soil.
d. Analysis for levels of toxic elements and compounds including arsenic, boron, cadmium, chromium, copper, lead mercury, molybdenum, nickel, zinc and PCB. Test results shall be cited in milligrams per kilogram.
d. Soluble salt by electrical conductivity of a 1:2 soil/water sample measured in Millimho per cm.
e. Cation Exchange Capacity (CEC).
f. Carbon/Nitrogen Ratio.

4. Submit 5 point minimum moisture density curve AASHTO T 99 test results for each Structural Soil sample without removing oversized aggregate.

5. Submit California Bearing Ratio test results for each Structural Soil sample indicating a soaked CBR minimum of 50 at peak standard density.

6. Submit Clay Loam-Crushed Stone ratio by splitting a known weight of oven dried material on a #4 sieve for each Structural Soil sample.

7. The approved Structural Soil samples shall be the standard for each lot of 500 cubic yards of material.

8. All testing and analysis shall be at the expense of the Contractor.

D. Maintenance Instructions: Prior to the time of Final Acceptance of the Work, submit maintenance instructions for the use, removal and replacement of Structural Soil for the Department's use. The instructions shall be reviewed by the Engineer as a pre-condition for Final Acceptance of the Work.

E. Submit to the Engineer for review a proposed plan and vertical section layout of all Structural Soil.

F. Submit one cubic foot sample per each 500 cubic yards of required material and for each sample, the following analysis for all Crushed Stone. The soil testing laboratory shall be approved by the Engineer.

A. All areas to receive Structural Soil shall be inspected by the Contractor before starting work and all defects such as incorrect grading, compaction and inadequate drainage etc. shall be reported to the Engineer prior to beginning this work.

B. The Contractor shall be responsible for judging the full extent of work requirements involved, including but not limited to the potential need for temporary storage and staging of soils, including moving soil stock piles at the site to accommodate scheduling of other work and the need to protect installed soils from compaction, erosion and contamination.

1.07 QUALITY ASSURANCE

A. Qualifications of Landscape or Pavement Material Contractor: The work of this section shall be performed by a Landscape Contracting firm which has a minimum of 5 years experience successfully installing planting mix of a similar quality, schedule requirement and construction detailing to this project. Proof of this experience shall be submitted as per paragraph, SAMPLES AND SUBMITTALS, of this Section.

MATERIALS

2.01 CLAY LOAM

A. Clay Loam shall be a "clay loam" based on the "USDA classification system" as determined by mechanical analysis (ASTM D-422) and it shall be of uniform composition, without admixture of subsoil. It shall be free of stones greater than one-half inch, lumps, plants and their roots, debris and other extraneous matter over one inch in diameter or excess of smaller pieces of the same materials as determined by the Engineer. It shall not contain toxic substances harmful to plant growth. It shall be obtained from naturally well drained areas which have never been stripped or top soil before and have a history of satisfactory vegetative growth. Clay Loam shall contain not less than 2% nor more than 5% organic matter as determined by the loss on ignition of oven-dried samples. Test samples shall be oven-dried to a constant weight at a temperature of 230 degrees F., plus or minus 9 degrees.

B. Mechanical analysis for Clay Loam shall be as follows:

Textural Class	% of total weight
Gravel	less than 5%
Sand	25 - 30%
Silt	20 - 40%
Clay	25 - 40%

C. Chemical analysis: Meet or be amended to meet the following criteria.

1. pH between 5.5 to 6.5
2. Percent organic matter 2 -5% by dry weight.
3. Nutrient levels as required by the testing laboratory recommendations for the type of plants to be grown in the soil.
4. Toxic elements and compounds below the United States Environmental Protection Agency Standards for Exceptional Quality sludge or local standard; whichever is more stringent.

B. Acceptable aggregate dimensions will not exceed 2.5:1.0 for any two dimensions chosen.
C. *Statement of angularity or % rounded edges*
D. Results of the Aggregate soundness loss test will not exceed 18%.
E. Losses from L.A. Abrasion tests will not exceed 40%.

2.07 HYDROGEL

A Hydrogel shall be a potassium propenoate-propenamide copolymer Hydrogel as manufactured by Gelscape by Amereq Corporation.

2.08 WATER

A. The Contractor shall be responsible to furnish his own supply of water to the site at no extra cost. All work injured or damaged due to the lack of water, or the use of too much water, shall be the Contractor's responsibility to correct. Water shall be free from impurities injurious to vegetation.

2.09 STRUCTURAL SOIL

A. A uniformly blended mixture of Crushed Stone, Clay Loam and Hydrogel, mixed to the following proportion:

MATERIAL	UNIT OF WEIGHT
Crushed Stone	100 dry weight
Loam	As determined by the test of the mix (Approx. 18 +/-)
Hydrogel	0.03 dry weight
Total moisture	10 (AASHTO T-99 optimum

B. The initial mix design for testing shall be determined by adjusting the ratio between the Crushed Stone and the Clay loam such that the volume percent of Clay Loam in the mix is less than 80% and more than 60% of the percent of voids in the Crushed Stone as determined from the stone rodded unit weight (1.04 F 3) and the bulk density of the soil. Adjust final mix dry weight mixing proportion to decrease soil in mixture if CBR test results fail to meet acceptance (CBR>=50).

CONSTRUCTION METHODS

3.01 MIX DESIGN

A. Prepare sample Structural Soil mixes to determine the ratio of mix components. Submit for approval.

1. Submit samples and the test results of each mix component for approval. Based on samples and the analysis of the mix components, the Engineer and the Contractor will jointly determine a mix ratios to be tested for conformance with the requirements of the specifications. For Structural Soil quantities greater than 500 cubic yards, test the mix ratio for each Clay

e. Auger out to stocking pile or transport vehical (or into pit if using a portable pugging operation).

4. Add soil amendments to alter soil fertility including fertilizers and pH adjustment at the time of mixing at the rates recommended by the soil test.

a. soil pH shall be adjusted to fall within a rate of 5.5 and 6.5 two months after mixing if the material is stored. Unless mixing with a high pH stone. Once pavement is layed, no adjustment should be imposed.

b. Soil component Carbon / nitrogen ratio shall be adjusted to be less than 1:33 within two months after mixing.

B. The Contractor shall mix sufficient material in advance of the time needed at the job site to allow adequate time for final quality control testing as required by the progress of the work. Structural Soil shall be stored in piles of approximately 500 cubic yards and each pile shall be numbered for identification and quality control purposes. Storage piles shall be protected from rain and erosion by covering with plastic sheeting.

C. During the mixing process, the Contractor shall take two - one cubic foot quality control samples per 500 cubic yards of production from the final Structural Soil. The samples shall be taken from random locations in the numbered stockpiles as required by paragraph 1.04.B of this specification. Each sample shall be tested for particle size analysis and chemical analysis as described in Paragraph 1.04. C.2 and 3 above. Submit the results directly to the Engineer for review and approval.

D. The quality control sample Clay Loam-Crushed Stone ratio's shall be no greater or less than 2% of the approved test sample as determined by splitting a known weight of oven dried material on a #4 sieve. In the event that the quality control samples varies significantly from the approved Structural Soil sample, as determined by the Engineer, remix and retest any lot of soil that fails to meet the correct analysis making adjustments to the mixing ratios and procedures to achieve the approved consistency.

3.03 UNDERGROUND UTILITIES AND SUBSURFACE CONDITIONS

A. Notify the Engineer of any subsurface conditions which will effect the Contractor's ability to complete the work.

B. Locate and confirm the location of all underground utility lines and structures prior to the start of any excavation.

C. Repair any underground utilities or foundations damaged by the Contractor during the progress of this work. The cost of all repair shall be at the Contractor's expense.

3.04 SITE PREPARATION

A. Do not proceed with the installation of the Structural Soil material until all walls, curb footings and utility work in the area has been installed. For site elements dependent on Structural Soil for foundation support, postpone installation until immediately after the installation of Structural Soil.

C. Install first 6 inch lift of Structural Soil material without damage to Filter Fabric at bottom and sides of trenches.

3.06 INSTALLATION OF STRUCTURAL SOIL MATERIAL

A. Install Structural Soil in 6 inch lifts and compact each lift.

B. Compact all materials to not less than 95% of peak dry density from a standard AASHTO compaction curve (AASHTO T 99). No compaction shall occur when moisture content exceeds maximum as listed herein. Delay compaction 24 hours if moisture content exceeds maximum allowable and protect Structural Soil during delays in compaction with plastic or plywood as directed by the Engineer.

C. Bring Structural Soils to finished grades as shown on the Drawings. Immediately protect the Structural Soil material from contamination by toxic materials, trash, debris, water containing cement, clay, silt or materials that will alter the particle size distribution of the mix with plastic or plywood as directed by the Engineer.

D. The Engineer may periodically check the material being delivered and installed at the site for color and texture consistency with the approved sample provided by the Contractor as part of the submittal for Structural Soil. In the event that the installed material varies significantly from the approved sample, the Engineer may request that the Contractor test the installed Structural Soil. Any soil which varies significantly from the approved testing results, as determined by the Engineer, shall be removed and new Structural Soil installed that meets these specifications.

3.07 FINE GRADING

A. After the initial placement and rough grading of the Structural Soil but prior to the start of fine grading, the Contractor shall request review of the rough grading by the Engineer. The Contractor shall set sufficient grade stakes for checking the finished grades.

B. Adjust the finish grades to meet field conditions as directed.

1. Provide smooth transitions between slopes of different gradients and direction..

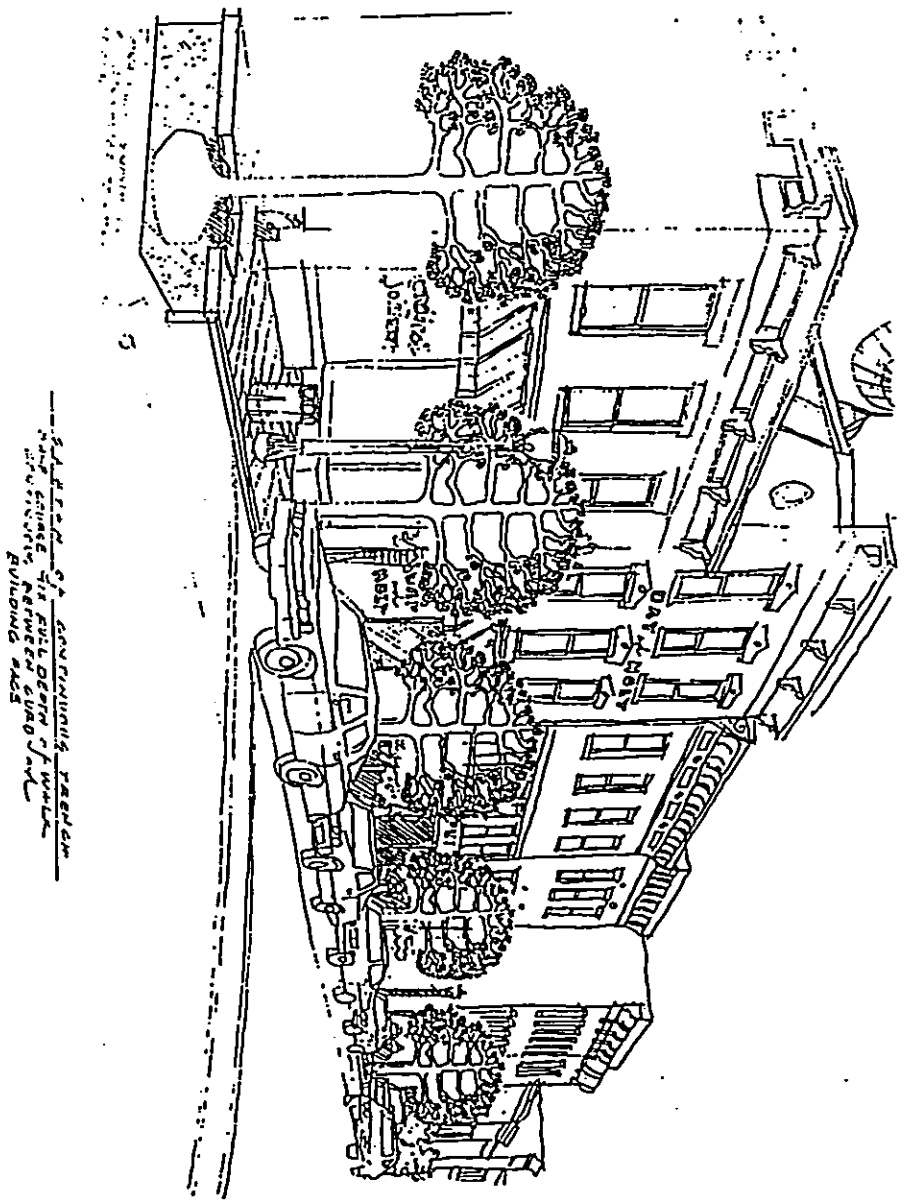
2. Fill all dips and remove any bumps in the overall plane of the slope.

a. The tolerance for dips and bumps in Structural Soil areas shall be a 2" deviation from the plane in 10'.

3. All fine grading shall be inspected and approved by the Engineer prior to the installation of other items to be placed on the Structural Soil.

C. The Engineer will inspect the work upon the request of the Contractor. Request for inspection shall be received by the Engineer at least 10 days before the anticipated date of inspection.

3.08 ACCEPTANCE STANDARDS



"RECIPE"

I. Materials

Stone: Angular Crushed Stone or gravel, sized as uniformly as possible between 0.75 and 1.5 inches in diameter. No fine grained contaminants.

Soil: Screened soil falling under the following parameters:

Gravel	<5%	
Coarse to medium sand	<5%	Falling under the USDA
Fine sand	5-10%	soil classifications
Very fine sand	10-30%	loam, silt loam or clay loam
Silt	20-60%	
Clay	20-35%	

Hydrogel: Gelscape® or approved equal

Amereq Inc. (914) 634-2400
19 Squadron Blvd (800) 832-8788
New City, NY 10956

II Determination of a mixing ratio

A. Make two or three test batches

i. 15%soil, 85%stone by weight
ii. 18%soil, 82%stone by weight
iii. 20% soil, 80% stone by weight

Hydrogel rate is constant for each blend at 30grams (1oz) dry powder hydrogel per 100 kilograms (210 lb) of stone.

B. Calculate ratio of stone to soil

i. Weigh out 25kg (55 lb)of dry stone (absorbency of stone material should be low <<1% so air-dry stone is acceptable for the mixing)
ii. Determine dry weight of soil

a.	Take a small representative sample of soil from the stock pile (40-50g) (1.4-1.8 oz)	48 grams (1.69 oz)
b.	Dry sample to a constant weight (about 48 hours) at 60C or 110 F	40 grams (1.41 oz)
c.	Weight the dry soil	

Send the 3 sample material blends to a soils engineering laboratory to run the following diagnostic tests.

- Standard Proctor Density curve: AASHTO T-99 to anchor your compaction specification should the material be used. This will also provided optimum moisture level for compaction.
- Strength testing as required by the project engineer. We have used a minimum criteria of California Bearing Ratio (96 hour soak) of 50. Even if the engineer is willing to accept a lesser strength material, we would strongly suggest this minimum CBR of 50 to meet both root growth and strength requirements.

When the results come back:

15% should give you acceptable strength.
IF 18% is at CBR = 50, reduce the soil in mixture to 15% (to allow for mixing variations)
- 20% may or may not give you acceptable strength. IF 20% is at CBR = 50, then reduce soil to 18% (again to account for mixing variation)

-or- graph the results of CBR against soil percentage in mix. Choose 2% less soil than level where line crosses CBR = 50

MIXING

Scale the mixing process to match the equipment available.

Mixing "on the flat" on a paved surface with a front end loader (shovel)

Spread a known weight of dry stone onto the flat surface in a thin layer. This requires knowing the unit weight of stone per loader bucket.	1000kg (2204.6 lb) stone in layer
Spread dry hydrogel evenly over the stone layer at the 30 units hydrogel per 100,000 units stone rate.	300grams (10.58 oz) hydrogel
Converting weight to volume of soil component:	A) 176 kg (388 lb) dry soil is needed for a 15% soil mix
Weigh one bucket load of soil moist	B) 105 kg (231.5 lb) moist soil per bucket in this example
Take 5 representative samples from the soil stock pile 2 days prior to mixing and tarp soil pile to minimize changes in the moisture content. Determine average soil moisture content as described earlier. NOTE: a Speedy® moisture kit could provide on site moisture content measurement Available	C) soil moisture was calculated at 20% in the previous example 100x(105 ÷ (100+%moisture in bucket load)) = weight of dry soil per bucket
water added in soil	17.5 kg (38.5 lb)(per bucket *2 buckets = 35 kg (77 lb) water
water needed to hit target moisture	106 kg - 35 kg = 71 kg water ---- 71 liters water 156.5 lb water ---- 18.75 gallons

If mixing the material in large quantities is expected, stockpile mixed material in 200-400 cyd batches.

For quality control, take a minimum of three 5 kg (11 lb) samples to be tested for:
- % moisture (if to be immediately used)
- particle size ratio stone to soil

To quickly measure ratio stone to soil

	Example
Collect sample and obtain moist weight	6.00 kg (13.2 lb)
Dry the stockpile sample and obtain sample dry weight	5.50 kg (12.1 lb)
Determine mixture moisture content	6 - 5.5 = 0.5 (13.2-12.1 = 1.1) 0.5 ÷ 5.5 = 0.091 = moisture content (1.1÷12.1= 0.091)
Submerge the sample in water and wash the stone free of soil	
Pass the material through a #40 seive, while washing any residual soil away. Retain and collect all stone from the sample	
dry the stone and obtain sample stone dry weight	4.68 kg (10.3 lb) stone
calculate the percentage of stone in the stone	4.68 kg stone ÷ 5.5 kg sample dry weight = 0.851 (10.3÷12.1 = 0.851) 0.851 * 100 = 85.1 Target mixture @ 85.0
Remember 95% of the stone should be retained on a 0.75 inch seive, now could be a good time to double check if stone is in question	

Installation

9. PARTIES CONSULTED DURING THE DRAFT EA

The following agencies and organizations were consulted during the public review period of the Draft EA. Of the 13 parties that formally replied during the review period, some had no comments while other provided substantive comments as indicated by the ✓ and ✓✓, respectively. All written comments are reproduced herein.

Federal Agencies

✓✓ U.S. Fish and Wildlife Service
✓ U.S. Natural Resource Conservation Service
✓✓ U.S. Army Corps of Engineers

State Agencies

Department of Business, Economic Development and Tourism (DBEDT)
✓✓ DBEDT, Land Use Commission
Department of Land and Natural Resources (DLNR)
DLNR, State Historic Preservation Division
DLNR, Division of Aquatic Resources
DLNR, Division of Forestry and Wildlife
✓ Department of Health (DOH)
DOH, Clean Water Branch
✓✓ University of Hawaii Environmental Center
✓✓ Office of Environmental Quality Control

County of Maui Agencies

Planning Department
Department of Public Works and Waste Management
✓✓ Department of Water Supply
✓✓ Police Department
✓ Fire Department
✓✓ Department of Parks and Recreation – Arborist Committee

Other

✓ Maui Electric Company
✓✓ Kihei Community Association
GTE Hawaiian Telephone
Hawaiian Cablevision Company

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO ATTENTION OF

January 25, 2000

RIF

Civil Works Technical Branch

Mr. Rodney Funakoshi, Project Manager
Wilson Okamoto and Associates
1907 South Beretania Street, Suite 400
Honolulu, Hawaii 96826

Dear Mr. Funakoshi:

Thank you for the opportunity to review and comment on the Draft Environmental Assessment (EA) for the South Kihei Road Improvements Project (Kulanihakoi to Lipoa Streets), Kihei, Maui (TMKs 3-9-1, 2, 7, 8, 22, 34, 46, and 52). The following comments are provided in accordance with Corps of Engineers authorities to provide flood hazard information and to issue Department of the Army (DA) permits.

a. The information provided in the DEA identifies two road crossings requiring activities which may involve work in waters of the U.S.; therefore, a DA permit may be required. For further information, please contact Mr. Farley Watanabe of our Operations Branch at (808) 438-7701 and refer to file number 200000015.

b. The flood hazard information provided on pages 3-6 of the DEA is correct.

Sincerely,

James Pennaz

James Pennaz, P.E.
Chief, Civil Works
Technical Branch

Copies Furnished:

Mr. Joe Krueger, Project Engineer
County of Maui
Department of Public Works and
Waste Management
200 South High Street
Wailuku, Maui, Hawaii 96763

Ms. Genevieve Salmonson, Director
State of Hawaii
Office of Environmental Quality Control
235 Beretania Street, Suite 702
Honolulu, Hawaii 96813

JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
Director

DAVID C. GOODE
Deputy Director

TEL. (808) 270-7745
FAX (808) 270-7975

COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
AND WASTE MANAGEMENT
ENGINEERING DIVISION
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

RALPH NAGAMINE, L.S., P.E.
Land Use and Codes Administration

RONALD R. RISKA, P.E.
Wastewater Reclamation Division

LLOYD P.C.W. LEE, P.E.
Engineering Division

ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

March 7, 2000

Mr. James Pennaz, P. E. Chief
Civil Works Technical Branch
U. S. Department of the Army
U. S. Army Engineer District, Honolulu
Fort Shafter, Hawaii 96858-5440

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII
FAP NO. STP-3100(11)

Dear Mr. Pennaz:

Thank you for your letter dated January 25, 2000, commenting on the subject EA. The potential requirement for a Department of the Army permit was acknowledged and noted in Section 6 of the draft EA. We appreciate your verification of the permit requirements and flood hazard information for the project.

Sincerely,

for LLOYD LEE
Engineering Division Chief

LL/JK:c(ED00-370)
A:\SRREA.ltr3.DOX.wpd

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

P.O. Box 50004
Honolulu, HI
96850

USDA

Our People...Our Islands...In Harmony

February 2, 2000

RECEIVED
FEB 04 2000
WILSON OKAMOTO & ASSOC., INC.

Mr. Rodney Funakoshi, Project Manager
Wilson Okamoto & Associates, Inc.
1907 South Beretania Street, Suite 400
Honolulu, Hawaii 96826

Dear Mr. Funakoshi:

Subject: Draft Environmental Assessment (EA) – South Kihei Road Improvements – Kulanihakoi Street to Lipoa Street, Kihei, Maui, Hawaii

We have reviewed the above mentioned document and have no comments to offer at this time.

Thank you for the opportunity to review this document.

Sincerely,

Chris Smith, acting for

KENNETH M. KANESHIRO
State Conservationist

Cc:
Mr. Joe Krueger, Project Engineer, County of Maui, Department of Public Works and Waste Management, 200 South High Street, Wailuku, HI 96793
Ms. Genevieve Salmonson, Director, State of Hawaii, Office of Environmental Quality Control, 235 N. Beretania Street, Suite 702, Honolulu, Hawaii 96813

JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
Director

DAVID C. GOODE
Deputy Director

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COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
AND WASTE MANAGEMENT
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Land Use and Codes Administration

RONALD R. RISKA, P.E.
Wastewater Reclamation Division

LLOYD P.C.W. LEE, P.E.
Engineering Division

ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

March 7, 2000

RECEIVED
MAR 09 2000
WILSON OKAMOTO & ASSOC., INC.

Mr. Kenneth M. Kaneshiro
State Conservationist
U. S. Department of Agriculture
Natural Resources Conservation Service
P. O. Box 50004
Honolulu, Hawaii 96850

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII
FAP NO. STP-3100(11)

Dear Mr. Kaneshiro:

Thank you for your letter dated February 2, 2000, indicating that you have no comments on the subject project. Your participation during the EA review process is appreciated.

Sincerely,

LLOYD LEE
Engineering Division Chief

LL/JK:cf(ED00-369)
K:\SAR\kanesp.jnk.wpd

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Ecoregion
300 Ala Moana Boulevard, Room 3-122
Box 50088
Honolulu, Hawai'i 96850

In Reply Refer To: BKP

FEB 11 2000

Rodney Funakoshi
Wilson Okamoto & Associates
1907 S. Beretania St.
Honolulu, Hawai'i 96826

FEB 15 2000

WILSON OKAMOTO & ASSOC. INC.

Re: Draft Environmental Assessment for the South Kihei Road Improvements Kūlanihāko'i Street to Lipoa Street, Kihei, Maui, Hawai'i, County Job No. 97-33

Dear Mr. Funakoshi:

The U.S. Fish and Wildlife Service (Service) has reviewed the Draft Environmental Assessment (DEA) for South Kihei Road Improvements at Kūlanihāko'i Street to Lipoa Street (County job No. 97-33). The project applicant is the County of Maui, Department of Public Works and Waste Management. The proposed project involves road widening, drainage, and related improvements to an approximately one-mile segment of South Kihei Road from Kūlanihāko'i Street to Lipoa Street. The Service offers the following comments for your consideration.

In a Service letter dated November 8, 1999 we provided technical assistance pertaining to lighting design to ensure protection of the endangered dark-rumped petrel (*Pterodroma phaeopygia sandwichensis)* and recommended a minimum height distance of 25 feet to discourage potential seabird fall-out. We also realize that Dr. Fern Duvall of the Hawai'i Department of Forestry and Wildlife (DOFAW) office on Maui was contacted after our recommendation, and that he will be providing specific information on an appropriate lighting design. In that same letter we recommended that the project area be surveyed for native flora and fauna, and this recommendation has since been included in section 3.4 of the DEA. Lastly, the Service recommended that Best Management Practices be incorporated into the project to minimize adverse impacts. Section 3.11.3 of the DEA includes a Best Management Practices Plan to mitigate impacts associated with construction activity, in or around drainage features.

The DEA adequately describes the fish and wildlife and other federal trust resources within the project location and adequately describes the impacts to these natural resources. Furthermore, the DEA describes adequate mitigation measures to minimize unavoidable impacts. Therefore, the Service would concur with your determination and support a "Finding of No Significant Impact."

We appreciate the opportunity to provide environmental review on the proposed project and your concern for endangered and threatened species. If you have questions regarding these comments, please contact Fish and Wildlife Biologist Benton Pang by telephone at (808) 541-3441 or by facsimile transmission at (808) 541-3470.

Sincerely,

Paul Henson
Field Supervisor

cc: DOFAW, Maui
DOFAW, Honolulu

JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
Director

DAVID C. GOODE
Deputy Director

TEL. (808) 270-7745
FAX (808) 270-7975

COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
AND WASTE MANAGEMENT
ENGINEERING DIVISION
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

RALPH NAGAMINE, L.S., P.E.
Land Use and Codes Administration

RONALD R. RISKA, P.E.
Wastewater Reclamation Division

LLOYD P.C.W. LEE, P.E.
Engineering Division

ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

March 7, 2000

Mr. Paul Henson, Field Supervisor
U. S. Department of the Interior
Fish and Wildlife Service
Pacific Islands Ecoregion
300 Ala Moana Boulevard, Rm 3-122
Box 50088
Honolulu, Hawaii 96850

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII
FAP NO. STP-3100(11)

Dear Mr. Henson:

Thank you for your letter dated February 11, 2000, indicating your concurrence with our Finding of No Significant Impact determination. Your participation during the EA review process is appreciated.

Sincerely,

LLOYD LEE
Engineering Division Chief

LL/JK:c(ED00-368)
K:\SchDv\esp.FWS.wpd

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

WILLIAM J. CAYETANO
GOVERNOR

ESTHER UEDA
EXECUTIVE OFFICER

STATE OF HAWAII
DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM
LAND USE COMMISSION
P.O. Box 2359
Honolulu, HI 96804-2359
Telephone: 808-587-3822
Fax: 808-587-3827

February 7, 2000

Mr. Rodney Funakoshi
Project Manager
Wilson Okamoto & Associates, Inc.
1907 South Beretania Street, Suite 400
Honolulu, Hawai'i 96826

Dear Mr. Funakoshi:

Subject: Draft Environmental Assessment (EA)
South Kihei Road Improvements – Kulanihakoi Street to Lipoa Street
County Project No. 97-33
TMK: (2) 3-9-001, 002, 007, 008, 022, 034, 046, 052: various
Kihei, Maui, Hawai'i

We have reviewed the subject draft environmental assessment forwarded by your transmittal dated January 5, 2000, and confirm that the proposed project is designated within the State Land Use Urban District.

Based on our review, there is a County drainage improvement project in a nearby westerly location to the road improvement project area. The Maui Planning Commission, County of Maui, had approved a special management area permit (SM1-990016) for a drainage improvement project by the Department of Public Works and Waste Management (DPWWM) at its December 14, 1999 meeting. The DPWWM project area will extend from the Kihei Community Center and Pool Complex on Lipoa Street south and west to South Kihei Road ending into a drainage channel running across the Kihei Kauhale Nani Subdivision. The DPWWM project is intended to address flooding problems of the subdivision during large scale storm events.

In a State Land Use District Boundary Amendment, LUC Docket No. A82-536, TMK: 2-2-002: portion of 42, the Commission approved the petition from Petitioner Haleakala Ranch Company (LUC Docket No. A82-536) to reclassify approximately 189.7 acres of land from the Agricultural District into the Urban District for residential development. The

petition area surrounds the site of the Kihei Elementary and Intermediate School and is mauka of the Kauhale Nani Subdivision. In the Commission's Decision and Order dated August 12, 1983, the Commission had indicated that the lower Kihei area has a history of drainage problems due to heavy rainfall at high elevations and poorly developed natural drainage system susceptible to overflowing. The Petitioner was willing to work with the County and State in providing on-site and off-site improvements necessary to accommodate storm runoff from the petition area and mauka lands owned by the petitioner. Ten (10) retention ponds were to be constructed on the west-side of the petition area (possibly areas within or near the future North South Collector Road) and the accumulated water was to be released into existing drainage channels after peak flows of a storm runoff. We do not know of the status of the improvements identified in the Decision and Order, since the Petitioner was not required to provide annual progress reports.

The DPWWM had informed the Commission through their letter dated November 18, 1999, that a retention basin was constructed in 1998 by the county at the north east corner of Lipoa Street and North-South Collector Road intersection. They identified that the detention basins offered by the Petitioner to assist in the drainage mitigation was not constructed, but is needed.

In light of the drainage issues of areas above South Kihei Road and the simultaneous work of drainage improvements in areas near the road improvement area, we suggest that the issues discussed above are considered into the final draft assessment and project planning.

We have no further comments to offer at this time. We appreciate the opportunity to comment on the subject application.

Should you have any questions, please feel free to call me or Russell Kumabe of our office at 587-3822.

Sincerely,

ESTHER UEDA
Executive Officer

EU:aa

cc: Department of Public Works and Waste Management,
County of Maui, Attn: Joe Krueger, Project Engineer ✓
OEQC

JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
Director

DAVID C. GOODE
Deputy Director

TEL. (808) 270-7745
FAX (808) 270-7975

COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
AND WASTE MANAGEMENT
ENGINEERING DIVISION
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

RALPH NAGAMINE, L.S., P.E.
Land Use and Codes Administration

RONALD R. RISKA, P.E.
Wastewater Reclamation Division

LLOYD P.C.W. LEE, P.E.
Engineering Division

ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

March 8, 2000

Ms. Esther Ueda, Executive Officer
State of Hawaii
Department of Business, Economic Development
and Tourism
Land Use Commission
P. O. Box 2359
Honolulu, Hawaii 96804-2359

SUBJECT: DRAFT ENVIRONMENT ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII
FAP NO. STP-3100(11)

Dear Ms. Ueda:

Thank you for your letter dated February 7, 2000 regarding the subject project. We appreciate your comments regarding other drainage improvements in proximity to the project. Attached for your information is a map of the drainage districts within which the project lies. Also, indicated on the map is the county drainage improvement project approved under SMA permit SM1-990016 (referred to as the Kihei School Off-Site Drainage Improvements), the county's retention basin located near the intersection Lipoa Street and North-South Collector Road, and the northern portion of the land use petition area described in LUC Docket No. A82-536.

As shown on the map, the project site lies within four drainage districts, including Kulanihakoi District Basin 3 (Kulanihakoi 3), Waipuilani District, Keokea District Basin 1 (Keokea 1), and Keokea District Basin 2 (Keokea 2). These areas are defined in the *Drainage Master Plan for Kihei, Maui, Hawaii* prepared by Norman Saito Engineering Consultants, Inc. for the County of Maui in August 1997.

The recommendations from the master plan are in various stages of implementation. In the Kulanihakoi 3 district, the existing box culvert at the North-South Collector Road and storm drain system for the residential development makai of Piilani Highway was recommended to be maintained. As such, this recommendation has been implemented. In the Waipuilani District, flows from the Waipuilani Gulch are recommended for diversions to the Kulanihakoi Gulch. Design plans for this diversion is anticipated by the summer of 2001, with construction to commence shortly thereafter. The culvert modification, which is part of the proposed South Kihei Road improvements, has been designed to accommodate drainage flows following the diversion.

In the Keokea 1 district, the master plan recommends that drainage flows cross beneath South Kihei Road and discharge into the wetland area located makai of the road. Provisions for a culvert crossing at South Kihei Road approximately 240 feet north of Nohokai Street have been included as part of the proposed roadway improvements. Upstream and downstream channel improvements for the culvert are not included as part of the project, and will be designed at a later time. No specific recommendations were provided for the Keokea 2 district. A drainage plan developed by the county (and referred to in the master plan), however, called for a retention pond makai of the Kihei Community Center and Pool Complex. In 1998, the Department constructed a one-acre retention pond to address this issue.

The drainage improvements incorporated in the South Kihei Road project are consistent with the drainage master plan within the Kulanihakoi 3, Waipuilani and Keokea 1 districts. No improvements are proposed for the portion of South Kihei Road that lies within the Keokea 2 district. The Kihei School Off-Site Drainage Improvements and the County's one-acre retention basin located near the intersection of Lipoa Street and North-South Collector Road is located within the Keokea 2 district.

The northern portion of the 189-acre petition area is described in LUC Docket NO. A82-536 lies approximately one mile mauka of the project site and is also transected by the four drainage districts (the southern portion of the petition area, not shown on the map, is located south of Kihei School and remains undeveloped). A 3.5-acre retention pond was constructed in the portion of the petition area that lies within the Keokea 1 district. The retention pond was constructed to accommodate drainage flows from the proposed Safeway Store project and its associated residential development. We understand that this is one of ten retention ponds that were required by the petitioner as part of the boundary amendment approval. We are not aware of the status of the remaining nine ponds.

The above discussion will be incorporated into the final EA. Your participation during the EA review process is appreciated.

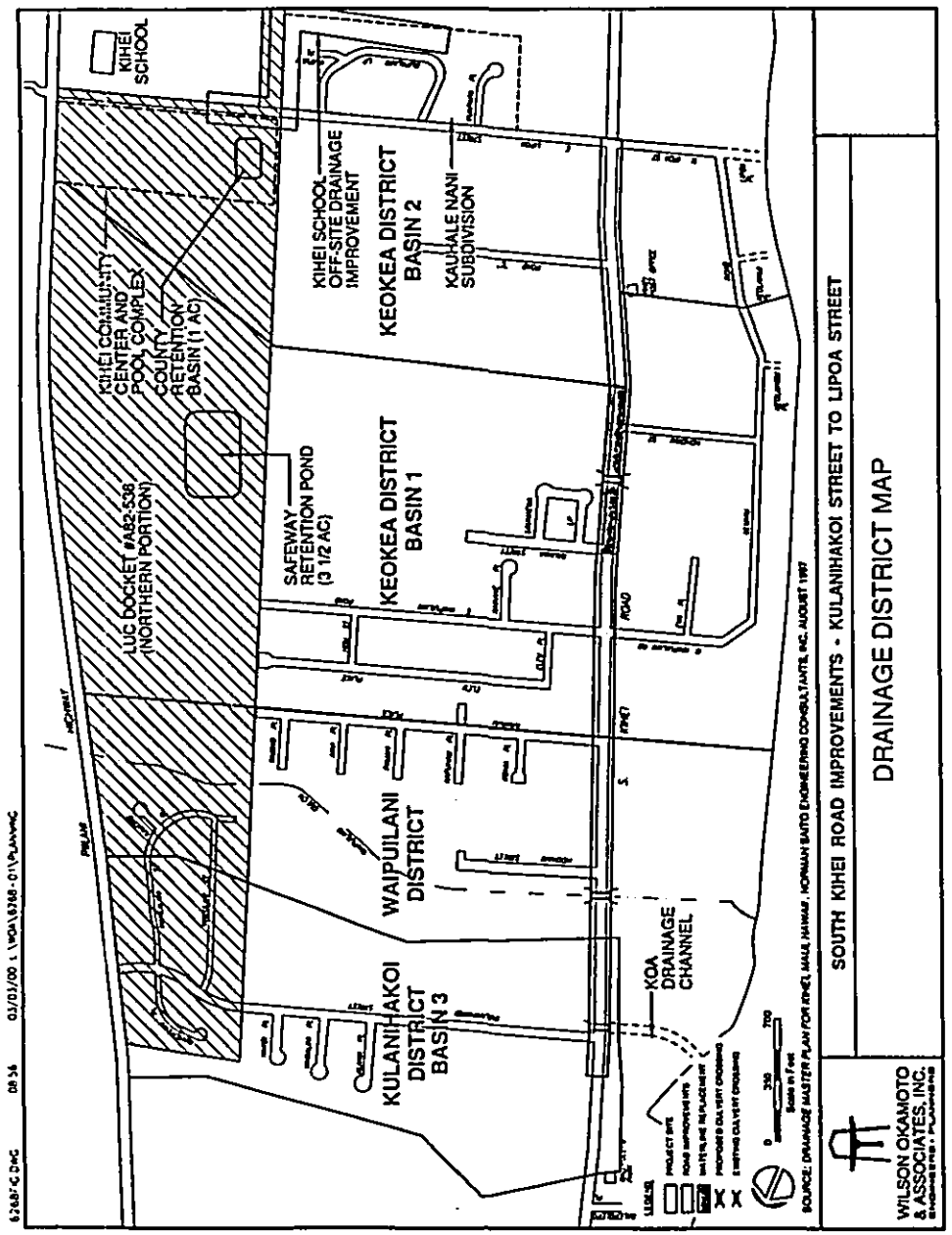
Sincerely,

LLOYD LEE
Engineering Division Chief

LL/JK:c:(EDDO-379)

Enclosure

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.



BENJAMIN J. CAYETANO
GOVERNOR

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
235 SOUTH BERETANIA STREET
SUITE 702
HONOLULU, HAWAII 96813
TELEPHONE (808) 586-4185
FACSIMILE (808) 586-4186

GENEVIEVE SALMONSON
DIRECTOR

RF

RECEIVED
FEB 08 2000
WILSON OKAMOTO & ASSOC., INC.

February 7, 2000

Mr. Joe Krueger
County of Maui Department of Public Works and Waste Management
200 South High Street
Wailuku, Hawai'i 96793

Dear Mr. Krueger:

This is written in response to your agency's December 1999, draft environmental assessment for the South Kihei Road Improvements, Kulanihakoi Street to Lipoa Street, County Job 97-33, prepared by Wilson Okamoto and Associates. We offer the following comments for your response.

1. **CONDEMNATION OF PRIVATE PROPERTY.** Please disclose what parcels the County will condemn for the road widening.
2. **CONSULTATION.** Please disclose whether residents to be affected by the proposed construction were consulted before preparation of the environmental assessment.
3. **SHORELINE AND WATER QUALITY IMPACTS.** The new culvert crossing at Waipuilani Gulch will channel water across the beach and may create conditions that may alter beach processes since the drainage through the beach will require periodic removal of sand from the mouth of the drainage channel. Additionally, the discharge of waters from the drainage channel may adversely impact water quality. Please discuss these impacts in the environmental assessment using the EA content recommendations specified in the enclosed shoreline hardening policy document.
4. **DUNE BURIALS.** Please consult with the Office of Hawaiian Affairs and the State Historic Preservation Division of the Department of Land and Natural Resources with respect to the possibility of native Hawaiian dune burials on the project site, especially if heavy moving equipment (i.e., bulldozers) will be used to periodically clear a channel to drain Waipuilani Gulch.

Thank you for the opportunity to comment. If you have any questions, please call Mr. Leslie Segundo of my staff at (808) 586-4185.

Sincerely,

GENEVIEVE SALMONSON
Director

cc: Mr. Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

Enclosure

Shoreline Hardening Policy and Environmental Assessment Guidelines

Office of Environmental Quality Control, December 1998

Shoreline Hardening Policy

For a more thorough and detailed discussion of these issues please refer to the Coastal Erosion Management Plan (COEMAP) of the Department of Land and Natural Resources (DLNR).

I. Definition of Problem

Coastal property owners bear tremendous risks. Their property is vulnerable to tsunamis, storm surges, floods, high wave impacts, and hurricanes. In addition, owners along the shoreline bear the risk that their property may erode (Coyne et al., in press). Under common law, a riparian land owner "loses title to lands that are submerged through the process of erosion."[1] The Hawaii Supreme Court has held that "registered ocean front property is subject to the same burdens and incidents as unregistered land, including erosion....[T]he precise location of the high water mark on the ground is subject to change and may always be altered by erosion."[2] Because the land seaward of the upper reaches of the wash of the waves -including the beach - is a public trust resource,[3] the state, as trustee, can restrain those activities that damage the resource.[4] A private property owner does not have the right to impair public trust resources.

Tide gauges maintained by the National Oceanic and Atmospheric Administration demonstrate that our islands are experiencing a relative rise in sea level due to both global sea-level rise and local geologic factors (Fletcher, 1992). Additionally, in many places, waves and currents and human activities may reduce, or otherwise negatively impact, the volume of sand along beaches. Processes associated with sea-level rise, wave and current action, and/or human impacts may cause chronic erosion of coastal lands leading to a retreat of the shoreline. It is frequently difficult to distinguish natural from anthropogenic causes of erosion, and the two may often operate together along a particular shoreline. In response shoreline movement may occur slowly at an average annual rate, beaches may erode and recover on a seasonal cycle, or erosion may occur episodically associated with storms at unpredictable times and rates. Erosion is only a problem needing mitigation where human developments along the coast are threatened by shoreline fluctuations.

---

[1] R.R. Powell 5A Powell on Real Property § 66.01 [2] (1994).

[2] County of Hawaii v. Sotomura. 55 Haw. 176, 180 (1973).

[3] Application of Sanborn. 57 Haw. 585, 562.

[4] Orion Corp. v. State 747 P.2d 1062 (Wash. 1987); U.S. v. State Water Resources Control Board. 227 Cal. Rptr 161 (Cal. App. 1 Dist 1986); State Dept. of Environmental Protection v. Jersey Central P & C Co. 308 A.2d 671 (N.J. Super L. 1973).

Armoring the shoreline with seawalls or revetments often stops the erosion of coastal land mauka of the structure. However, where beaches are undergoing long-term retreat, shoreline hardening eventually leads to beach narrowing, followed by beach loss (Hall, 1964; Birkemeier, 1981; Fischer, 1986; Hanson and Kraus, 1986; Komar and McDougal, 1988; Kraus, 1988; Tait and Griggs, 1990; Fletcher et al., 1997; Pope, 1997, and others). A hardened structure tends to shift the focus of erosion from the land to the beach fronting the wall. Seawalls and revetments are not a cure for the cause of erosion, but rather a defensive mechanism to mitigate land loss without regard for resulting impacts to adjacent environments such as the beach or the laterally adjacent shoreline (Raynor, 1953; U.S. Army Corps of Engineers, 1964; Walton and Sensabaugh, 1983; Tait and Griggs, 1990). Shoreline hardening not only leads to beach loss where shorelines are undergoing long-term retreat, but it may also exacerbate the erosion problem on adjacent shorelines through the process of sediment impoundment, or trapping of sand behind the wall. This has the effect of decreasing the overall sand volume available to beaches in the immediate vicinity thus reducing their ability to withstand and recover from normal seasonal wave stresses (Terich, 1975; McDougal, Sturtevant and Komar, 1987; Wood, 1988; Kraus, 1988; Komar and McDougal, 1988; Pope et al., 1997).

Studies of historical vegetation line movement in Hawaii indicate that many coasts are experiencing long-term retreat (Hwang, 1981; Sea Engineering, 1988; Makai Ocean Engineering and Sea Engineering, 1992; Fletcher et al., 1997; Coyne et al., in press) and that many of these coasts have been hardened as a result of the need to stop land loss. The trend of hardening has led to beach narrowing and beach loss on all islands (Hwang and Fletcher, 1992), especially on the islands of Oahu and Maui, where the combination of sea-level rise, sediment deficiencies, wave and current action, and extensive coastal development has resulted in significant beach loss (Hwang and Fletcher, 1992; Fletcher et al., 1997).

II. General Policy

Hardening of the shoreline should be considered the erosion management option of last resort, and it's use should be avoided if other options are available. In addition, development in coastal hazard zones, including erosion hazard zones and coastal flood zones should be avoided in order to:

(1) prevent the inevitable financial and personal hardships that befall individuals and families, and the expenditure of public funds that accompany the occurrence of coastal hazards on developed shorelines;

(2) prevent the inevitable need to harden the shoreline where there is chronic erosion and the resulting loss of public beaches, lateral shoreline access, open space and view corridors, and littoral sand due to sediment impoundment behind walls;

(3) mitigate threats to inhabited structures, and public infrastructure from coastal hazards; and

(4) avoid the need for future public expenditures in responding to damage caused by hurricanes, tsunami, high wave impacts and other coastal hazards;

III. Response to applications for seawalls, groins and revetments

All decision makers should discourage the construction of seawalls, revetments or other shoreline hardening devices that have the potential to lead to beach loss and that also have the tendency to encourage development in areas of chronic erosion.

As an alternative to a hardened structure, applicants should consider the applicability of coastal dune enhancement, beach and dune restoration, sand replenishment, and other "soft" approaches to mitigating coastal erosion. Applicants should also evaluate the potential for moving dwellings and other structures away from the shoreline as a means of mitigating the effects of erosion. Finally, any application should include the information requested in the attached guidelines for assessing shoreline alteration and hardening projects.

If after a thorough analysis of an application, the decision maker finds by clear and convincing evidence that the impact on public trust resources would be negligible, alternatives to hardening would be impractical, substantial hardship to the applicant is real, and these compelling reasons dictate that a hardened structure should be approved, any approval that is granted should be conditioned on the applicant monitoring shoreline response to the structure. Monitoring should be conducted using standard coastal surveying techniques to document short-term and long term changes in the beach profile both on the subaerial beach and offshore. In order to ensure that planning authorities retain the ability to protect our beaches and because future events may require the removal of seawalls, revetments or groins, all variances and permits should either have an expiration date (subject to renewal), or be revocable upon a finding of environmental impact. In other words, the variance or permit should not confer a vested right to keep the structure in perpetuity.

In general, a variance should be viewed as an extraordinary exception which should be granted sparingly. The reasons to justify approval must be substantial, serious and compelling.[5]

IV. Response to existing illegal seawalls, revetments, groins, or other structure or illegal activity

In assessing whether to remove existing seawalls, revetments and other shoreline hardening devices that have been constructed without proper review and approval, decision makers should consider:

(1) the impact the structure or activity is having on coastal processes and access;

(2) the impact of removal of the structure, or cessation of the activity on the coastline;

(3) the immediate impact of removal of the structure, or cessation of the activity on nearby dwellings; and

(4) alternatives to the structure or activity which can mitigate erosion impacts;

(5) the assessment of fines or easement costs to be applied along the coastline as compensation for mitigating the negative impacts of the structure or activity.

---

[5] R.R. Powell 6 Powell on Real Property § 79c.16[1] (1995).

Removal should be encouraged where removal will lead to restoration or improvement of coastal resources without causing substantial hardship to the owner, or creating a public hazard.

V. Long-term response to development in coastal hazard zones including erosion and flood hazard zones

So long as construction is allowed in coastal hazard zones, landowners and land managers will face financial burdens and threats to human safety. Where development is allowed in erosion or flood hazard zones, and structures are threatened by erosion or flooding, owners will consider protecting their investments with seawalls and revetments that may have a negative impact of the natural environment. A long-term solution will require that land use decision makers use: public awareness and education efforts; community-based resource protection programs; willing-owner redevelopment plans; hazard avoidance and minimization zoning and planning; and other participant-based and proactive environmental restoration, conservation and hazard avoidance discretionary authority they may have to recover lost coastal resources and mitigate future impacts. When state land use classifications are changed, CDUA's and SMA applications approved, zoning amended or subdivisions approved, conditions should be attached that restrict an applicant's (re)development proposals so that all construction activities occur outside of coastal hazard (erosion and flood) zones and future projected coastal hazard zones and above Base Flood Elevations (BFE's) as mapped by the Federal Emergency Management Agency and updated by state programs, and that beaches and coastal dunes are conserved or enhanced. This in general will require that construction activities recognize adequate, site-specific setbacks from the shoreline and appropriate landscaping and development practices. Applicants are encouraged to refer to the FEMA Coastal Construction Manual for guidelines (to be updated in 2000).

Counties should also consider establishing guidelines and procedures for redeveloping coastal areas where the beach and/or dune has been degraded by shoreline armoring. In the case of Honolulu, the use of Community Facilities Districts to establish enhanced opportunities for funding and implementing a combined beach-dune preservation or restoration system may be useful. Such efforts can translate to significant reductions in the cost of homeowner flood insurance through the National Flood-Insurance Program (NFIP) Community Rating System (CRS).

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Guidelines for Assessing Shoreline Alteration and Hardening Projects

It is the policy of the State of Hawaii under HRS Chapter 205A to discourage all shoreline hardening that may affect access to, or the configuration of, our island beaches.

Any Environmental Assessment prepared in conjunction with an application to construct a seawall, revetment or similar structure, or an activity that will alter in any way littoral processes affecting the shoreline, should be accompanied by appropriate justification and detailed studies including, but not limited to, the following:

1. Historical shoreline analysis of coastal erosion and accretion rates

This should include a description of all movements of the neighboring shoreline over at least the past 30 years. This analysis should be based, at least in part, on aerial photographs available through government agencies and private vendors.[6] The analysis should provide a detailed history of erosion and accretion patterns using all available evidence. This analysis should include descriptions of shoreline erosion rates, a map (with scale, north arrow, and title) showing past positions of the shoreline in the project area, and an analysis of the causes of erosion. It is especially important to describe how the project will mitigate the cause(s) of erosion, and avoid exacerbating erosion on the adjacent shoreline.

2. Shoreline type

A description of the nature of the affected shoreline, whether sandy, rocky, mud flats or any other configuration. The history and characteristics of adjoining sand dunes, streams and channels, and reefs should be included.

3. Site maps

Submit maps with title, north arrow and scale, and photographs that clearly show the current certified shoreline, previous certified shorelines, the private property line and the location of the proposed structure. Any nearby public access right-of-way should also be depicted. Applicants should also include a color copy of a color vertical aerial photograph[7] that shows the project area and the adjacent offshore region. The applicant may wish to identify important components of the project on the color photo. Color aerial photos exist for most of the shoreline area of Hawaii and often clearly show important geologic and geographic features that are critical to fully evaluating the environmental context, and even the likelyhood of success, of a proposed project. Evaluation of an aerial photo of

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[6]Aerial photographs may be obtained from Air Surveys Hawaii, Inc.; Towill, R.M., Corp.; City and County of Honolulu, Coastal Lands Program, Department of Planning and Permitting; DBEDT, Office of Planning; and the various planning and permitting departments in each county.

[7]Color vertical aerial photographs usually can be purchased at reasonable price from Air Surveys Hawaii, Inc.

a project site can be an important tool yielding significant information relevant to the applicants planning efforts.

4. Beach profiles

Submit beach profiles that extend offshore at appropriate intervals along the beach indicating the width and slope of both the submerged and dry portions of the beach and showing major features of the beach. Profiles should extend from the mauka toe of the primary dune to the offshore depth of closure of profile fluctuations.[8]

5. Existing walls

Submit an analysis of any existing nearby walls or revetments and their cumulative impacts on the shoreline.

6. Description of improvements

A description of structures and improvements (such as homes or swimming pools) on the subject property, their distance from the property line and shoreline, how they may be affected by the construction of the proposed hardening project, and the specific feasibility of relocating them as a hazard mitigation activity.

7. Coastal hazard history

A coastal hazard analysis for the area in question. This should include any relevant coastal processes such as hazardous currents and seasonal wave patterns, including a description of the recent incidence of damaging high waves, high winds or water levels from storms, vulnerability to tsunami, and the best estimate of Base Flood Elevations and flood zone designation as mapped by the FEMA Flood Insurance Rate Maps.

8. Waves and currents

A description of the wave and current regime acting along the shoreline in question, including, a wave refraction analysis (one simple form of this analysis is to describe wave crest patterns as shown in an aerial photograph), a description of littoral currents and their seasonal patterns and the impact of the proposed activity on these patterns.

[8] Note: Please refer to U.S. Army Corps of Engineers Coastal Engineering Technical Notices II-31 (11/93), II-40, 3/98, and other relevant documents for guidance.

9. Sediment movement

If the proposed activity involves any action that may interfere with the normal pattern of sediment transport along the coast, or alter in any way the morphology of the shoreline or the resident sand volume, applicants must submit a description of these alterations and their impact on shoreline processes including an estimate of the annual volume of sediment in transport and seasonal patterns of transport, and whether these impacts may have any deleterious effects on neighboring shoreline segments.

10. Thirty-year erosion hazard

An analysis that uses annual erosion rate data to project the location of the 30-yr erosion hazard zone as measured from the certified shoreline or vegetation line in the absence of any shoreline stabilization structures. This information should be provided in the form of a mapped line or zone, and accompany text descriptions. The analysis may be combined with items 1 or 3, or submitted independently.

11. Photographs

Eye-level (taken by an individual standing on the ground) photos of the site that illustrate past and present conditions and locate the proposed structure.

12. Alternatives

All alternatives to shoreline hardening should be thoroughly researched and analyzed. These alternatives should include beach and/or dune restoration using sand replenishment, retreat from the shoreline by moving existing structures inland, and a no action alternative.

13. P.E. Seal

The seal of a Professional Engineer (P.E.) with experience in the area of coastal engineering should be included with any technical plans for a shoreline hardening structure that accompany the application.

The inclusion of this information will help make an Environmental Assessment complete and meet the requirements of Chapter 343, HRS. Only after thorough study and analysis should any permit for shoreline hardening be considered.

JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
Director

DAVID C. GOODE
Deputy Director

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LLOYD P.C.W. LEE, P.E.
Engineering Division

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Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

March 3, 2000

Ms. Genevieve Salmonson, Director
State of Hawaii
Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu, Hawaii 96813

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII

Dear Ms. Salmonson:

Thank you for your letter dated February 7, 2000 commenting on the subject project. The following is offered in response to your comments:

Condemnation of Private Property: A preliminary list of parcels to be affected by the land acquisition was provided in Table 3-2 (Page 3-12) of the draft EA.

Consultation: As the proposed project was in the conceptual design stage at the time, consultation with the landowners and lessees was not undertaken prior to preparation of the EA. We, however, consult with the Kihei Community Association prior to the draft EA preparation. The department will be consulting with landowners and lessees with the Special Management Area (SMA) permit process, recently initiated.

Shoreline and Water Quality Impacts: The Department has a maintenance program in place to remove sand plugs that may form at the mouth of drainage channels, including at Waipuilani Gulch. The maintenance program, which was approved under a Department of the Army permit, allows for the regular removal of problematic sand plugs. Any sand plugs that may continue to form after the proposed improvements to the Waipuilani Gulch are completed will be removed as needed under the authorized maintenance program.

We appreciate the information you provided regarding shoreline hardening policy. No seawalls, revetments or other shoreline hardening devices are proposed as part of the project. The proposed modifications to the drainage culvert at Waipuilani Gulch are situated approximately 1,000 feet mauka of the shoreline, and are not expected to directly affect shoreline processes. According to the *Aerial Photograph Analysis of Coastal Erosion of the Island of Kauai, Molokai, Lanai, Maui and Hawaii*, prepared by Makai Ocean Engineering, Inc. and Sea Engineering, Inc. in June 1991, as well as the Flood Insurance Rate Map (FIRM) prepared by the Federal Emergency Management Agency (FEMA), we provide the following information on the historical shoreline analysis of coastal accretion and erosion rates, description of improvements, and coastal hazard history:

Historical Shoreline Analysis of Coastal Accretion and Erosion Rates
The sandy shoreline area from Kalepolepo Beach to Kawililipoa covering areas makai of the project site has undergone dramatic changes between 1949 and 1988. During the 40-year period, the beach area approximately 750 feet north of Waipuilani Gulch has accreted from 100 to 115 feet, while the beach area approximately 1,000 feet to the south as eroded from 32 to 92 feet. These changes are likely due to a regional shift in longshore currents. The consistent nature of the accretion and erosion indicates that the beach is still responding to the shift in currents, and has not reached a stable state of equilibrium. A shallow reef spanning at least 1,000 feet wide is situated offshore.

Description of Improvements
The proposed culvert modification is located approximately 1,000 feet mauka of the shoreline. Beachfront resort hotels located to the north and south of Waipuilani Gulch is sited more than 300 feet from the shoreline and hotels have been designated as a state beach reserve. The grassy lawn of the beach area has aided in controlling erosion. Access to the reserve area is along Waipuilani Gulch.

Coastal Hazard History
According to the FIRM Community Panel Number 150003 0265 C 9 (revised September 6, 1989), the project site lies within Zones AH, A3, and A4 flood designations. Zone AH includes areas prone to the 100-year shallow flood where depths are between one and three feet. Zones A3 and A4 include areas within the 100-year flood, where based flood elevations and flood hazard factors are determined.

Dune Burials: The archaeological report prepared for the project and included in the draft EA did not indicate the existence of or potential for dune burials within the project site. The State Historic Preservation Division of the Department of Land and Natural Resources has been consulted during the pre-assessment and draft EA phase. The Office of Hawaiian Affairs is expected to be consulted during the SMA agency review. It should also be noted that past improvements along the South Kihei Road have not revealed any potential for burials.

Your participation during the EA review process is appreciated.

Sincerely,

LLOYD LEE
Engineering Division Chief

LL/JK:c(ED00-367)
Attachments cc: see

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

Mr. Joe Krueger
February 7, 2000
Page 3

Economy (section 3.10.2) Impacts to local businesses including retail, restaurants, professional offices, and the Post Office, during the construction phase of the project are not discussed. These businesses may experience reduced patronage due to their inaccessibility as a result of the construction. Kihei is a popular tourist destination, whose hotels and condominiums may suffer short-term losses as a result of their proximity to the roadwork. Disruptions to the daily activities of the local residents and businesses should be discussed and mitigative measures suggested.

Recreational Resources Section 3.10.6 on recreational resources states that "there are no shoreline parks within or makai of the proposed roadway right-of-way," however, the Kihei-Makena Community Plan Map (figure 4-1, page 4-4) and the Zoning Map (figure 4-2, page 4-5) both show park designations makai of the proposed project. Our reviewers requested a clarification of this designation. Also, regardless of the presence of a park, are there any recreational or shoreline activities that may be affected by the project? How might access to this shoreline be accommodated?

Traffic

Missing from the DEA was a traffic assessment of the area, including possible rerouting during construction, and expected traffic flow after completion of the improvements. This would be helpful in determining possible concerns such as effects on local businesses, the effects on Piilani Highway, and the possibility of increased speeding (such as that experienced on Kalanianaole Highway) once the roadwork has ended.

Possible rerouting of traffic onto Piilani Highway during construction is also a concern. This highway is capable of handling a greater volume of traffic than it currently does, but movement onto the highway is often difficult and dangerous due to the high speeds of motorists on this road and lack of traffic lights which would allow for left turn access onto the highway.

Summary and Recommendations

This DEA provides information on assessing the impacts due to the proposed road improvements. However, there are several issues we would like to see addressed in the final EA. Particularly, the lack of discussion on traffic patterns and short-term effects on local businesses and activities should be addressed.

Thank you for the opportunity to comment on this Draft EA

Sincerely,

Peter Rappa
Assistant Environmental Coordinator

cc: OEQC
County of Maui, Department of Public Works and Waste Management
Sherri Hiraoka

JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
Director

DAVID C. GOODE
Deputy Director

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ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

March 3, 2000

Mr. Peter Rappa
Assistant Environmental Coordinator
University of Hawaii
Environmental Center
2550 Campus Road, Crawford 317
Honolulu, Hawaii 96822

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII

Dear Mr. Rappa:

Thank you for your letter dated February 7, 2000 (Reference EA: 00192) commenting on the subject project. The following is offered in response to your comments:

Project Description: In response to your comments, typical road sections proposed for the project will be included in the final EA (see attached figure).

Geology and Topography: The Department will be coordinating with landowners of available vacant properties along the project site regarding the use of these areas for temporary storage of excavated materials and construction equipment.

Soils: According to the U. S. Department of Agriculture Natural Resources Conservation Service, Jaucas Sand is highly erodible. Information regarding the runoff and erosion potential for Dune Lands is not available. The final EA will include information from the Preliminary Erosion Control Plan prepared fro the project. Such measures will include the use of temporary berms, early construction of drainage control features, use of temporary sprinklers in non-active construction areas where ground cover is removed, and use of silt screens where appropriate.

Surface Water: Impacts to recreation activities resulting from construction activities are not anticipated to be significant. Erosion control measures included in the Preliminary Erosion Control Plan will mitigate possible impacts to near shore waters during construction of the project.

Flood Hazard: The method proposed to mitigate flood impacts will include a replacement culvert at Waipuilani Gulch. The culvert will include two 7-foot by 5-foot cells and will replace the existing 10-foot by 3-foot culvert. In addition, a new culvert crossing involving four 8-foot by 5-foot cells is proposed to be located approximately 240 feet north of Nohokai Street. Upstream and downstream channel improvements for the culvert are not included as part of the project, and will be designed at a later time. The above information will be included in the final EA.

Air Quality: Construction will generally be restricted to typical non-peak traffic hours from 8:30 a.m. to 3:30 p.m. The construction contractor will be required to adhere to this schedule for equipment mobilization.

To the extent possible, native plants will be considered and used in landscaping plans.

Archaeological Resources: Additional information on these fishpond and anticipated impacts will be provided in the final EA. The four fishponds are not located in the immediate vicinity of the project site, but rather along the shoreline, several hundred feet away (see an attached map). The fishpond located nearest to the project site is referred to variably as Ko'ie'ie Liko'ia, Kaonoulu-Kai, or Kalepolepo (State Site #50-50-09-1288) and is located approximately 400 feet northwest of the project site. The fishpond is currently being restored by the Hawaiian Island Humpback Whale National Marine Sanctuary Library and Museum. The remaining three, Waiohulikai (State Site NO. 50-50-09-1704), Keokea-kai (Sate Site No. 50-50-09-1738), and an unnamed pond (no site number assigned), appear to have been severely damaged by high surf and tsunami. While the proposed project is not anticipated to significantly impact the fishponds, erosion control measures included in the Preliminary Erosion Control Plan will be implemented to mitigate possible impacts to near shore waters during construction of the project.

Community Setting: We acknowledge that the project, in alleviating existing traffic congestion in this area of Kihei tow, may impact the population of the Kihei-Makena region. We note, however, that the new roadway will be maintained as a two-lane road such that there will not be an increase in operational capacity.

Economy: The final EA will include a brief discussion of the construction-related impacts to the area business, residents, and visitors. Short-term impacts to the community associated with construction activities may occur as a result of the proposed project. Motorists, pedestrians, and bicyclists traveling in and around the immediate construction area may experience minor inconveniences and delays in travel time. While access to driveways will be maintained to the extent possible, businesses may experience minor disruptions in the flow of customers due to the temporary construction activities. Advanced notification will be sent to all residents and businesses in the project area. A traffic control plan will be prepared and submitted to our Department for approval. Any road closures or detours, if deemed necessary, will be coordinated with area residents and businesses, the Fire

Prevention Bureau of the County Department of Fire Control, and the County Police Department.

Recreational Resources: We concur that there are shoreline parks located makai of the project site, and will revise Section 3.10.6 accordingly. Significant impacts to shoreline and recreational activities are not anticipated as a result of the proposed improvements. A traffic control plan will be prepared for the project to ensure that access to shoreline areas will be maintained.

Traffic: A traffic impact assessment was not prepared specifically for the project. The traffic basis for proposed roadway improvements in the region is the *Kihei Traffic Master Plan,* a long-range regional roadway plan for Kihei (Austin, Tsutsumi & Associates, Inc., October 1989).

We share your concerns relative to impacts on area businesses and traffic safety. A traffic control plan will be prepared and submitted to our Department for approval. Any road closures or detours, as may be necessary, will be coordinated with area residents and businesses, the Fire Prevention Bureau of the County Department of Fire Control, and the County Police Department.

Your participation during the EA review process is appreciated.

Sincerely,

for LLOYD LEE
Engineering Division Chief

LL:JK:c(ED00-365)

Enclosure

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P.O. BOX 3378
HONOLULU, HAWAII 96801

BRUCE S. ANDERSON, Ph.D., M.P.H.
DIRECTOR OF HEALTH

In reply, please refer to
File

February 10, 2000

99-146A/epo

RYF

Mr. Rodney Funakoshi
Project Manager
Wilson Okamoto & Associates, Inc.
1907 S. Beretania Street, Suite 400
Honolulu, Hawaii 96826

RECEIVED
FEB 11 2000
WILSON OKAMOTO & ASSOC., INC

Dear Mr. Funakoshi:

Subject: Draft Environmental Assessment
South Kihei Road Improvements - Kulanihakoi Street
to Lipoa Street (County Project No. 97-33)
Kihei, Maui
TMK: 3-9-1 and others

Thank you for allowing us to review and comment on the subject DEA. We do not have any comments to offer at this time.

Sincerely,

GARY GILL
Deputy Director for
Environmental Health

c: Maui County, Dept of Public Works
and Waste Management

JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
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March 3, 2000

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Mr. Gary Gill
Deputy Director for Environmental Health
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SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII

Dear Mr. Gill:

Thank you for your letter dated February 10, 2000 (Reference 99-146A/epo) indicating that you have no comments on the subject project. Your participation during the EA review process is appreciated.

Sincerely,

for LLOYD LEE
Engineering Division Chief

LL/JK:c(ED00-366)
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xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

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

EA: 00192
February 7, 2000

Mr. Joe Krueger
Project Engineer
County of Maui
Department of Public Works and Waste Management
200 South High Street
Wailuku, Hawaii 96793

Dear Mr. Krueger,

Draft Environmental Assessment
South Kihei Road Improvements-
Kulanihakoi Street to Lipoa Street
Kihei, Maui

The County of Maui Department of Public Works and Waste Management proposes to improve an approximately 5,100-foot portion of South Kihei Road between Kulanihakoi Street and Lipoa Street. Improvements include the addition of bike lanes, dedicated left-turn lanes at all intersections, dedicated right-turn lanes at selected intersections, a parking lane on one side of the road, a new culvert crossing at Waipuilani Gulch, a sidewalk on each side of the road, and a curb and gutter on each side of the road. Project goals include: (1) alleviating traffic congestion in this area of Kihei and (2) allowing the current infrastructure to keep pace with the level of development which occurred in the region in the past 20 years. The Draft Environmental Assessment (DEA) examines the effects of such road improvements, which will run through business as well as residential lands, will affect traffic patterns and local activities, and therefore represent issues to be considered carefully.

This review was prepared with the assistance of Sherri Hiranka, Environmental Center.

Project Description

The Final Environmental Assessment (EA) should include an illustration of the major improvements being proposed to allow for a more complete visualization of the end result.

Geology and Topography

In section 3.2, the document states that grading and excavation are planned to provide for the roadway foundation. Where are the excavated materials proposed to be relocated? Where will the equipment be stored when not in use?

Soils

Section 3.3 describes the erosion potential for the Alae Sandy Loam soils in the project area but fails to detail the runoff and erosion potentials for Dune Lands and Jaucas Sand, also found in the area. Our reviewers suggest that you provide more details of the Erosion Control Plan in the Final EA to allow the public to determine if adequate measures will be taken.

Surface Water

According to the Site Plan Map (figure 2-2), the Kulanihakoi Street terminus of the project is within 700 feet of the shoreline. Is there a possibility that runoff from the construction site will enter the nearshore waters? If so, could that affect any recreation activities such as snorkeling, or any nearshore marine life? This should be discussed in section 3.5.

Flood Hazard

Under "Impacts and Mitigation Measures" on page 3-9, the DEA suggests that the proposed road improvements will conform to the conditions in the Executive Order for projects that cannot avoid being located in the base floodplain. How will those requirements be met? A discussion of methods should be included in the Final EA.

Air Quality

In mitigating short-term air quality issues, the applicant proposes in section 3.7, minimizing movement of construction equipment during peak hours. How will this be accomplished? How will the "optimal time of vehicle movement" to and from the site be determined?

On page 3-10, the DEA proposes landscaping after construction to control the generation of fugitive dust. Native plants should be considered when landscaping.

Archaeological Resources

Section 3.9 indicates the presence of four Hawaiian fishponds in the immediate vicinity of the proposed project site. How will these fishponds be affected, and are they protected?

Community Setting

Population (section 3.10.1) The road improvements are not projected to impact population in the Kihei area, but roads are often population attractors. This is due to the ease of travel to employment centers provided by improved road conditions. Was this point considered?

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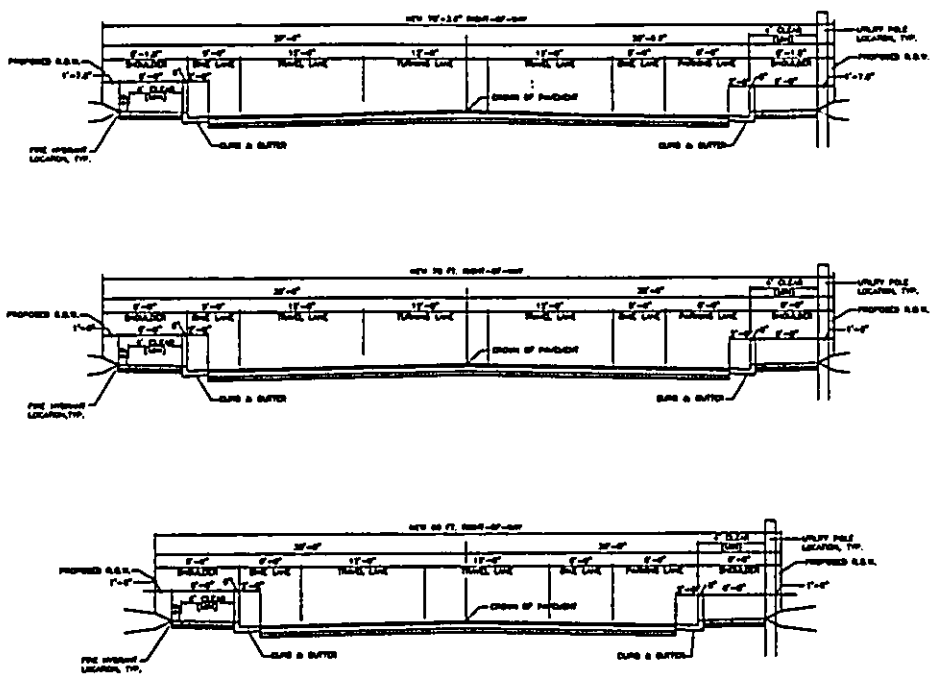


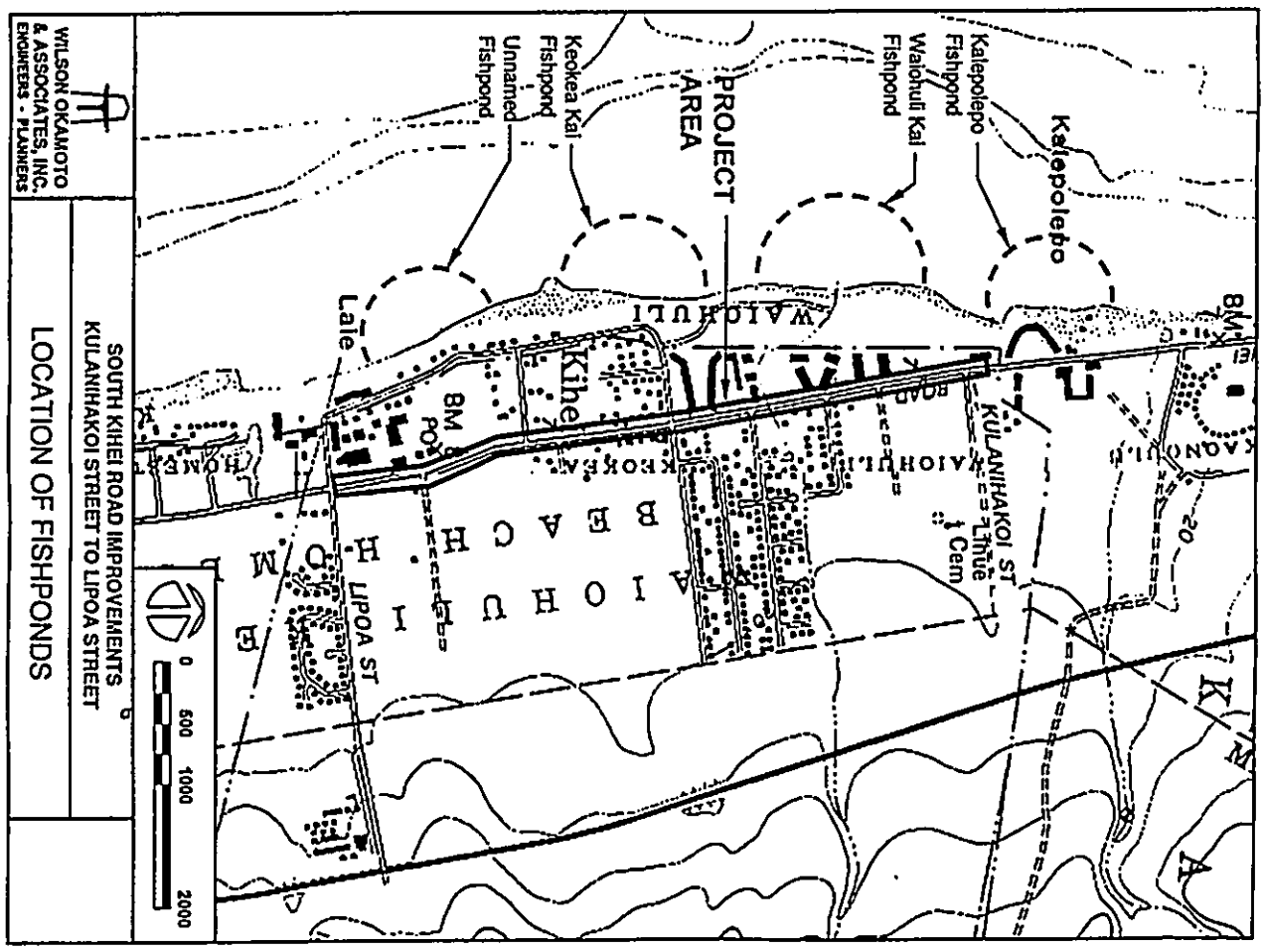
0 6 12 24

Scale in Feet

WILSON OKAMOTO & ASSOCIATES, INC.
ENGINEERS - PLANNERS

SOUTH KIHEI ROAD IMPROVEMENTS - KULANIHAKOI STREET TO LIPOA STREET

TYPICAL ROAD SECTIONS



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ENGINEERS - PLANNERS

SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET

LOCATION OF FISHPONDS

JAMES "KIMO" APANA
MAYOR

CLAYTON T ISHIKAWA
CHIEF

FRANK E. FERNANDEZ, JR.
DEPUTY CHIEF

COUNTY OF MAUI
DEPARTMENT OF FIRE CONTROL

200 DAIRY ROAD
KAHULUI, MAUI, HAWAII 96732
(808) 243-7561
FAX (808) 243-7919

January 13, 2000

RECEIVED
JAN 18 2000
WILSON OKAMOTO & ASSOC., INC.

Mr. Rodney Y. Funakoshi, AICP
Wilson Okamoto & Associates, Inc.
1907 South Beretania Street, Suite 400
Honolulu, HI 96826

RE: South Kihei Road Improvements-Kulanihakoi Street to Lipoa Street

Dear Mr. Funakoshi,

Thank you for the opportunity to comment on the South Kihei Road Improvements.

The Department of Fire Control has no comment at this time.

If you have any further questions, direct them in writing to the Fire Prevention Bureau, 21 Kinipopo Street, Wailuku, HI 96793.

Sincerely,

LEONARD F NIEMCZYK
Captain, Fire Prevention Bureau

JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
Director

DAVID C. GOODE
Deputy Director

TEL. (808) 270-7745
FAX (808) 270-7975

RALPH NAGAMINE, L.S., P.E.
Land Use and Codes Administration

RONALD R. RISKA, P.E.
Wastewater Reclamation Division

LLOYD P.C.W. LEE, P.E.
Engineering Division

ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
AND WASTE MANAGEMENT
ENGINEERING DIVISION
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

March 3, 2000

Mr. Leonard Niemczyk, Captain
Fire Prevention Bureau
County of Maui
Department of Fire Control
200 Dairy Road
Kahului, Hawaii 96732

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII

Dear Mr. Niemczyk:

Thank you for your letter dated January 13, 2000 indicating that you have no comments on the subject project. Your participation during the EA review process is appreciated.

Sincerely,

LLOYD LEE
Engineering Division Chief

LL/JK:c:(ED00-364)
K:\SHARED\ESD.DOF.wpd

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

JAMES "KIMO" APANA
MAYOR

OUR REFERENCE

YOUR REFERENCE

POLICE DEPARTMENT
COUNTY OF MAUI

55 MAHALANI STREET
WAILUKU, HAWAII 96793
(808) 244-6400
FAX (808) 244-6411

THOMAS M. PHILLIPS
CHIEF OF POLICE

DEPUTY CHIEF OF POLICE

January 19, 2000

RYF

Rodney Y. Funakoshi, AICP
Project Manager
Wilson Okamoto & Associates, Inc.
1907 South Beretania Street, Suite 400
Honolulu, Hawaii 96826

Dear Mr. Funakoshi:

Subject: Draft Environmental Assessment (EA)
South Kihei Road Improvements-Kulanihakoi Street to Lipoa Street
County Project No. 97-33
Tax Map Keys: (2)3-9-1, 2, 7, 8, 22, 34, 46, 52:various
Kihei, Maui, Hawaii

Thank you for your letter of January 5, 2000 requesting comments on the above subject.

We have reviewed the project summary and have found that the questions and concerns we had on your pre-assessment report have been taken into consideration. Thank you for the opportunity to comment on this project.

Very truly yours,

Assistant Chief Robert Tam Ho
for: Thomas M. Phillips
Chief of Police

Enclosure
c: Joe Krueger, DPWWM
Ms. Genevieve Salmonson, Director
Office of Environmental Quality Control

JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
Director

DAVID C. GOODE
Deputy Director

TEL. (808) 270-7745
FAX (808) 270-7975

COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
AND WASTE MANAGEMENT
ENGINEERING DIVISION
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

March 3, 2000

RALPH NAGAMINE, L.S., P.E.
Land Use and Codes Administration

RONALD R. RISKA, P.E.
Wastewater Reclamation Division

LLOYD P.C.W. LEE, P.E.
Engineering Division

ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

Mr. Thomas M. Phillips
Chief of Police
County of Maui
Maui Police Department
55 Mahalani
Wailuku, Hawaii 96793

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII
FAP NO. STP-3100(11)

Dear Mr. Phillips:

We have received your letter dated January 19, 2000 indicating that your concerns expressed during the pre-assessment phase of the EA have been addressed.

Thank you for your participation during the EA review process.

Sincerely,

for LLOYD LEE
Engineering Division Chief

LL/JK:c(ED00-363)
A:\LtrRes\Kresp.MPD.wpd

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

RMF

DEPARTMENT OF WATER SUPPLY
COUNTY OF MAUI
P.O. BOX 1109
WAILUKU, MAUI, HAWAII 96793-6109
Telephone (808) 270-7816 • Fax (808) 270-7833

February 10, 2000

Mr. Rodney Funakoshi
Wilson Okamoto & Associates, Inc.
1907 South Beretania Street, Suite 400
Honolulu, Hawaii 96826

Subject: Draft Environmental Assessment (EA) South Kihei Road Improvements - Kulanihakoi Street to Lipoa Street County Project No. 97-33. Tax Map Keys: 3-9-1, 2, 7, 8, 22, 34, 46, 52: various Kihei, Maui, Hawaii

Dear Mr Funakoshi,

Thank you for the opportunity to review this Draft Environmental Assessment (EA). The Department of Water Supply (DWS) provides the following information:

DWS is coordinating on a portion of this project to include water line replacement.

We have attached Best Management Practices (BMPs) for principle operations for your reference. These are designed to minimize infiltration from all construction activities and related vehicle operations. Additional information is available from the State Department of Health.

The project site is located in "Maui County Planting Plan" - Plant Zones 3 and 5. Please refer to the "Maui County Planting Plan", and to the attached documents. We encourage the applicants to consider using climate-adapted and salt-tolerant native plants where any roadside landscaping is intended and when revegetating the construction corridors. Native plants adapted to the area, conserve water and further protect the watershed from degradation due to invasive alien species.

Should you have any questions, please contact the Water Resources Planning Division at 270-7199.

Sincerely,

David Craddick
Director

emb

cc: Engineering Division
County of Maui Department of Public Works and Waste Management
State of Hawaii Office of Environmental Quality Control

attachments:

1) "Saving Water in the Yard: What & How to Plant in Your Area"
2) Selected BMPs from "Guidance Specifying Management Measures For Sources Of Nonpoint Pollution In Coastal Waters"
3) References for further reading from the "Massachusetts Nonpoint Source Management Manual - The Megamanual "

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MASSACHUSETTS NONPOINT SOURCE MANAGEMENT MANUAL

"THE MEGAMANUAL"

A GUIDANCE DOCUMENT FOR MUNICIPAL OFFICIALS

Prepared by:

Laurence N. Boutiette, Jr., P.E.
Civil Engineer
U.S.D.A., Soil Conservation Service

Christine L. Duerring
Environmental Analyst
MA Dept. of Environmental Protection

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF WATERSHED MANAGEMENT
NONPOINT SOURCE PROGRAM
BOSTON, MA

Executive Office of Environmental Affairs
Trudy Coxe, Secretary

Massachusetts Department of Environmental Protection
Thomas B. Powers, Acting Commissioner

Policy and Program Development
Arleen O'Donnell, Acting Deputy Commissioner

Bureau of Resource Protection
Dean Spencer, Acting Assistant Commissioner

Office of Watershed Management
Andrew Gottlieb, Director

May 1994
Revised

Publication No. 17356-500-500-6/93-67.00
Approved by: Philmore Anderson III, State Purchasing Agent

United States Environmental Protection Agency | Office of Water Washington, DC 20460 | 840-B-92-002 January 1993

EPA

Guidance Specifying Management Measures For Sources Of Nonpoint Pollution In Coastal Waters

Issued Under the Authority of
Section 6217(g) of the Coastal Zone Act
Reauthorization Amendments of 1990

a highway and a watercourse that is needed to buffer the runoff flow and prevent potential contaminants from entering surface waters. Other design elements such as project alignment, gradient, cross section, and the number of stream crossings also must be taken into account to achieve successful control of erosion and nonpoint sources of pollution. (Refer to Chapter 3 of this guidance for details on road designs for different terrains.)

The following case study illustrates some of the problems and associated costs that may occur due to poor road construction and design. These issues should be addressed in the planning and design phase.

> ***CASE STUDY - ANNAPOLIS, MARYLAND***
>
> Poor road siting and design resulted in concentrated runoff flows and heavy erosion that threatened several house foundations adjacent to the road. Sediment-laden runoff was also discharged into Herring Bay. To protect the Chesapeake Bay and the nearby houses, the county corrected the problem by installing diversions, a curb-and-drain urban runoff conveyance, and a rock wall filtration system, at a total cost of $100,000 (Munsey, 1992).

3. Management Measure Selection

This management measure was selected because it follows the approach to highway development recommended by the American Association of State Highway and Transportation Officials (AASHTO), Federal Highway Administration (FHWA) guidance, and highway location and design guidelines used by the States of Virginia, Maryland, Washington, and others.

Additionally, AASHTO has location and design guidelines (AASHTO, 1990, 1991) available for State highway agency use that describe the considerations necessary to control erosion and highway-related pollutants. Federal Highway Administration policy (FHWA, 1991) requires that Federal-aid highway projects and highways constructed under direct supervision of the FHWA be located, designed, constructed, and operated according to standards that will minimize erosion and sediment damage to the highway and adjacent properties and abate pollution of surface water and ground-water resources.

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

- *a. Consider type and location of permanent erosion and sediment controls (e.g., vegetated filter strips, grassed swales, pond systems, infiltration systems, constructed urban runoff wetlands, and energy dissipators and velocity controls) during the planning phase of roads, highway, and bridges. (AASHTO, 1991; Hartigan et al., 1989)*

- *b. All wetlands that are within the highway corridor and that cannot be avoided should be mitigated. These actions will be subject to Federal Clean Water Act section 404 requirements and State regulations.*

- *c. Assess and establish adequate setback distances near wetlands, waterbodies, and riparian areas to ensure protection from encroachment in the vicinity of these areas.*

Setback distances should be determined on a site-specific basis since several variables may be involved such as topography, soils, floodplains, cut-and-fill slopes, and design geometry. In level or gently sloping terrain, a general rule of thumb is to establish a setback of 50 to 100 feet from the edge of the wetland or riparian area and the right-of-way. In areas of steeply sloping terrain (20 percent or greater), setbacks of 100 feet or more are recommended. Right-of-way setbacks from major waterbodies (oceans, lakes, estuaries, rivers) should be in excess of 100 to 1000 feet.

- *d. Avoid locations requiring excessive cut and fill. (AASHTO, 1991)*

- *e. Avoid locations subject to subsidence, sink holes, landslides, rock outcroppings, and highly erodible soils. (AASHTO, 1991; TRB, Campbell, 1988)*

- *f. Size rights-of-way to include space for siting runoff pollution control structures as appropriate. (AASHTO, 1991; Hartigan, et al., 1989)*

Erosion and sediment control structures (extended detention dry ponds, permanent sediment traps, catchment basins, etc.) should be planned and located during the design phase and included as part of the design specifications to ensure that such structures, where needed, are provided within the highway right-of-way.

- *g. Plan residential roads and streets in accordance with local subdivision regulations, zoning ordinances, and other local site planning requirements (International City Managers Association, Model Zoning/Subdivision Codes). Residential road and street pavements should be designed with minimum widths.*

Local roads and streets should have right-of-way widths of 36 to 50 feet, with lane widths of 10 to 12 feet. Minimum pavement widths for residential streets where street parking is permitted range from 24 to 28 feet between curbs. In large-lot subdivisions (1 acre or more), grassed drainage swales can be used in lieu of curbs and gutters and the width of paved road surface can be between 18 and 20 feet.

- *h. Select the most economic and environmentally sound route location. (FHWA, 1991)*

- *i. Use appropriate computer models and methods to determine urban runoff impacts with all proposed route corridors. (Driscoll, 1990)*

Computer models to determine urban runoff from streets and highways include TR-55 (Soil Conservation Service model for controlling peak runoff); the P-8 model to determine storage capacity (Palmstrom and Walker); the FHWA highway runoff model (Driscoll et al., 1990); and others (e.g., SWMM, EPA's stormwater management model; HSP continuous simulation model by Hydrocomp, Inc.).

- *j. Comply with National Environmental Policy Act requirements including other State and local requirements. (FHWA, T6640.8A)*

- *k. Coordinate the design of pollution controls with appropriate State and Federal environmental agencies. (Maryland DOE, 1983)*

l. Develop local official mapping to show location of proposed highway corridors.

Official mapping can be used to reserve land areas needed for public facilities such as roads, highways, bridges, and urban runoff treatment devices. Areas that require protection, such as those which are sensitive to disturbance or development-related nonpoint source pollution, can be reserved by planning and mapping necessary infrastructure for location in suitable areas.

5. Effectiveness Information and Cost Information

The most economical time to consider the type and location of erosion, sediment, and NPS pollution control is early in the planning and design phase of roads and highways. It is much more costly to correct polluted runoff problems after a road or highway has already been built. The most effective and often the most economical control is to design roads and highways as close to existing grade as possible to minimize the area that must be cut or filled and to avoid locations that encroach upon adjacent watercourses and wet areas. However, some portions of roads and highways cannot always be located where NPS pollution does not pose a threat to surface waters. In these cases, the impact from potential pollutant loadings should be mitigated. Interactive computer models designed to run on a PC are available (e.g., FHWA's model, Driscoll et al., 1990) and can be used to examine and project the runoff impacts of a proposed road or highway design on surface waters. Where controls are determined to be needed, several cost-effective management practices, such as vegetated filter strips, grassed swales, and pond systems, can be considered and used to treat the polluted runoff. These mitigating practices are described in detail in the discussion on urban developments (Management Measure IV.A).

B. Management Measure for Bridges

Site, design, and maintain bridge structures so that sensitive and valuable aquatic ecosystems and areas providing important water quality benefits are protected from adverse effects.

1. Applicability

This management measure is intended to be applied by States to new, relocated, and rehabilitated bridge structures in order to control erosion, streambed scouring, and surface runoff from such activities. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal NPS programs in conformity with this management measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

This measure requires that NPS runoff impacts on surface waters from bridge decks be assessed and that appropriate management and treatment be employed to protect critical habitats, wetlands, fisheries, shellfish beds, and domestic water supplies. The siting of bridges should be a coordinated effort among the States, the FHWA, the U.S. Coast Guard, and the Army Corps of Engineers. Locating bridges in coastal areas can cause significant erosion and sedimentation, resulting in the loss of wetlands and riparian areas. Additionally, since bridge pavements are extensions of the connecting highway, runoff waters from bridge decks also deliver loadings of heavy metals, hydrocarbons, toxic substances, and deicing chemicals to surface waters as a result of discharge through scupper drains with no overland buffering. Bridge maintenance can also contribute heavy loads of lead, rust particles, paint, abrasive, solvents, and cleaners into surface waters. Protection against possible pollutant overloads can be afforded by minimizing the use of scuppers on bridges traversing very sensitive waters and conveying deck drainage to land for treatment. Whenever practical, bridge structures should be located to avoid crossing over sensitive fisheries and shellfish-harvesting areas to prevent washing polluted runoff through scuppers into the waters below. Also, bridge design should account for potential scour and erosion, which may affect shellfish beds and bottom sediments.

3. Management Measure Selection

This management measure was selected because of its documented effectiveness and to protect against potential pollution impacts from siting bridges over sensitive waters and tributaries in the coastal zone. There are several examples of siting bridges to protect sensitive areas. The Isle of Palms Bridge near Charleston, South Carolina, was designed without scupper drains to protect a local fishery from polluted runoff by preventing direct discharge into the waters below. In another example, the Louisiana Department of Transportation and Development specified stringent requirements before allowing the construction of a bridge to protect destruction of fragile wetlands near New Orleans. A similar requirement was specified for bridge construction in the Tampa Bay area in Florida (ENR, 1991).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

Additional erosion and sediment control management practices are listed in the construction section for urban sources of pollution (Management Measure IV.A).

a. Coordinate design with FHWA, USCG, COE, and other State and Federal agencies as appropriate.

b. Review National Environmental Policy Act requirements to ensure that environmental concerns are met (FHWA, T6640.8A and 23 CFR 771).

c. Avoid highway locations requiring numerous river crossings. (AASHTO, 1991)

d. Direct pollutant loadings away from bridge decks by diverting runoff waters to land for treatment.

Bridge decks should be designed to keep runoff velocities low and control pollutant loadings. Runoff waters should be conveyed away from contact with the watercourse and directed to a stable storm drainage, wetland, or detention pond. Conveyance systems should be designed to withstand the velocities of projected peak discharge.

e. Restrict the use of scupper drains on bridges less than 400 feet in length and on bridges crossing very sensitive ecosystems.

Scupper drains allow direct discharge of runoff into surface waters below the bridge deck. Such discharges can be of concern where the waterbody is highly susceptible to degradation or is an outstanding resource such as a spawning area or shellfish bed. Other sensitive waters include water supply sources, recreational waters, and irrigation systems. Care should be taken to protect these areas from contaminated runoff.

f. Site and design new bridges to avoid sensitive ecosystems.

Pristine waters and sensitive ecosystems should be protected from degradation as much as possible. Bridge structures should be located in alternative areas where only minimal environmental damage would result.

g. On bridges with scupper drains, provide equivalent urban runoff treatment in terms of pollutant load reduction elsewhere on the project to compensate for the loading discharged off the bridge.

5. Effectiveness Information and Cost Information

Effectively controlling NPS pollutants such as road contaminants, fugitive dirt, and debris and preventing accidental spills from entering surface waters via bridge decks are necessary to protect wetlands and other sensitive ecosystems. Therefore, management practices such as minimizing the use of scupper drains and diverting runoff waters to land for treatment in detention ponds and infiltration systems are known to be effective in mitigating pollutant loadings. Tables 4-7 and 4-8 in Section II provide cost and effectiveness data for ponds, constructed wetlands, and filtration devices.

C. Management Measure for Construction Projects

(1) Reduce erosion and, to the extent practicable, retain sediment onsite during and after construction and

(2) Prior to land disturbance, prepare and implement an approved erosion control plan or similar administrative document that contains erosion and sediment control provisions.

1. Applicability

This management measure is intended to be applied by States to new, replaced, restored, and rehabilitated road, highway, and bridge construction projects in order to control erosion and offsite movement of sediment from such project sites. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal NPS programs in conformity with this management measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

Erosion and sedimentation from construction of roads, highways, and bridges, and from unstabilized cut-and-fill areas, can significantly impact surface waters and wetlands with silt and other pollutants including heavy metals, hydrocarbons, and toxic substances. Erosion and sediment control plans are effective in describing procedures for mitigating erosion problems at construction sites before any land-disturbing activity begins. Additional relevant practices are described in Management Measures III.A and III.B of this chapter.

Bridge construction projects include grade separations (bridges over roads) and waterbody crossings. Erosion problems at grade separations result from water running off the bridge deck and runoff waters flowing onto the bridge deck during construction. Controlling this runoff can prevent erosion of slope fills and the undermining failure of the concrete slab at the bridge approach. Bridge construction over waterbodies requires careful planning to limit the disturbance of streambanks. Soil materials excavated for footings in or near the water should be removed and relocated to prevent the material from being washed back into the waterbody. Protective berms, diversion ditches, and silt fences parallel to the waterway can be effective in preventing sediment from reaching the waterbody.

Wetland areas will need special consideration if affected by highway construction, particularly in areas where construction involves adding fill, dredging, or installing pilings. Highway development is most disruptive in wetlands since it may cause increased sediment loss, alteration of surface drainage patterns, changes in the subsurface water table, and loss of wetland habitat. Highway structures should not restrict tidal flows into salt marshes and other coastal wetland areas because this might allow the intrusion of freshwater plants and reduce the growth of salt-tolerant species. To safeguard these fragile areas, the best practice is to locate roads and highways with sufficient setback distances between the highway right-of-way and any wetlands or riparian areas. Bridge construction also can impact water circulation and quality in wetland areas, making special techniques necessary to accommodate construction. The following case study provides an example of a construction project where special considerations were given to wetlands.

CASE STUDY - BRIDGING WETLANDS IN LOUISIANA

To provide protection for an environmentally critical wetland outside New Orleans, the Louisiana Department of Transportation and Development (DOTD) required a special construction technique to build almost 2 miles of twin elevated structures for the Interstate 310 link between I-10 and U.S. Route 90. A technique known as "end-on" construction was devised to work from the decks of the structures, building each section of the bridge from the top of the last completed section and using heavy cranes to push each section forward one bay at a time. The cranes were also used to position steel platforms, drive in support pilings, and lay deck slabs, alternating this procedure between each bay. Without this technique, the Louisiana DOTD would not have been permitted to build this structure. The twin 9,200-foot bridges took 485 days to complete at a cost of $25.3 million (*Engineering News Record*, 1991).

3. Management Measure Selection

This management measure was selected because it supports FHWA's erosion and sediment control policy for all highway and bridge construction projects and is the administrative policy of several State highway departments and local governmental agencies involved in land development activity. Examples of erosion and sediment controls and NPS pollutant control practices are described in AASHTO guidelines and in several State erosion control manuals (AASHTO, 1991; North Carolina DOT, 1991; Washington State DOT, 1988). A detailed discussion of cost-effective management practices is available in the urban development section (Section II) of this chapter. These example practices are also effective for highway construction projects.

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

Additional erosion and sediment control management practices are listed in the construction section (Section III) of this chapter.

■ *a. Write erosion and sediment control requirements into plans, specifications, and estimates for Federal aid construction projects for highways and bridges (FHWA, 1991) and develop erosion control plans for earth-disturbing activities.*

Erosion and sediment control decisions made during the planning and location phase should be written into the contract, plans, specifications, and special provisions provided to the construction contractor. This approach can establish contractor responsibility to carry out the explicit contract plan recommendations for the project and the erosion control practices needed.

■ *b. Coordinate erosion and sediment controls with FHWA, AASHTO, and State guidelines.*

Coordination and scheduling of the project work with State and local authorities are major considerations in controlling anticipated erosion and sediment problems. In addition, the contractor should submit a general work schedule and plan that indicates planned implementation of temporary and permanent erosion control practices, including shutdown procedures for winter and other work interruptions. The plan also should include proposed methods of control on restoring borrow pits and the disposal of waste and hazardous materials.

■ *c. Install permanent erosion and sediment control structures at the earliest practicable time in the construction phase.*

Permanent or temporary soil stabilization practices should be applied to cleared areas within 15 days after final grade is reached on any portion of the site. Soil stabilization should also be applied within 15 days to denuded areas that may not be at final grade but will remain exposed to rain for 30 days or more. Soil stabilization practices protect soil from the erosive forces of raindrop impact and flowing water. Temporary erosion control practices usually include seeding, mulching, establishing general vegetation, and early application of a gravel base on areas to be paved. Permanent soil stabilization practices include vegetation, filter strips, and structural devices.

Sediment basins and traps, perimeter dikes, sediment barriers, and other practices intended to trap sediment on site should be constructed as a first step in grading and should be functional before upslope land disturbance takes place. Structural practices such as earthen dams, dikes, and diversions should be seeded and mulched within 15 days of installation.

■ *d. Coordinate temporary erosion and sediment control structures with permanent practices.*

All temporary erosion and sediment controls should be removed and disposed of within 30 days after final site stabilization is achieved or after the temporary practices are no longer needed. Trapped sediment and other disturbed soil areas resulting from the disposition of temporary controls should be permanently stabilized to prevent further erosion and sedimentation (AASHTO, 1991).

■ *e. Wash all vehicles prior to leaving the construction site to remove mud and other deposits. Vehicles entering or leaving the site with trash or other loose materials should be covered to prevent transport of dust, dirt, and debris. Install and maintain mud and silt traps.*

■ *f. Mitigate wetland areas destroyed during construction.*

Marshes and some types of wetlands can often be developed in areas where fill material was extracted or in ponds designed for sediment control during construction. Vegetated strips of native marsh grasses established along highway embankments near wetlands or riparian areas can be effective to protect these areas from erosion and sedimentation (FHWA, 1991).

■ *g. Minimize the area that is cleared for construction.*

■ *h. Construct cut-and-fill slopes in a manner that will minimize erosion.*

Cut-and-fill slopes should be constructed in a manner that will minimize erosion by taking into consideration the length and steepness of slopes, soil types, upslope drainage areas, and ground-water conditions. Suggested recommendations are as follows: reduce the length of long steep slopes by adding diversions or terraces; prevent concentrated runoff from flowing down cut-and-fill slopes by containing these flows within flumes or slope drain structures; and create roughened soil surfaces on cut-and-fill slopes to slow runoff flows. Wherever a slope face crosses a water seepage plane, thereby endangering the stability of the slope, adequate subsurface drainage should be provided.

■ *i. Minimize runoff entering and leaving the site through perimeter and onsite sediment controls.*

■ *j. Inspect and maintain erosion and sediment control practices (both on-site and perimeter) until disturbed areas are permanently stabilized.*

k. *Divert and convey offsite runoff around disturbed soils and steep slopes to stable areas in order to prevent transport of pollutants off site.*

l. *After construction, remove temporary control structures and restore the affected area. Dispose of sediments in accordance with State and Federal regulations.*

m. *All storm drain inlets that are made operable during construction should be protected so that sediment-laden water will not enter the conveyance system without first being filtered or otherwise treated to remove sediment.*

5. Effectiveness Information and Cost Information

The detailed cost and effectiveness information presented under the construction measure for urban development is also applicable to road, highway, and bridge construction. See Tables 4-15 and 4-16 in Section III.

D. Management Measure for Construction Site Chemical Control

(1) Limit the application, generation, and migration of toxic substances;

(2) Ensure the proper storage and disposal of toxic materials; and

(3) Apply nutrients at rates necessary to establish and maintain vegetation without causing significant nutrient runoff to surface water.

1. Applicability

This management measure is intended to be applied by States to new, resurfaced, restored, and rehabilitated road, highway, and bridge construction projects in order to reduce toxic and nutrient loadings from such project sites. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal NPS programs in conformity with this management measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

The objective of this measure is to guard against toxic spills and hazardous loadings at construction sites from equipment and fuel storage sites. Toxic substances tend to bind to fine soil particles; however, by controlling sediment mobilization, it is possible to limit the loadings of these pollutants. Also, some substances such as fuels and solvents are hazardous and excess applications or spills during construction can pose significant environmental impacts. Proper management and control of toxic substances and hazardous materials should be the adopted procedure for all construction projects and should be established by erosion and sediment control plans. Additional relevant practices are described in Management Measure III.B of this chapter.

3. Management Measure Selection

This management measure was selected because of existing practices that have been shown to be effective in mitigating construction-generated NPS pollution at highway project sites and equipment storage yards. In addition, maintenance areas containing road salt storage, fertilizers and pesticides, snowplows and trucks, and tractor mowers have the potential to contribute NPS pollutants to adjacent watercourses if not properly managed (AASHTO, 1988, 1991a). This measure is intended to safeguard surface waters and ground water from toxic and hazardous pollutants generated at construction sites. Examples of effective implementation of this measure are presented in the section on construction in urban areas. Several State environmental agencies are using this approach to regulate toxic and hazardous pollutants (Florida DER, 1988; Puget Sound Basin, 1991).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

The practices that are applicable to this management measure are described in Section III.B.

5. Effectiveness Information and Cost Information

The detailed cost and effectiveness data presented in the Section III.A of this chapter describing NPS controls for construction projects in urban development areas are also applicable to highway construction projects.

E. Management Measure for Operation and Maintenance

Incorporate pollution prevention procedures into the operation and maintenance of roads, highways, and bridges to reduce pollutant loadings to surface waters.

1. Applicability

This management measure is intended to be applied by States to existing, restored, and rehabilitated roads, highways, and bridges. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal NPS programs in conformity with this management measures and will have some flexibility in doing so. The application of measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

Substantial amounts of eroded material and other pollutants can be generated by operation and maintenance procedures for roads, highways, and bridges, and from sparsely vegetated areas, cracked pavements, potholes, and poorly operating urban runoff control structures. This measure is intended to ensure that pollutant loadings from roads, highways, and bridges are minimized by the development and implementation of a program and associated practices to ensure that sediment and toxic substance loadings from operation and maintenance activities do not impair coastal surface waters. The program to be developed, using the practices described in this management measure, should consist of and identify standard operating procedures for nutrient and pesticide management, road salt use minimization, and maintenance guidelines (e.g., capture and contain paint chips and other particulates from bridge maintenance operations, resurfacing, and pothole repairs).

3. Management Measure Selection

This management measure for operation and maintenance was selected because (1) it is recommended by FHWA as a cost-effective practice (FHWA, 1991); (2) it is protective of the human environment (Puget Sound Water Quality Authority, 1989); (3) it is effective in controlling erosion by revegetating bare slopes (AASHTO, 1991b); (4) it is helpful in minimizing polluted runoff from road pavements (Transportation Research Board, 1991); and (5) both Federal (Richardson, 1974) and State highway agencies (Minnesota Pollution Control Agency, 1989; Pitt, 1973) advocate highway maintenance as an effective practice for minimizing pollutant loadings.

Maintenance of erosion and sediment control practices is of critical importance. Both temporary and permanent controls require frequent and periodic cleanout of accumulated sediment. Any trapping or filtering device, such as silt fences, sediment basins, buffers, inlets, and check dams, should be checked and cleaned out when approximately 50 percent of their capacity is reached, as determined by the erodible nature of the soil, flow velocity, and quantity of runoff. Seasonal and climatic differences may require more frequent cleanout of these structures. The sediments removed from these control devices should be deposited in permanently stabilized areas to prevent further erosion and sediment from reaching drainages and receiving streams. After periods of use, control devices may require replacement of deteriorated materials such as straw bales and silt fence fabrics, or restoration and reconstruction of sediment basins and riprap installations.

Permanent erosion controls such as vegetated filter strips, grassed swales, and velocity dissipators should be inspected periodically to determine their integrity and continued effectiveness. Continual deterioration or damage to these controls may indicate a need for better design or construction.

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully apply to achieve the management measure described above.

a. *Seed and fertilize, seed and mulch, and/or sod damaged vegetated areas and slopes.*

b. *Establish pesticide/herbicide use and nutrient management programs.*

Refer to the Management Measure for Construction Site Chemical Control in this chapter.

c. *Restrict herbicide and pesticide use in highway rights-of-way to applicators certified under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) to ensure safe and effective application.*

d. *The use of chemicals such as soil stabilizers, dust palliatives, sterilants, and growth inhibitors should be limited to the best estimate of optimum application rates. All feasible measures should be taken to avoid excess application and consequent intrusion of such chemicals into surface runoff.*

e. *Sweep, vacuum, and wash residential/urban streets and parking lots.*

f. *Collect and remove road debris.*

g. *Cover salt storage piles and other deicing materials to reduce contamination of surface waters. Locate them outside the 100-year floodplain.*

h. *Regulate the application of deicing salts to prevent oversalting of pavement.*

i. *Use specially equipped salt application trucks.*

j. *Use alternative deicing materials, such as sand or salt substitutes, where sensitive ecosystems should be protected.*

k. *Prevent dumping of accumulated snow into surface waters.*

l. *Maintain retaining walls and pavements to minimize cracks and leakage.*

m. *Repair potholes.*

n. *Encourage litter and debris control management.*

o. *Develop an inspection program to ensure that general maintenance is performed on urban runoff and NPS pollution control facilities.*

To be effective, erosion and sediment control devices and practices must receive thorough and periodic inspection checks. The following is a suggested checklist for the inspection of erosion and sediment controls (AASHTO Operating Subcommittee on Design, 1990):

- Clean out sediment basins and traps; ensure that structures are stable.
- Inspect silt fences and replace deteriorated fabrics and wire connections; properly dispose of deteriorated materials.
- Renew riprapped areas and reapply supplemental rock as necessary.
- Repair/replace check dams and brush barriers; replace or stabilize straw bales as needed.
- Regrade and shape berms and drainage ditches to ensure that runoff is properly channeled.
- Apply seed and mulch where bare spots appear, and replace matting material if deteriorated.
- Ensure that culverts and inlets are protected from siltation.
- Inspect all permanent erosion and sediment controls on a scheduled, programmed basis.

p. *Ensure that energy dissipators and velocity controls to minimize runoff velocity and erosion are maintained.*

q. *Dispose of accumulated sediment collected from urban runoff management and pollution control facilities, and any wastes generated during maintenance operations, in accordance with appropriate local, State, and Federal regulations.*

r. *Use techniques such as suspended tarps, vacuums, or booms to reduce, to the extent practicable, the delivery to surface waters of pollutants used or generated during bridge maintenance (e.g., paint, solvents, scrapings).*

s. *Develop education programs to promote the practices listed above.*

5. Effectiveness Information and Cost Information

Preventive maintenance is a time-proven, cost-effective management approach. Operation schedules and maintenance procedures to restore vegetation, proper management of salt and fertilizer application, regular cleaning of urban runoff structures, and frequent sweeping and vacuuming of urban streets have effective results in pollution control. Litter control, clean-up, and fix-up practices are a low-cost means for eliminating causes of pollution, as is the proper handling of fertilizers, pesticides, and other toxic materials including deicing salts and abrasives. Table 4-30 presents summary information on the cost and effectiveness of operation and maintenance practices for roads, highways, and bridges. Many States and communities are already implementing several of these practices within their budget limitations. As shown in Table 4-30, the use of road salt alternatives such as calcium magnesium acetate (CMA) can be very costly. Some researchers have indicated, however, that reductions in corrosion of infrastructure, damage to roadside vegetation, and the quantity of material that needs to be applied may offset the higher cost of CMA. Use of road salt minimization practices such as salt storage protection and special salt spreading equipment reduces the amount of salt that a State or community must purchase. Consequently, implementation of these practices can pay for itself through savings in salt purchasing costs. Similar programs such as nutrient and pesticide management can also lead to decreased expenditures for materials.

CMA Eligible for Matching Funds

Calcium magnesium acetate (CMA) is now eligible for Federal matching funds under the Bridge Program of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. The Act provides 80 percent funding for use of CMA on salt-sensitive bridges in order to protect against corrosion and to extend their useful life. CMA can also be used to protect vegetation from salt damage in environmentally sensitive areas.

Table 4-30. Effectiveness and Cost Summary for Roads, Highways, and Bridges Operation and Maintenance Management Practices

Management Practice	% Removal TSS	TP	TN	COD	Pb	Zn	Cost
MAINTAIN VEGETATION							
For Sediment Control							
Average:	90	NA	NA	NA	NA	NA	Natural succession allowed to occur - Avg: $100/ac/year
Reported Range:	50-100	NA	NA	NA	NA	NA	Reported Range: $50-$200/ac/year
Probable Range:	80-100	-	-	-	-	-	
For Pollutant Removal							
Average:	60	40	40	50	50	50	Natural succession not allowed to occur - Avg: $800/ac/year
Reported Range	0-100	0-100	0-70	20-80	0-100	50-80	Reported Range: $700-$900/ac/year
Probable Range:	0-100	0-100	0-100	0-100	0-100	0-100	
PESTICIDE/HERBICIDE USE MANAGEMENT							Generally accepted as an economical program to control excessive use
Average:	NA						
Reported Range:	NA						
Probable Range:							
STREET SWEEPING							
Smooth Street, Frequent Cleaning (One or More Passes Per Week)							Avg: $20/curb mile Reported Range: $10-$30/curb mile
Average:	20	NA	NA	5	25	NA	
Reported Range:	20	NA	NA	0-10	5-35	NA	
Probable Range:	20-50	-	-	0-10	20-50	10-30	
Infrequent Cleaning (One Pass Per Month or Less)							
Average:	NA	NA	NA	NA	5	NA	
Reported Range:	NA	NA	NA	NA	0-10	NA	
Probable Range:	0-20	-	-	-	0-20	0-10	
LITTER CONTROL							
Average:	NA						Generally accepted as an economical approach to control excessive use
Reported Range:	NA						
Probable Range:							

CMA Eligible for Matching Funds

Calcium magnesium acetate (CMA) is now eligible for Federal matching funds under the Bridge Program of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. The Act provides 80 percent funding for use of CMA on salt-sensitive bridges in order to protect against corrosion and to extend their useful life. CMA can also be used to protect vegetation from salt damage in environmentally sensitive areas.

Table 4-30. Effectiveness and Cost Summary for Roads, Highways, and Bridges Operation and Maintenance Management Practices

Management Practice	% Removal						Cost
	TSS	TP	TN	COD	Pb	Zn	
MAINTAIN VEGETATION For Sediment Control							
Average:	90	NA	NA	NA	NA	NA	Natural succession allowed to occur - Avg: $100/ac/year Reported Range: $50-$200/ac/year
Reported Range:	50-100	NA	NA	NA	NA	NA	
Probable Range:	80-100	-	-	-	-	-	
For Pollutant Removal							
Average:	60	40	40	50	50	50	Natural succession not allowed to occur - Avg: $800/ac/year Reported Range: $700-$900/ac/year
Reported Range	0-100	0-100	0-70	20-80	0-100	0-100	
Probable Range:	0-100	0-100	0-100	0-100	0-100	0-100	
PESTICIDE/HERBICIDE USE MANAGEMENT							Generally accepted as an economical program to control excessive use
Average:	NA						
Reported Range:	NA						
Probable Range:							
STREET SWEEPING							
Smooth Street, Frequent Cleaning (One or More Passes Per Week)							
Average:	20	NA	NA	5		25	Avg: $20/curb mile Reported Range: $10-$30/curb mile
Reported Range:	20	NA	NA	0-10		NA	
Probable Range:	20-50	-	-	0-10		10-30	
Infrequent Cleaning (One Pass Per Month or Less)							
Average:	NA	NA	NA	NA		5	
Reported Range:	NA	NA	NA	NA		0-10	
Probable Range:	0-20	-	-	-		0-20	
LITTER CONTROL							Generally accepted as an economical approach to control excessive use
Average:	NA					NA	
Reported Range:	NA					NA	
Probable Range:						0-10	

Table 4-30. (Continued)

Management Practice	% Removal TSS	TP	TN	COD	Pb	Zn	Cost
GENERAL MAINTENANCE (e.g. pothole and roadside repairs)							Generally accepted as an economical preventive maintenance program by local and State agencies
Average:	NA						
Reported Range:	NA						
Probable Range:							
PROTECTION OF SALT PILES							For salt storage building - Ave: $30/ton salt Reported Range: $10-$70/ton salt
Average:	NA						
Reported Range:	NA						
Probable Range:	90-100[a]						
MINIMIZATION OF APPLICATION OF DEICING SALTS							Generally accepted as an economical preventive maintenance program by local and State agencies
Average:	NA						
Reported Range:	NA						
Probable Range:	*Deicing salts that are not applied to roads will not enter runoff.*[a]						
SPECIALLY EQUIPPED SALT APPLICATION TRUCKS							For spread rate control on truck - Ave: $8,000/truck Reported Range: $6,000/truck
Average:	NA						
Reported Range:	NA						
Probable Range:	Deicing salts that are not applied to roads will not enter runoff.[a]						
USE OF ALTERNATIVE DEICING MATERIALS							CMA - Ave: $650/ton Reported Range: $850/ton (note: cost of salt $30/ton)
Average:	NA						
Reported Range:	NA						
Probable Range:	Deicing salts that are not applied to roads will not enter runoff.[a]						
CONTAIN POLLUTANTS GENERATED DURING BRIDGE MAINTENANCE							Varies with method of containment use
Average:	NA						
Reported Range:	NA						
Probable Range:	50-100[b]						

NA = Not applicable.
[a]Measured as reduction in salt.
[b]Measured as reduction of all pollutants.

F. Management Measure for Road, Highway, and Bridge Runoff Systems

Develop and implement runoff management systems for existing roads, highways, and bridges to reduce runoff pollutant concentrations and volumes entering surface waters.

(1) Identify priority and watershed pollutant reduction opportunities (e.g., improvements to existing urban runoff control structures; and

(2) Establish schedules for implementing appropriate controls.

1. Applicability

This management measure is intended to be applied by States to existing, resurfaced, restored, and rehabilitated roads, highways, and bridges that contribute to adverse effects in surface waters. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal NPS programs in conformity with this management measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

This measure requires that operation and maintenance systems include the development of retrofit projects, where needed, to collect NPS pollutant loadings from existing, reconstructed, and rehabilitated roads, highways, and bridges. Poorly designed or maintained roads and bridges can generate significant erosion and pollution loads containing heavy metals, hydrocarbons, sediment, and debris that run off into and threaten the quality of surface waters and their tributaries. In areas where such adverse impacts to surface waters can be attributed to adjacent roads or bridges, retrofit management projects to protect these waters may be needed (e.g., installation of structural or nonstructural pollution controls). Retrofit projects can be located in existing rights-of-way, within interchange loops, or on adjacent land areas. Areas with severe erosion and pollution runoff problems may require relocation or reconstruction to mitigate these impacts.

Runoff management systems are a combination of nonstructural and structural practices selected to reduce nonpoint source loadings from roads, highways, and bridges. These systems are expected to include structural improvements to existing runoff control structures for water quality purposes; construction of new runoff control devices, where necessary to protect water quality; and scheduled operation and maintenance activities for these runoff control practices. Typical runoff controls for roads, highways, and bridges include vegetated filter strips, grassed swales, detention basins, constructed wetlands, and infiltration trenches.

3. Management Measure Selection

This management measure was selected because of the demonstrated effectiveness of retrofit systems for existing roads and highways that were constructed with inadequate nonpoint source pollution controls or without such controls. Structural practices for mitigating polluted runoff from existing highways are described in the literature (Silverman, 1988).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

- *a. Locate runoff treatment facilities within existing rights-of-way or in medians and interchange loops.*
- *b. Develop multiple-use treatment facilities on adjacent lands (e.g., parks and golf courses).*
- *c. Acquire additional land for locating treatment facilities.*
- *d. Use underground storage where no alternative is available.*
- *e. Maximize the length and width of vegetated filter strips to slow the travel time of sheet flow and increase the infiltration rate of urban runoff.*

5. Effectiveness Information and Cost Information

Cost and effectiveness data for structural urban runoff management and pollution control facilities are outlined in Tables 4-15 and 4-16 in Section III and discussed in Section IV of this chapter and are applicable to determine the cost and effectiveness of retrofit projects. Retrofit projects can often be more costly to construct because of the need to locate the required structures within existing space or the need to locate the structures within adjacent property that requires purchase. However, the use of multiple-use facilities on adjacent lands, such as diverting runoff waters to parkland or golf courses, can offset this cost. Nonstructural practices described in the urban section also can be effective in achieving source control. As with other sections of this document, the costs of loss of habitat, fisheries, and recreational areas must be weighed against the cost of retrofitting control structures within existing rights-of-way.

6. Pollutants of Concern

Table 4-31 lists the pollutants commonly found in urban runoff from roads, highways, and bridges and their sources. The disposition and subsequent magnitude of pollutants found in highway runoff are site-specific and are affected by traffic volume, road or highway design, surrounding land use, climate, and accidental spills.

The FHWA conducted an extensive field monitoring and laboratory analysis program to determine the pollutant concentration in highway runoff from 31 sites in 11 States (Driscoll et al., 1990). The event mean concentrations (EMCs) developed in the study for a number of pollutants are presented in Table 4-32. The study also indicated that for highways discharging into lakes, the pollutants of major concern are phosphorus and heavy metals. For highways discharging into streams, the pollutants of major concern are heavy metals—cadmium, copper, lead, and zinc.

Table 4-31. Highway Runoff Constituents and Their Primary Sources

Constituents	Primary Sources
Particulates	Pavement wear, vehicles, atmosphere, maintenance
Nitrogen, Phosphorus	Atmosphere, roadside fertilizer application
Lead	Leaded gasoline (auto exhaust), tire wear (lead oxide filler material, lubricating oil and grease, bearing wear)
Zinc	Tire wear (filler material), motor oil (stabilizing additive), grease
Iron	Auto body rust, steel highway structures (guard rails, bridges, etc.), moving engine parts
Copper	Metal plating, bearing and bushing wear, moving engine parts, brake lining wear, fungicides and insecticides
Cadmium	Tire wear (filler material), insecticide application
Chromium	Metal plating, moving engine parts, break lining wear
Nickel	Diesel fuel and gasoline (exhaust), lubricating oil, metal plating, bushing wear, brake lining wear, asphalt paving
Manganese	Moving engine parts
Cyanide	Anticake compound (ferric ferrocyanide, sodium ferrocyanide, yellow prussiate of soda) used to keep deicing salt granular
Sodium, Calcium, Chloride	Deicing salts
Sulphate	Roadway beds, fuel, deicing salts
Petroleum	Spills, leaks or blow-by of motor lubricants, antifreeze and hydraulic fluids, asphalt surface leachate

In colder regions where deicing agents are used, deicing chemicals and abrasives are the largest source of pollutants during winter months. Deicing salt (primarily sodium chloride, NaCl) is the most commonly used deicing agent. Potential pollutants from deicing salt include sodium chloride, ferric ferrocyanide (used to keep the salt in granular form), and sulfates such as gypsum. Table 4-33 summarizes potential environmental impacts caused by road salt. Other chemicals used as a salt substitute include calcium magnesium acetate (CMA) and, less frequently, urea and glycol compounds. Researchers have differing opinions on the environmental impacts of CMA compared to those of road salt (Chevron Chemical Company, 1991; Salt Institute, undated; Transportation Research Board, 1991).

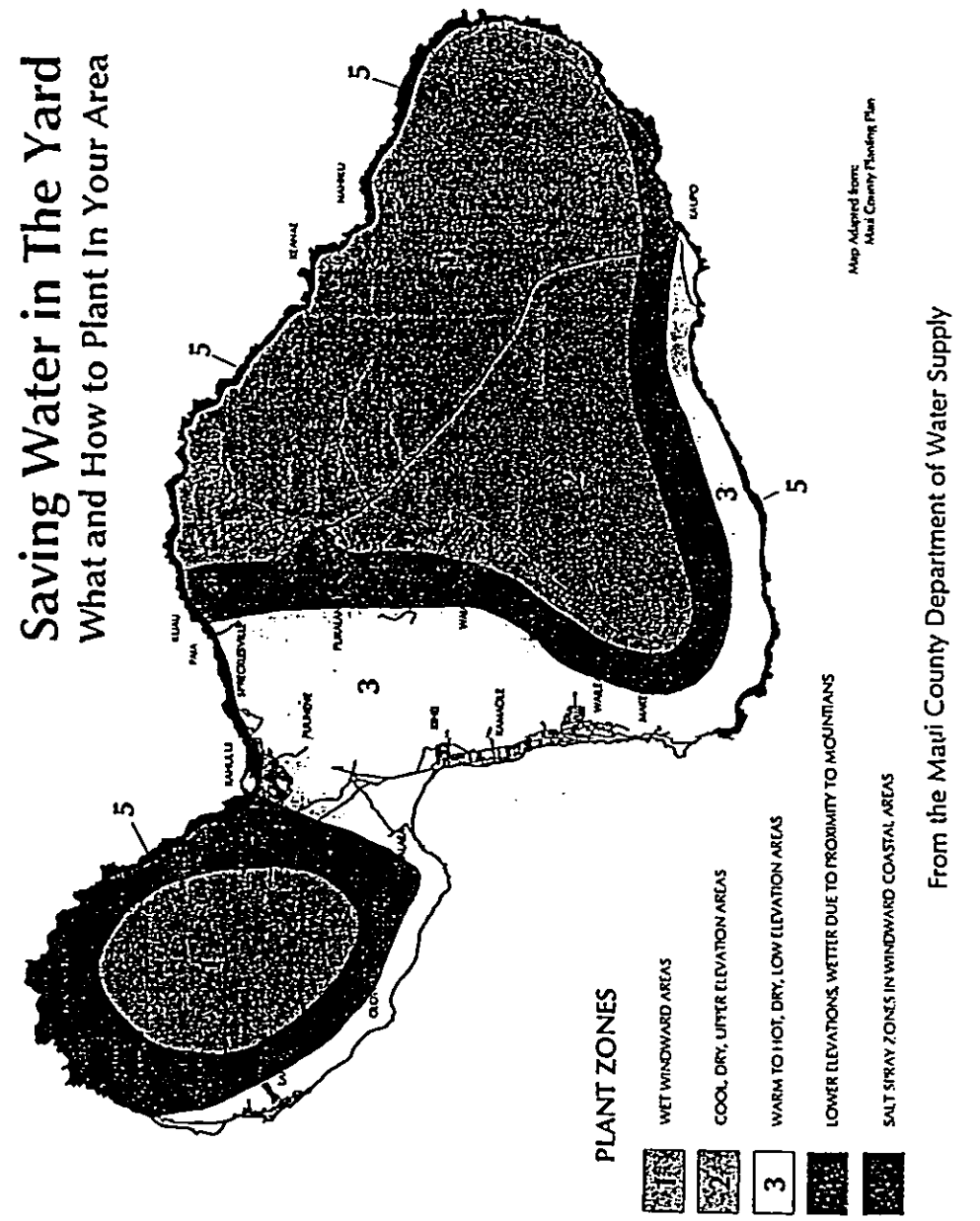
Table 4-32. Pollutant Concentrations in Highway Runoff (Driscoll et al., 1990)

Pollutant	Event Mean Concentration for Highways With Fewer Than 30,000 Vehicles/Day[a] (mg/L)	Event Mean Concentration for Highways With More Than 30,000 Vehicles/Day[a] (mg/L)
Total Suspended Solids	41	142
Volatile Suspended Solids	12	39
Total Organic Carbon	8	25
Chemical Oxygen Demand	49	114
Nitrite and Nitrate	0.46	0.76
Total Kjeldahl Nitrogen	0.87	1.83
Phosphate Phosphorus	0.16	0.40
Copper	0.022	0.054
Lead	0.060	0.400
Zinc	0.080	0.329

[a]Event mean concentrations are for the 50% median site.

Table 4-33. Potential Environmental Impacts of Road Salts

Environmental Resource	Potential Environmental Impact of Road Salt (NaCl)
Soils	May accumulate in soil. Breaks down soil structure, increases erosion. Causes soil compaction that results in decreased permeability.
Vegetation	Osmotic stress and soil compaction harm root systems. Spray causes foliage dehydration damage. Many plant species are salt-sensitive.
Ground Water	Mobile Na and Cl ions readily reach ground water. Increases NaCl concentration in well water, as well as alkalinity and hardness.
Surface Water	Causes density stratification in ponds and lakes that can prevent reoxygenation. Increases runoff of heavy metals and nutrients through increased erosion.
Aquatic Life	Monovalent Na and Cl ions stress osmotic balances. Toxic levels: Na - 500 ppm for stickleback; Cl - 400 ppm for trout.
Human/Mammalian	Sodium is linked to heart disease and hypertension. Chlorine causes unpleasant taste in drinking water. Mild skin and eye irritant. Acute oral LD_{50} in rats is approximately 3,000 mg/kg (slightly toxic).



Selection

As a general rule, it is best to select the largest and healthiest specimens. However, be sure to note that they are not pot-bound. Smaller, younger plants may result in a low rate of plant survival.[1] When selecting native species, consider the site they are to be planted in, and the space that you have to plant. For example: Mountain species such as koa and maile will not grow well in hot coastal areas exposed to strong ocean breezes. Lowland and coastal species such as wiliwili and Kou require abundant sunshine and porus soil. They will not grow well with frequent cloud cover, high rainfall and heavy soil.

Consider too, the size that the species will grow to be. It is not wise to plant trees that will grow too large.[2] Overplanting tends to be a big problem in the landscape due to the underestimation of a species' height, width or spread.

A large, dense canopied tree such as the kukui is a good shade tree for a lawn. However, it's canopy size and density of shade will limit what can be planted in the surrounding area. Shade cast by a koa and ohia lehua is relatively light and will not inhibit growth beneath it.

Keep seasons in mind when you are selecting your plants. Not all plants look good year round, some plants such as ilima will look scraggly after they have flowered and formed seeds. Avoid planting large areas with only one native plant. Mixing plants which naturally grow together will ensure the garden will look good all year round.[3] Looking at natural habitats helps to show how plants grow naturally in the landscape.

When planting an area with a mixed-ecosystem, keep in mind the size and ecological requirements of each plant. Start with the hardiest and most easily grown species, but allow space for fragile ones in subsequent plantings.

Acquiring natives

Plants in their wild habitat must be protected and maintained. It is best and easiest to get your plants from nurseries (see list), or friend's gardens. Obtain proper permits from landowners and make sure you follow a few common sense rules:

- collect sparingly from each plant or area.
- some plants are on the state or Federal Endangered Species list. Make sure you get permits (see app. A,B)

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[1] K. Nagata, P.6

[2] K. Nagata, P.9

[3] Nagata, P.9

Soil

Once you have selected your site and the plants you wish to establish there, you must look at the soil conditions on the site. Proper soil is necessary for the successful growth of most native plants, which preform poorly in hard pan, clay or adobe soils. If natives are to be planted in these types of soil, it would be wise to dig planting holes several times the size of the rootball and backfill with 50-75% compost.[4] A large planting hole ensures the development of a strong root system. The plant will have a headstart before the roots penetrate the surrounding poor soil.[5]

It is recommended that native plants not be planted in ground that is more dense than potting soil. If there is no alternative, dig a hole in a mound of soil mixed with volcanic cinder which encourages maximum root development. Fill the hole with water, if the water tends to puddle or drain too slowly, dig a deeper hole until the water does not puddle longer than 1 or 2 minutes.[6] Well-drained soil is one of the most important things when planting natives as you will soe in the next section.

Irrigation

Most natives do very poorly in waterlogged conditions. Do not water if the soil is damp. Water when the soil is dry and the plants are wilting. Once established, a good soaking twice a week should suffice. Deep soaking encourages the development of stronger, and deeper root systems. This is better than frequent and shallow watering which encourage weaker, more shallow root systems.

The following is a watering schedule from Kenneth Nagata's Booklet, *How To Plant A Native Hawaiian Garden*:

WATER REQUIREMENT	WATERING FREQUENCY
Heavy	3x / week
Moderate	2x / week
Light	1x / week

Red clay soils hold more water for a longer period of time than sandy soils do. If your area is very sunny or near a beach, things will dry out faster. Even in the area of one garden, there are parts that will need more or less water. Soils can vary and amount of shade and wind differ. After plants are established (a month or two for most plants, up to a year for some trees), you can back off watering.

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[4] Nagata, p. 6

[5] Nagata, p. 8

[6] Nagata, p. 8

Automatic sprinkler systems are expensive to install and must be checked and adjusted regularly. Above-ground systems allow you to monitor how much water is being put out, but you lose a lot due to malfunctioning of sprinkler heads and wind. The most efficient way to save water and make sure your plants get enough water, is to hand-water. This way you are getting our precious water to the right places in the right amounts.[7]

Fertilizer

An all-purpose fertilizer 10-10-10 is adequate for most species. They should be applied at planting time, 3 months later, and 6 months thereafter. Use half the dosage recommended for ornamentals and pay special attention to native ferns which are sensitive to strong fertilizers. Use of organic composts and aged animal manures is suggested instead of chemical fertilizers. In addition, use of cinders for providing trace minerals is strongly recommended.[8]

Natives are plants which were here hundreds of years before the polynesians inhabited the Hawaiian Islands. They were brought here by birds, or survived the harsh ocean conditions to float here. They are well-adapted to Hawaii's varying soil and environmental conditions. This is why they make prime specimens for a xeriscape garden. However, natives will not thrive on their own, especially under harsh conditions. On the other hand, like any other plant, if you over-water and over-fertilize them, they will die. Follow the instructions given to you by the nursery you buy the plant from, or from this booklet. Better yet, buy a book (suggested readings can be found in the bibliography in the back of this pamphlet), read it, and learn more about native plants. I guarantee that you will be pleased with the results.

[7] Bornhorst, p. 19-20

[8] Nagata, p. 6

Propagation

There are many ways to propagate and plant-out native Hawaiian species. One of the most thourough and helpful book is Heidi Bornhorst's book, *Growing Native Hawaiian Plants*. The easiest, and best way to obtain natives for the novice gardener is to get them from a reputable nursery (see appendix c). That way all you will have to do is know how to transplant (if necessary) and plant-out when you are ready. These are the two methods I have listed here.

Transplanting

1. Use pots that are one size bigger than the potted plant is in
2. Get your potting medium ready

Good potting medium is a ½, ½ mixture of peat moss and perlite. If the plant is from a dry or coastal area, add chunks of cinder of extra perlite. If it is a wet forest species, add more peat moss or compost. Be aware that peat moss is very acidic and certain plants react severely to acidity.

If the plant is to eventually be planted into the ground, make a mix of equal parts peat moss, perlite, and soil from the area in which the plant is to be planted. Slow-release fertilizer can be mixed into the potting medium.

3. Once pots, potting medium, fertilizer and water are ready, you can begin re-potting. Keep the plant stem at the same depth it was in the original pot. Avoid putting the plant in too large a pot, as the plant may not be able to soak up all the water in the soil and the roots may drown and rot.

Mix potting medium and add slow-release fertilizer at this time. Pre-wet the medium to keep dust down and lessen shock to the plant. Put medium in bottom of pot. Measure for the correct depth in the new pot. Make sure there is from ½ to 2 inches from the top of the pot so the plant can get adequate water. Try to stand the plant upright and center the stem in the middle of the pot.

Water the plant thoroughly after transplanting. A vitamin B-1 transplanting solution can help to lessen the transplant shock. Keep the plant in the same type of environment as it was before, sun or shade. If roots were broken, trimm off some of the leaves to compensate for the loss.[9]

Planting out

1. Plant most native Hawaiian plants in a sunny location in soil that is well-drained.
2. Make the planting hole twice as wide as the root ball or present pot, and just as deep.

If the soil is clay-like, and drains slowly, mix in some coarse red or bland cinder, coarse perlite or

[9] Bornhorst, p.20-21

coarse compost. Place some slow-release fertilizer at the bottom of the hole.

3. Carefully remove the plant from the container and place it in the hole.

The top of the soil should be at the same level as the top of the hole, if it is too high or too low, adjust the soil level so that the plant is at the right depth.

4. Water thoroughly after you transplant.

Mulch

Most natives cannot compete with weeds, and therefore must be weeded around constantly in order to thrive. Mulch is a practical alternative, which discourages and prevents weeds from growing.

Hawaii's hot, humid climate leads to the breaking down of organic mulches. Thick organic mulches such as wood chips and leaves, may also be hiding places for pests.

Stone mulches are attractive, permanent and can help to improve soil quality. Red or black cinder, blue rock chips, smooth river rocks and coral chips are some natural choices.[10] Macadamia nut hulls are also easy to find and can make a nice mulch.[11]

Never pile up mulch right next to the stem or trunk of a plant, keep it a few inches away.

[10] Bornhorst, p. 24

[11] Nagata, p. 7

PLACES TO SEE NATIVES ON:

The following places propagate native Hawaiian plants from seeds and/or cuttings. Their purpose is to protect and preserve these native plants. Please contact them before going to view the sites, they can provide valuable information and referral to other sources.

Maui:

1. Hoolawa Farms, P.O. Box 731, Haiku, Hawaii, 96708	572-4835
2. The Hawaiian Collection, 1127 Manu St., Kula, Hawaii, 96790	878-1701
3. Kula Botanical Gardens, RR 4, Box 228, Kula, Hawaii, 96790	878-1715
4. Maui Botanical Gardens, Kanaloa Avenue across from stadium	243-7337
5. Kula Forest Reserve, access road at the end of Waipouli Rd. Call the Maui District Forester	984-8100
6. Wailea Point, Private Condominium residence, 4000 Wailea Alanui, public access points at Four Seasons Resort or Polo Beach	875-9557
7. Kahanu Gardens, National Tropical Botanical Garden, Alau Pl, Hana, Hawaii, 96713	248-8912
9. Kahului Library Courtyard, 20 School Street, Kahului, Hawaii	873-3097

ZONES

The Maui County Planting Plan has compiled a system of 5 zones of plant growth for Maui County. The descriptions of zones and maps for these zones are as follows:

Zone 1:
Wet areas on the windward side of the island. More than 40 inches of rain per year. Higher than 3,000 feet.

Zone 2:
Cool, dry areas in higher elevations (above 1,000 feet). 20 to 40 inches of rain per year.

Zone 3:
Low, drier areas, warm to hot. Less than 20 inches of rain per year. Sea level to 1,000 feet.

Zone 4:
Lower elevations which are wetter due to proximity of mountains. 1,000 to 3,000 feet.

Zone 5:
Salt spray zones in coastal areas on the windward side.

These zones are to be used as a general guide to planting for Maui County. In addition to looking at the maps, read the descriptions of the zones and decide which zone best fits your area. Plants can be listed in more than one zone and can be planted in a variety of conditions. For best results, take notes on the rainfall, wind, sun and salt conditions of your site. Use the zones as a general guide for selection and read about the plants to decide which best fits your needs as far as care and or function.

PLACES TO BUY NATIVES ON:

Maui:

1. Hoolawa Farms, P.O. Box 731, Haiku, Hawaii, 96708 — 572-4835
   The largest and best collection of natives in the state
   They will deliver, but it's worth the drive to go and see!
   Will propagate upon request

2. Kula True Value Nursery — 878-2557
   Many natives in stock
   Get most of their plants from Hoolawa farms
   They take special requests

3. Kihei Garden and Landscape — 244-3804

4. Maui Garden and Hardware — 877-0447
   Will bring in special orders

5. Kihana Nursery, Kihei — 879-1165

6. Pukalani Plant Company, Jimmy Jones — 572-8950
   Commercial wholesale only

7. The Hawaiian Collection
   Specialize in Sandalwood propagation — 878-1701
   Will propagate special requests

Zone-specific Native and Polynesian plants for Maui County

Zone 3

TYPE: F Fern G Grass Gr Ground Cover Sh Shrub P Palm S Sedge Tr Tree V Vine

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
F	Psilotum nudum	moa, moa kula	1'	1'	sea to 3,000'	Dry to Wet
G	Colubrina asiatica	'anapanapa	3'	10'	sea to 1,000'	Dry to Wet
G	Eragrostis monticola	kalamalo	1'	2'	sea to 3,000'	Dry to Medium
G	Eragrostis variabilis	'emo-loa	1'	2'	sea to 3,000'	Dry to Medium
G	Fimbristylis cymosa ssp. spathacea	mau'u'aki'aki fimbristylis	0.5'	1'	sea to 1,000'	Dry to Medium
Gr	Boerhavia repens	alena	0.5'	4'	sea to 1,000'	Dry to Medium
Gr	Chamaesyce celastroides var. laehiensis	'akoko	2'	3'	sea to 1,000'	Dry to Medium
Gr	Cressa truxillensis	cressa	0.5'	1'	sea to 1,000'	Dry to Medium
Gr	Heliotropium anomalum var. argenteum	hinahina ku kahakai	1'	2'	sea to 1,000'	Dry to Medium
Gr	Ipomoea tuboides	Hawaiian moon flower, 'uala	1'	10'	sea to 3,000'	Dry to Medium
Gr	Jacquemontia ovalifolia ssp. sandwicensis	pa'u o hi'iaka	0.5'	6'	sea to 1,000'	Dry to Medium
Gr	Lipochaeta integrifolia	nehe	1'	5'	sea to 1,00'	Dry to Medium
Gr	Peperomia leptostachya	'ala'ala-wai-nui	1'	1'	sea to 3,000'	Dry to Medium
Gr	Plumbago zeylanica	'ilie'e	1'			
Gr	Sesuvium portulacastrum	'akulikuli, sea-purslane	0.5'	2'	sea to 1,000'	Dry to Wet
Gr	Sida fallax	'ilima	0.5'	3'	sea to 1,000'	Dry to Medium
Gr	Tephrosia purpurea var. purpurea	'auhuhu	2'	2'	sea to 1,000'	Dry to Medium
Gr - Sh	Hibiscus calyphyllus	ma'o hau hele, Rock's hibiscus	3'	2'	sea to 3,000'	Dry to Medium
Gr - Sh	Lipochaeta rockii	nehe	2'	2'	sea to 3,000'	Dry to Medium
Gr - Sh	Lipochaeta succulenta	nehe	2'	5'	sea to 1,000'	Dry to Wet
Gr - Sh	Lycium sandwicense	'ohelo-kai, 'ae'ae	2'	2'	sea to 1,000'	Dry to Medium
P	Cocos nucifera	coconut, niu	100'	30'	sea to 1,000'	Dry to Wet
P	Pritchardia hillebrandii	lo'ulu, fan palm	25'	15'	sea to 1,000'	Dry to Wet
S	Mariscus javanicus	marsh cypress, 'ahu'awa	0.5'	0.5'	sea to 1,000'	Dry to Medium

Zone-specific Native and Polynesian plants for Maui County

Zone 3

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
Sh	Argemone glauca var. deciplens	pua kala	3'	2'	sea to 3,000'	Dry to Medium
Sh	Bidens mauiensis	ko'oko'olau	1'	3'	sea to 1,000'	Dry to Medium
Sh	Bidens menziesii ssp. menziesii	ko'oko'olau	1'	3'		
Sh	Bidens micrantha ssp. micrantha	ko'oko'olau	1'	3'		
Sh	Chenopodium oahuense	'aheahea, 'aweoweo	6'		sea to higher	Dry to Medium
Sh	Dianella sandwicensis	'uki	2'	2'	1,000' to higher	Dry to Medium
Sh	Gossypium tomentosum	mao, Hawaiian cotton	5'	8'	sea to 1,000'	Dry to Medium
Sh	Hedyotis spp.	au, pilo	3'	2'	1,000' to 3,000'	Dry to Wet
Sh	Lipochaeta lavarum	nehe	3'	3'	sea to 3,000'	Dry to Medium
Sh	Osteomeles anthyllidifolia	'ulei, eluehe	4'	6'	sea to 3,000'	Dry to Medium
Sh	Scaevola sericea	naupaka, naupaka-kahakai	6'	8'	sea to 1,000'	Dry to Medium
Sh	Senna gaudichaudii	kolomona	5'	5'	sea to 3,000'	Dry to Medium
Sh	Solanum nelsonii	'akia, beach solanum	3'	3'	sea to 1,00'	Dry to Medium
Sh	Styphelia tameiameiae	pukiawe	6'	6'	1,000' to higher	Dry to Medium
Sh	Vitex rotundifolia	pohinahina	3'	4'	sea to 1,000'	Dry to Medium
Sh	Wikstroemia uva-ursi kauaiensis kauaiensis	'akia, Molokai osmanthus				
Sh - Tr	Broussonetia papyrifera	wauke, paper mulberry	8'	6'	sea to 1,000'	Dry to Medium
Sh - Tr	Myoporum sandwicense	naio, false sandalwood	10'	10'	sea to higher	Dry to Medium
Sh - Tr	Nototrichium sandwicense	kului	8'	8'	sea to 3,000'	Dry to Medium
Sh-Tr	Dodonaea viscosa	'a'ali'i	6'	8'	sea to higher	Dry to Medium
Tr	Aleurites moluccana	candlenut, kukui	50'	50'	sea to 3,000'	Medium to Wet
Tr	Calophyllum inophyllum	kamani, alexandrian laurel	60'	40'	sea to 3,000'	Medium to Wet
Tr	Canthium odoratum	Alahe'e, 'ohe'e, walahe'e	12'	8'	sea to 3,000'	Dry to Medium
Tr	Cordia subcordata	kou	30'	25'	sea to 1,000'	Dry to Wet
Tr	Diospyros sandwicensis	lama	12'	15'	sea to 3,000'	Dry to Medium
Tr	Erythrina sandwicensis	wiliwili	20'	20'	sea to 1,000'	Dry
Tr	Metrosideros polymorpha var. macrophylla	ohi'a lehua	25'	25'	sea to 1,000'	Dry to Wet

Zone-specific Native and Polynesian plants for Maui County- Zone 3

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
Tr	Morinda citrifolia	indian mulberry, noni	20'	15'	sea to 1,000'	Dry to Wet
Tr	Nesoluma polynesicum	keahi	15'	15'	sea to 3,00'	Dry
Tr	Neslegia sandwicensis	olopua	15'	15'	1,000' to 3,000'	Dry to Medium
Tr	Pandanus tectorius	hala, puhala (HALELIST)	35'	25'	sea to 1,000'	Dry to Wet
Tr	Pleomele auwahiensis	halapepe	20'			
Tr	Rauvolfia sandwicensis	hao	20'	15'	sea to 3,000'	Dry to Medium
Tr	Reynoldsia sandwicensis	'ohe makai	20'	20'	1,000' to 3,000'	Dry
Tr	Santalum ellipticum	coastal sandalwood, 'iii-ahi	8'	8'	sea to 3,000'	Dry to Medium
Tr	Thespesia populnea	milo	30'	30'	sea to 3,000'	Dry to Wet

Zone-specific Native and Polynesian plants for Maui County

Zone 5

TYPE: F Fern G Grass Gr Ground Cover Sh Shrub P Palm S Sedge Tr Tree V Vine

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
G	Colubrina asiatica	'anapanapa	3'	10'	sea to 1,000'	Dry to Wet
G	Eragrostis variabilis	'emo-loa	1'	2'	sea to 3,000'	Dry to Medium
G	Fimbristylis cymosa ssp. spathacea	mau'u'aki'aki fimbristylis	0.5'	1'	sea to 1,000'	Dry to Medium
Gr	Boerhavia repens	alena	0.5'	4'	sea to 1,000'	Dry to Medium
Gr	Chamaesyce celastroides var. laehiensis	'akoko	2'	3'	sea to 1,000'	Dry to Medium
Gr	Cressa truxillensis	cressa	0.5'	1'	sea to 1,000'	Dry to Medium
Gr	Heliotropium anomalum var. argenteum	hinahina ku kahakai	1'	2'	sea to 1,000'	Dry to Medium
Gr	Jacquemontia ovalifolia ssp. sandwicensis	pa'u o hi'iaka	0.5'	6'	sea to 1,000'	Dry to Medium
Gr	Lipochaeta integrifolia	nehe	1'	5'	sea to 1,00'	Dry to Medium
Gr	Sesuvium portulacastrum	'akulikuli, sea-purslane	0.5'	2'	sea to 1,000'	Dry to Wet
Gr	Sida fallax	'ilima	0.5'	3'	sea to 1,000'	Dry to Medium
Gr	Tephrosia purpurea var. purpurea	'auhuhu	2'	2'	sea to 1,000'	Dry to Medium
Gr - Sh	Hibiscus calyphyllus	ma'o hau hele, Rock's hibiscus	3'	2'	sea to 3,000'	Dry to Medium
Gr - Sh	Lycium sandwicense	'ohelo-kai, 'ae'ae	2'	2'	sea to 1,000'	Dry to Medium
P	Cocos nucifera	coconut, niu	100'	30'	sea to 1,000'	Dry to Wet
P	Pritchardia hillebrandii	lo'ulu, fan palm	25'	15'	sea to 1,000'	Dry to Wet
S	Mariscus javanicus	marsh cypress, 'ahu'awa	0.5'	0.5'	sea to 1,000'	Dry to Medium
Sh	Argemone glauca var. decipiens	pua kala	3'	2'	sea to 3,000'	Dry to Medium
Sh	Artemisia australis	'ahinahina	2'	3'	sea to 3,000'	Dry to Medium
Sh	Bidens hillebrandiana ssp. hillebrandiana	ko'oko'olau	1'	2'	sea to 1,000'	Dry to Wet
Sh	Bidens mauiensis	ko'oko'olau	1'	3'	sea to 1,000'	Dry to Medium
Sh	Chenopodium oahuense	'aheahea, 'aweoweo	6'		sea to higher	Dry to Medium
Sh	Dianella sandwicensis	'uki	2'	2'	1,000' to higher	Dry to Medium
Sh	Gossypium tomentosum	mao, Hawaiian cotton	5'	8'	sea to 1,000'	Dry to Medium

Zone-specific Native and Polynesian plants for Maui County

Zone 5

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
Sh	Hedyotis spp.	au, pilo	3'	2'	1,000' to 3,000'	Dry to Wet
Sh	Lipochaeta lavarum	nehe	3'	3'	sea to 3,000'	Dry to Medium
Sh	Osteomeles anthyllidifolia	'ulei, eluehe	4'	6'	sea to 3,000'	Dry to Medium
Sh	Scaevola sericea	naupaka, naupaka-kahakai	6'	8'	sea to 1,000'	Dry to Medium
Sh	Senna gaudichaudii	kolomana	5'	5'	sea to 3,000'	Dry to Medium
Sh	Solanum nelsonii	'akia, beach solanum	3'	3'	sea to 1,00'	Dry to Medium
Sh	Vitex rotundifolia	pohinahina	3'	4'	sea to 1,000'	Dry to Medium
Sh	Wikstroemia uva-ursi kauaiensis kauaiensis	'akia, Molokai osmanthus				
Sh - Tr	Myoporum sandwicense	naio, false sandalwood	10'	10'	sea to higher	Dry to Medium
Sh-Tr	Dodonaea viscosa	'a'ali'i	6'	8'	sea to higher	Dry to Medium
Tr	Aleurites moluccana	candlenut, kukui	50'	50'	sea to 3,000'	Medium to Wet
Tr	Calophyllum inophyllum	kamani, alexandrian laurel	60'	40'	sea to 3,000'	Medium to Wet
Tr	Cordia subcordata	kou	30'	25'	sea to 1,000'	Dry to Wet
Tr	Hibiscus furcellatus	'akiohala, hau-hele	8'			
Tr	Morinda citrifolia	indian mulberry, noni	20'	15'	sea to 1,000'	Dry to Wet
Tr	Pandanus tectorius	hala, puhala (HALELIST)	35'	25'	sea to 1,000'	Dry to Wet
Tr	Thespesia populnea	milo	30'	30'	sea to 3,000'	Dry to Wet
V	Ipomoea pes-caprae	beach morning glory, pohuehue	1'			

Zone-specific Native and Polynesian plants for Maui County

Zone 5

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
Sh	Hedyotis spp.	au, pilo	3'	2'	1,000' to 3,000'	Dry to Wet
Sh	Lipochaeta lavarum	nehe	3'	3'	sea to 3,000'	Dry to Medium
Sh	Osteomeles anthyllidifolia	'ulei, eluehe	4'	6'	sea to 3,000'	Dry to Medium
Sh	Scaevola sericea	naupaka, naupaka-kahakai	6'	8'	sea to 1,000'	Dry to Medium
Sh	Senna gaudichaudii	kolomana	5'	5'	sea to 3,000'	Dry to Medium
Sh	Solanum nelsonii	'akia, beach solanum	3'	3'	sea to 1,00'	Dry to Medium
Sh	Vitex rotundifolia	pohinahina	3'	4'	sea to 1,000'	Dry to Medium
Sh	Wikstroemia uva-ursi kauaiensis kauaiensis	'akia, Molokai osmanthus				
Sh - Tr	Myoporum sandwicense	naio, false sandalwood	10'	10'	sea to higher	Dry to Medium
Sh-Tr	Dodonaea viscosa	'a'ali'i	6'	8'	sea to higher	Dry to Medium
Tr	Aleurites moluccana	candlenut, kukui	50'	50'	sea to 3,000'	Medium to Wet
Tr	Calophyllum inophyllum	kamani, alexandrian laurel	60'	40'	sea to 3,000'	Medium to Wet
Tr	Cordia subcordata	kou	30'	25'	sea to 1,000'	Dry to Wet
Tr	Hibiscus furcellatus	'akiohala, hau-hele	8'			
Tr	Morinda citrifolia	indian mulberry, noni	20'	15'	sea to 1,000'	Dry to Wet
Tr	Pandanus tectorius	hala, puhala (HALELIST)	35'	25'	sea to 1,000'	Dry to Wet
Tr	Thespesia populnea	milo	30'	30'	sea to 3,000'	Dry to Wet
V	Ipomoea pes-caprae	beach morning glory, pohuehue	1'			

DO NOT PLANT THESE PLANTS !!!

Common name	Scientific name	Plant family
	Jasminum fluminense	Oleaceae
	Arthrostema ciliatum	Melastomataceae
	Dissotis rotundifolia	Melastomataceae
	Erigeron karvinskianus	Asteraceae
	Eucalyptus robusta	Myrtaceae
	Hedychium gardnerianum	Zingiberaceae
	Juncus planifolius	Juncaceae
	Lophostemon confertus	Myrtaceae
	Medinilla cumingii	Melastomataceae
	Medinilla magnifica	Melastomataceae
	Medinilla venosa	Melastomataceae
	Melastoma candidum	Melastomataceae
	Melinis minutiflora	Poaceae
	Olea europaea	
	Oxyspora paniculata	Melastomataceae
	Panicum maximum	Poaceae
	Paspalum urvillei	Poaceae
	Passiflora edulis	Passifloraceae
	Phormium tenax	Agavaceae
	Pinus taeda	Pinaceae
	Prosopis pallida	Fabaceae
	Pterolepis glomerata	Melastomataceae
	Rhodomyrtus tomentosa	Myrtaceae
	Schefflera actinophylla	Araliaceae
	Syzygium jambos	Myrtaceae
Australian blackwood	Acacia melanoxylon	Mimosaceae
Australian tree fern	Cyathea cooperi	Cyatheaceae
Australian tree fern	Sphaeropteris cooperi	Cyatheaceae
Beggar's tick, Spanish needle	Bidens pilosa	Asteraceae
California grass	Brachiaria mutica	Poaceae
Chinese banyon, Malayan banyon	Ficus microcarpa	Moraceae
Chinese violet	Asystasia gangetica	Acanthaceae
Christmasberry, Brazilian pepper	Schinus terebinthifolius	Anacardiaceae
Formosan koa	Acacia confusa	Mimosaceae
German ivy	Senecio mikanioides	Asteraceae
Japanese honeysuckle	Lonicera japonica	Caprifoliaceae
Koster's curse	Clidemia hirta	Melastomataceae
Lantana	Lantana camara	Verbenaceae
Mauritius hemp	Furcraea foetida	Agavaceae
Mexican ash, tropical ash	Fraxinus uhdei	Oleaceae
Mexican tulip poppy	Hunnemannia fumariifolia	Papaveraceae
Mules foot, Madagascar tree fern	Angiopteris evecta	Marattiaceae
New Zealand laurel, karakaranut	Corynocarpus laevigatus	Corynocarpaceae
New Zealand tea	Leptospermum scoparium	Myrtaceae
Pampas grass	Cortaderia jubata	Poaceae
Panama rubber tree, Mexican rubber tree	Castilloa elastica	Moraceae
Shoebutton ardisia	Ardisia elliptica	Myrsinaceae
banana poka	Passiflora mollissima	Passifloraceae

DO NOT PLANT THESE PLANTS !!!

Common name	Scientific name	Plant family
black wattle	Acacia mearnsii	Mimosaceae
blackberry	Rubus argutus	Rosaceae
blue gum	Eucalyptus globulus	Myrtaceae
bocconia	Bocconia frutescens	Papaveraceae
broad-leaved cordia	Cordia glabra	Boraginaceae
broomsedge, yellow bluestem	Andropogon virginicus	Poaceae
buffelgrass	Cenchrus ciliaris	Poaceae
butterfly bush, smoke bush	Buddleja madagascariensis	Buddlejaceae
cats claw, Mysore thorn, wait-a-bit	Caesalpinia decapetala	Caesalpiniaceae
common ironwood	Casuarina equisetifolia	Casuarinaceae
common velvet grass, Yorkshire fog	Holcus lanatus	Poaceae
fiddlewood	Citharexylum spinosum	Verbenaceae
fire tree, faya tree	Myrica faya	Myricaceae
glorybower	Clerodendrum laponicum	Verbenaceae
hairy cat's ear, gosmore	Hypochoeris radicata	Asteraceae
haole koa	Leucaena leucocephala	Fabaceae
ivy gourd, scarlet-fruited gourd	Coccinia grandis	Cucurbitaceae
juniper berry	Citharexylum caudatum	Verbenaceae
kahili flower	Grevillea banksii	Proteaceae
klu, popinac	Acacia farnesiana	Mimosaceae
logwood, bloodwood tree	Haematoxylon campechianum	Caesalpiniaceae
loquat	Eriobotrya japonica	Rosaceae
meadow ricegrass	Ehrharta stipoides	Poaceae
melaleuca	Melaleuca quinquenervia	Myrtaceae
miconia, velvet leaf	Miconia calvescens	Melastomataceae
narrow-leaved carpetgrass	Axonopus fissifolius	Poaceae
oleaster	Elaeagnus umbellata	Elaeagnaceae
oriental mangrove	Bruguiera gymnorrhiza	Rhizophoraceae
padang cassia	Cinnamomum burmanii	Lauraceae
palmgrass	Setaria palmifolia	Poaceae
pearl flower	Heterocentron subtriplinervium	Melastomataceae
quinine tree	Cinchona pubescens	Rubiaceae
satin leaf, caimitillo	Chrysophyllum oliviformo	Sapotaceae
silkwood, Queensland maple	Flindersia brayleyana	Rutaceae
silky oak, silver oak	Grevillea robusta	Proteaceae
strawberry guava	Psidium cattleianum	Myrtaceae
swamp oak, saltmarsh, longleaf ironwood	Casuarina glauca	Casuarinaceae
sweet vernalgrass	Anthoxanthum odoratum	Poaceae
tree of heaven	Ailanthus altissima	Simaroubaceae
trumpet tree, guarumo	Cecropia obtusifolia	Cecropiaceae
white ginger	Hedychium coronarium	Zingiberaceae
white moho	Heliocarpus popayanensis	Tiliaceae
yellow ginger	Hedychium flavescens	Zingiberaceae

APPENDIX C

REFERENCES FOR FURTHER READING

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JAMES "KIMO" APANA
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CHARLES JENCKS
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DAVID C. GOODE
Deputy Director

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FAX (808) 270-7975

COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
AND WASTE MANAGEMENT
ENGINEERING DIVISION
200 SOUTH HIGH STREET
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RALPH NAGAMINE, L.S., P.E.
Land Use and Codes Administration

RONALD R. RISKA, P.E.
Wastewater Reclamation Division

LLOYD P.C.W. LEE, P.E.
Engineering Division

ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

March 3, 2000

Mr. David Craddick, Director
County of Maui
Department of Water Supply
P. O Box 1109
Wailuku, Hawaii 96793-6109

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII
FAP NO. STP-3100(11)

Dear Mr. Craddick:

We have received your letter dated February 10, 2000 commenting on the subject project. We appreciate the information you provided regarding Best Management Practices (BMPs), as well as the excerpts from the Maui County Planting Plan. The recommended BMPs will be incorporated into the project design as applicable. In addition, to the practicable extent, we will consider your suggested planting and irrigation recommendations.

Thank you for your participation during the EA review process.

Sincerely,

for LLOYD LEE
Engineering Division Chief

LL/JK:c(ED00-362)
A:\craddick.ltr DWS.wpd

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

Maui Electric Company, Ltd. • 210 West Kamehameha Avenue • PO Box 398 • Kahului, Maui, HI 96733-6898 • (808) 871-8461

RYC

RECEIVED
JAN 12 2000
WILSON OKAMOTO & ASSOC., INC.

January 11, 2000

Mr. Rodney Funakoshi
Project Manager
Wilson Okamoto & Associates, Inc.
1907 S. Beretania St., Suite 400
Honolulu, HI 96826

Dear Mr. Funakoshi:

Subject: Draft Environmental Assessment(EA)
South Kihei Road Improvements - Kulanihakoi Street to Lipoa Street
County Project No. 97-33
Tax Map Keys: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52:various
Kihei, Maui, Hawaii

Thank you for the opportunity to review and comment on the subject project. We have no additional comments to our letter dated October 29, 1999.

If you have any questions or concerns, please call Dan Takahata at 871-2385.

Sincerely,

Edward L. Reinhardt
Manager, Engineering

Cc: Mr. Joe Krueger, County of Maui, Dept. of Public Works and Waste Management
Ms. Genevieve Salmonson, State of Hawaii, Office of Environmental Quality Control

JAMES "KIMO" APANA
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COUNTY OF MAUI
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ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

March 3, 2000

Mr. Edward Reinhardt
Manager, Engineering
Maui Electric Company, Ltd.
210 West Kamehameha Avenue
Kahului, Hawaii 96732

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII
FAP NO. STP-3100(11)

Dear Mr. Reinhardt:

We have received your letter dated January 11, 2000 indicating that you have no comments regarding the subject project. Thank you for your participation during the EA review process.

Sincerely,

LLOYD LEE
Engineering Division Chief

LL/JK:c(ED00-361)
K:\CHLet\rep.MEC.wpd

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

MAUI COUNTY ARBORIST COMMITTEE

275 UHU STREET · KAHULUI · HAWAII 96732 · (808) 243-7325 · FAX (808) 243-7953

November 22, 1999

Mr. Rodney Y. Funakoshi, AICP
Project Manager
Wilson Okamoto & Associates, Inc.
1907 S. Beretania Street
Honolulu, Hawaii 96826

Dear Mr. Funakoshi:

At its November 10, 1999 meeting the Maui County Arborist Committee reviewed your request for input regarding the widening of South Kihei Road. The Committee strongly recommends that trees already growing in the area be kept because they provide much needed shade. Any that are removed should be replaced with specimens that will provide shade as soon as possible. Sidewalks, curbs, etc. should be adequately reinforced to minimize lifting by roots in the future. Oftentimes "hardscapes" are not sufficiently reinforced and result in an engineering failure and not a tree root problem.

Hopefully new trees will be planted along the improved highway. I am enclosing literature we provided the Engineering Standards Committee (Public Works Department) for your review and transmission to whoever designs the road and planting spaces. These novel methods of planting street trees are designed to minimize root/hardscape problems. Using connected underground vaults enable larger shade trees to be planted without impacting sidewalks, curbs, and roads. Connecting tree planting sites with a buried synthetic fabric encourages root growth along these pathways.

We hope the SMA review board and the County of Maui are willing to plant trees with one or several of these different methods. This is an excellent opportunity to achieve shade from larger trees without the damaging effects to hardscapes.

The Maui County Arborist Committee is available to provide support to creative solutions to planting street trees along South Kihei Road, or any other area. If you have any questions, please contact us through Sue Kiang at 243-7325.

I am enclosing a copy of the assessment of the Monkey Pod trees growing along South Kihei Road we sent to Mr. Charles Jencks in February, 1999.

Thank you for including the Arborist Committee in the initial planning stage.

Sincerely,

Ernest H Rezents

ERNEST H. REZENTS
Chairman

Enclosures

1. The Journal of Arboriculture 24(3):May 1998 has many excellent suggestions. Figure 2 on page 124 looks very promising.
2. Principles and Practice of Planting Trees and Shrubs, page 45 has similar inclusions and holds tremendous promise.
3. Arborist News (ISA) is for general information.
4. The Cornell University packet is a source of good information.
5. South Kihei Road Monkey Pod tree Assessment.

c: Ms. Jeannie Pezolli, President
Maui Outdoor Circle (w/o enclosures)
Engineering Standards Committee (w/o enclosures)

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FILE

MAUI COUNTY ARBORIST COMMITTEE

375 UHU STREET · KAHULUI · HAWAII 96732 · (808) 243-7325 · FAX (808) 243-7953

February 23, 1999

Mr. Charles Jencks, Director
County of Maui
Department of Public Works and
Waste Management
200 South High Street
Wailuku, Hawaii 96793

Dear Mr. Jencks:

The Monkey Pod trees growing on South Kihei road in front of Kauhale Makai condominium were discussed at the February 10, 1999 Maui County Arborist Committee meeting. A meeting of the Tree Concerns subcommittee was scheduled on site for February 23rd. The Arborist Committee requested that following this meeting a letter be sent to you with suggestions on how to deal with the root/sidewalk impact.

Because the trees provide a great deal of welcomed shade to an other wise hot area, there is community support for keeping the street trees. The tree concerns subcommittee inspected the trees and sidewalk beginning from the North end at Village by the Sea condominium.

Observations:

Some of the trees have large exposed surface roots and others do not. This may be due to a shallow soil. Some Kihei developers used large rocks as fill and then covered them with soil prior to planting a landscape. We did not excavate to verify what occurred here. Nonetheless this would not solve the present concerns. We learned that the trees are about 20 years old.

1. Monkey Pod #1. Large surface roots. No sidewalk lifting. Recommend that the sidewalk be curved towards the curb to provide the tree with a larger space for trunk and root growth. This method has been observed in mainland communities.

2. Monkey Pod # 2. No sidewalk impact.
3. Monkey Pod # 3. Same as tree number 1.
4. Monkey Pod # 4. No sidewalk impact.
5. Monkey Pod # 5. Same as tree # 1.

Entrance into Luana Kai Condominium.

6. Monkey Pod # 6. There is some sidewalk lifting at the ramp. Some root pruning occurred in the past. Solve by providing more growing space as in tree # 1.
7. Monkey Pod # 7. Provide an enlarged growing space at base of the tree as recommended in tree # 1.
8. Monkey Pod # 8. No sidewalk impact.
9. Monkey Pod # 9. Provide more growing space as recommended in tree # 1.
10. Monkey Pod # 10. Provide more growing space as recommended in tree # 1.
11. Monkey Pod # 11. Roots have impacted with the sidewalk. Provide more growing space as in tree # 1.
12. Monkey Pod # 12. Same as tree # 1.

Entrance to parking lot.

13. Monkey Pod trees # 13, 14, and 15. These three trees have raised the sidewalk the most. Provide more growing space by elevating the sidewalk as discussed below. Sidewalk repair in any other method will probably require root pruning. This is not a recommended practice.

Possible Solutions:

1. Elevating the sidewalk: Move the entire sidewalk towards the curb and elevate it by adding 3-4 inches of soil and 3-4 inches minimum of crushed

blue rock on top of it. Compact the blue rock some. Pour a new sidewalk reinforced with steel. The curb may need to be raised to level the elevated sidewalk with it. A railing could be installed between the sidewalk and the curb instead. Fill between the sidewalk and trees with top soil.

The soil and blue rock will provide more space for expanding roots and the steel will lessen any future lifting by the roots. This technique should provide some years of impact free growth.

2. Provide an enlarged growing space for trees # 1, 3, 5, 6, 7, 9, 10, 11, and 12 by curving the sidewalk towards the curb. The new sidewalk should be steel reinforced and tied into the existing sidewalk sections. For trees number 13, 14, and 15, because the distance is only about 40 feet and each tree is raising the sidewalk it is recommended that a new sidewalk be constructed as proposed in solution # 1.

3. Do number 2 without steel reinforcements or blue rock base. This will fix the problem but not provide long term correction.

Other Suggestions:

1. Do not prune the roots because this practice affects tree stability and opens up sites for root decay.

2. The Arborist Committee has learned of new creative methods for building underground spaces for improved root growth that lessens root/sidewalk and curb impact. We have shared a video from Cornell University with the Planning Department and would like to offer it for your department's review. However, these methods are used prior to planting and not to correct an existing problem.

We are interested in using this technique, or some other one, for street/parking lot tree planting in a private or public project. If you are aware of a project where such an experiment could be conducted, please bring it to our attention. We are interested in changing the way we plant trees to provide better growth and lessen root impact with hardscapes.

We hope these suggestions will help you resolve the Monkey Pod's impact with the sidewalk in Kihei. We all want to keep the trees and yet make the area safer for walkers. Thank you for your assistance on this matter. If you have any questions please contact Sue Kiang at the Volunteer Action Program at 243-7325.

Sincerely,

ERNEST H. REZENTS
Chairman

c: Elaine Malina, Tree Concerns Subcommittee
David Sakoda, County Arborist

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DESIGNING URBAN PAVEMENT SUB-BASES TO SUPPORT TREES

by Palle Kristoffersen

Abstract. In Denmark, poor growth conditions for urban trees have been perceived as a problem since the 1980s. Restricted planting-pit sizes are mainly responsible for this problem. In 1996, a survey found that the average size of municipal planting pits had increased from 0.1 m³ (3.5 ft³) in the late 1960s, to 3.4 m³ (120 ft³) in 1996. To increase the volume of the planting pit, several materials have been introduced to mix with soil to allow root growth under pavements. Three methods are available for installing these materials under pavements. During the last 5 years, more than 800 trees have been planted on more than 30 sites using these materials and installation methods. Every method has advantages and disadvantages. No serious difficulties due to load-bearing capacity or frost heaves have been recorded.

Planting pits for urban trees are surrounded with soil that has been either unintentionally compacted or replaced with compacted road-building materials (Kopinga 1985; Lichter and Lindsey 1994; Randrup 1997). The restricted planting pits allow only limited root growth, and insufficient rooting volumes in urban situations often result in destructive roots. Roots outgrow the planting pits and often spread immediately below the pavement surface, lifting and eventually destroying the pavement. This is a serious and expensive problem that stresses trees (Kopinga 1991, 1992). Sycamore maples (*Acer pseudoplatanus*) grown under stressed conditions exhibit limited height growth, more capital axes, fewer cardinal axes, and twisted and crooked stems (Bonsen 1996). This irregularity of growth causes aesthetic as well as maintenance problems in system plantings in which all trees are important in forming a unified appearance. If system plantings are established in paved, partly paved, and unpaved areas, the chances of obtaining a homogeneous appearance will be reduced further.

The usual method of establishing urban trees in Denmark has been to plant trees in individual planting pits. The size of the planting pit has increased since the 1960s, when it was often less than 0.1 m³ (3.5 ft³). Since then, the average volume of planting pits, as found in 11 Danish municipalities, has increased to 3.4 m³ (120 ft³), ranging from 0.8 to 8.1 m³ (28 to 286 ft³) (Teilmann and Kristoffersen 1996).

Applying one of the predeveloped models to estimate soil volumes for urban trees based on the soil's water-holding capacity shows that a tree with a canopy diameter of 10 m (33 ft) requires a 35 to 40 m³ (377 to 431 ft³) planting pit (Lindsey and Bassuk 1992). In urban areas, it is almost impossible to plan unpaved planting beds of this size. Therefore, several methods for integrating the growing media under paved surfaces have been described. These methods consist of a mix of medium-course sand (Couenberg 1994), a load-bearing matrix mixed of stones and soil (Grabosky and Bassuk 1995), and pavements constructed with a span above a growing media, such as top soil (Urban 1989).

In Denmark, pavements are defined to consist of a sub-base and a base, both usually compacted to densities that impede root growth, and of a top layer of bricks, pavers, or asphalt (Patterson 1977; Vejdirektoratet 1984). The sub-base material usually consists of sand or other materials that promote drainage. The base is often made of screened and graded gravel but almost never concrete, as it is in the United States.

Design and Installation Methods

In Denmark, more than 800 trees were integrated into pavements at 30 different sites using a load-bearing matrix or different sand mixes. A number of matrix materials were used, and 3 mixing methods have been developed.

Materials. Stones, ranging from 32 to 150 mm (1 to 6 in.) diameter gravel, granite, lava slags, crushed bricks, and blocks of Leca-concrete have been used as load-bearing matrixes (Table 1). Leca-concrete is made of

Table 1. Materials and mixing methods used as sub-base to support trees.

	Materials					
	Stones (80–150 mm)	Stones/ crushed stones (32–80 mm) (32–45 mm)	Leca-concrete blocks* (100 x 100 mm)	Crushed lava (32–45 mm)	Crushed bricks (25–50 mm)	Sand mix (0 2–0 5 mm)
Installation methods	water mix dry mix	premix water mix	premix	premix water mix dry mix	premix water mix	premix
Growing medium	topsoil	topsoil	topsoil	topsoil	topsoil	humus/ compost
Density of material (g/cm³)	2.7	2.7	1 0	1.8	1.8	2 6
Porosity of material (vol. – %)	0	0	approx 15	approx 55	approx. 30	0
Voids in compacted material (vol. – %)	45	45/40	56	38	35	45

*Leca is the Danish commercial name for Light Expanded Clay Aggregates

Leca nuts mixed with cement and formed to blocks. Leca is a commercial name and an acronym for Light Expanded Clay Aggregates. The Leca nuts consist of an inner clinkerized cellular structure with a hard, resistant outside coating. The material porosity is presumed to influence the air and water exchange in the soil mix.

Methods of installation. Soil is used to fill the voids in the load-bearing matrix. Because compacted soil impedes root growth, it is necessary to prevent compaction during the installation process. Three mixing and installation methods have been developed and tested: premixing before installation, water mixing during installation, and dry mixing during installation.

(1) ***Premixing before installation.*** Stones and soil are mixed at a predetermined ratio. Mixing can be done with a front loader, a power shovel, a concrete mixer, or similar equipment. Separation of soil from stones may occur after mixing if the mixture is moved or transported; therefore, remixing before installation may be necessary to restore uniformity. The matrix of stone and soil is compacted after spreading to establish contact between the individual stones, thereby transferring the load of pedestrian and vehicles to the subgrade. When the soil and stone mix is compacted, the stones will be rearranged as the soil fills the voids (Harris 1971). To obtain the proper degree of compaction, the stone-soil mix should be installed in layers of no more than 15 to 20 cm (6 to 8 in.).

The correct mixture of stones and soil (i.e., the point at which the soil is not compacted during the installation) can be determined by measuring the stone weight per cubic unit or by filling a known volume of stones with water and then estimating the volume of the voids. The volume of soil added should be less than this volume. If the applied stone material has 20% voids after compacting, the correct mixing ratio of stone to soil will be 5:1. An incorrect mixing ratio of 4:1 will lead to a filling level of 125%, which means that the soil will be compacted in the voids and the stones will not be touching each other. At a mixing ratio of 6:1, only 80% of the voids would be filled but, considering root growing, this seems to be sufficient and better than overfilling the voids and compacting the soil (Kristoffersen 1998).

(2) ***Water mixing during installation.*** Layers of stones are installed and compacted. Then a layer of screened soil (e.g., sandy loam) is spread on top of the stones and watered into the voids. The stone layer can be up to 25 cm (10 in.) thick when stones of 80 to 150 mm (3 to 6 in.) in diameter are used. When using smaller stones and broken stones, the recommended thickness is 10 to 15 cm (4 to 6 in.).

(3) ***Dry mixing during installation.*** Another method of mixing during installation is installing stones in layers of 15 to 25 cm (6 to 10 in.) and

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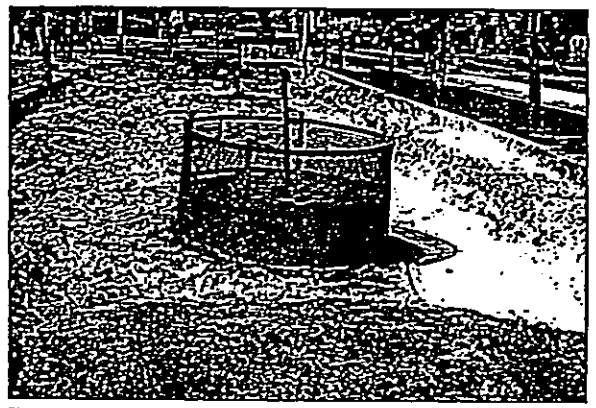

Figure 1. Use of sand mix at The Christians Havns Square, Copenhagen. The material is used in a 3-m wide, 57-m long pit, in which 7 linden trees (*Tilia tomentosa*) were planted. The soil in the planting pits is separated from the sand mix by a wire basket during the installation process.

subsequently filling the voids with dry soil by sweeping and vibration. Both the stones and the soil must be completely dry, and installation must be carried out in dry weather. The dry-mixing method has been used only with stones of 80 to 150 mm (3 to 6 in.) in diameter and is not suitable for use with smaller stones. This method can cause difficulties because most construction work is carried out when rainy weather can occur.

Sand mix. The Dutch experience has shown that uniform graded sand can be used to expand the rooting volume beneath pavements. The sand is mixed with up to 4% or 5% of humus in the form of compost or sphagnum. In Denmark, the sand mix has been used and installed as described by Couenberg (1994) (Figure 1). The intention of using sand mix is to achieve a compaction level of 70% to 80% proctor density (Couenberg 1994). Therefore, penetration resistance is measured to ensure that the degree of compaction does not exceed the critical limit for root growth. This quality check is not practiced in Denmark.

Technical Construction of Planting Site

When topsoil and other materials containing humus are installed under pavements, there is a risk that the obstruction of aeration could cause anaerobic conditions. This risk is increased by insufficiencies in drainage (e.g., if the soil is compacted) (Harris 1992). Sufficient air movement in the soil or sand mix is achieved by installing a layer of stones or broken stones between the root growth area and the pavement above. The aeration layer receives air via pipes or the planting pit (Urban 1989) and should be covered with a suitable geotextile to prevent filling from the layers above (Figure 2). The same type of aeration layer is recommended when raising the grade around existing trees (Harris 1992). Although the effect of an aeration layer has not been documented in the Danish examples, it is considered to have a beneficial effect on the soil and the root growth (Smith 1995). The aeration layer may also be used to irrigate the trees (Urban 1989).

Applications in Denmark

More than 800 trees have been successfully planted since 1991 on more than 30 construction sites in Denmark using these alternative materials and methods.

Table 2 shows that stones or broken stones, in various size classes, are the most commonly used materials for load-bearing matrixes and are used with more than 75% of planted trees. Premixing before installation is the most frequently used installation method. Dry mixing during installation is only occasionally used. Each installation method has advantages and disadvantages (Table 3).

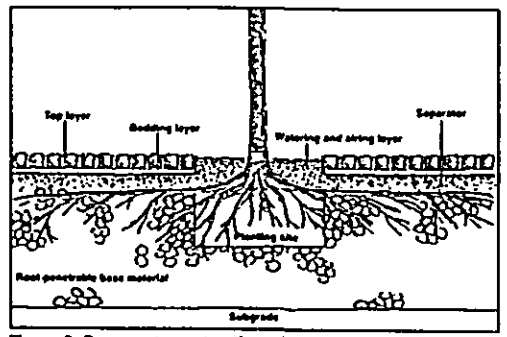

Figure 2. Pavement construction with load-bearing matrix and aeration layer.

The major disadvantages of using the premix of stone and soil is that separation might occur during transportation and installation. A tackifier can help the soil adhere to the stones (Grabosky and Bassuk 1995). The calculation of mixing ratio is also problematic. In a stone and soil mix, a calculated void percentage (e.g., 25%) has often led to a recommended mixing ratio of 3:1. In one case, this ratio led to compaction of the soil in the voids, which caused subsequent settling. The correct mixing ratio should have been 4:1 to secure 25% voids in a stone and soil mix. Dry mixing has been the most effective and practical method. However, the dry mixing method requires dry weather, dry stones, and dry soil.

Measurements of soil densities are included in the original Dutch method, in which sand mix was used (Couenberg 1994). Although the degree of compaction is intended to be optimized for plant growth, there is a risk of subsequent soil compaction of soil and settling of the pavement.

Conclusion

During the last 5 years, soil mixes, sand mixes, and load-bearing stone have been introduced for use in Denmark. Most landscape projects involving trees in paved areas use these new methods. No difficulties with load-bearing capacities, irregularities, or frost-heaving of pavements have been recorded. Compared to normal Danish conditions, the winter of 1995–1996 was long and cold, with continuous frost from the start of November to the middle of March. A top layer of at least 0.5 m (20 in.) was frozen, which influenced all layers of load-bearing mixes installed below pavements. None of the methods applied appear to have higher susceptibility to frost heave than does traditional pavement construction.

To reduce the visual effects of possible irregularities caused by heaves and settlements, landscape architects often changed the pavement on the load-bearing matrix materials so that it differed from the rest of the pavement. As a result, the possible height differences are less conspicuous than would be the case with uniform pavements. In addition, the change in pavement shows where the tree has its roots.

Table 2. Examples of load-bearing matrixes used in Denmark.

	Stones	Lava	Bricks	Leca	Sand	Totals
Premixing	8 locations 256 trees	2 locations 3 trees	6 locations 46 trees	1 location 40 trees	8 locations 114 trees	25 locations 459 trees
Water mixing during installation	5 locations 181 trees	2 locations 12 trees	1 location 3 trees	— —	— —	8 locations 196 trees
Dry mixing during installation	4 locations 141 trees	1 location 22 trees	— —	— —	— —	5 locations 163 trees
Totals	17 locations 578 trees	5 locations 37 trees	7 locations 49 trees	1 location 40 trees	8 locations 114 trees	38 locations 818 trees

Table 3. Comparison of advantages and disadvantages of installation methods.

Mixing method	Advantages	Disadvantages
Premixing	Can be done by machine Risk of soil compaction in voids Can require special mixing equipment	Separation during transportation and installation
Water mixing during installation	Contact between stones is ensured Independent of weather Prevents soil compaction	Can require large volumes of water Most suitable at large aggregate sizes
Dry mixing during installation	Contact between stones is ensured Prevents soil compaction	Dry weather required Requires dry soil
Sand mix	Rational mixing with right equipment Inexpensive ingredients Easy to install	Risk of soil compaction to a degree that impedes root growth The compaction level must be controlled Poor load-bearing capacity

All examples presented in this article were established between 1991 and 1996. None of these trees have been measured for growth rates. Fast and accurate results were obtained by conducting growth experiments with 8 materials and 3 tree species beginning in spring 1994. These results illustrate the growth capacities of the different materials (Kristoffersen 1998).

Acknowledgements. The author wishes to thank the municipalities involved in the planning and the construction of the cases studied. Thanks are also due to Dr. Thomas B. Randrup for valuable discussions in connection with this paper.

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Résumé. Au Danemark, les conditions pauvres de croissance pour les arbres en milieu urbain ont été perçues comme un problème depuis les années '80. Les dimensions restreintes des fosses de plantation sont principalement responsables de ce problème. Une recherche effectuée en 1996 a mis en lumière le fait que les fosses moyennes de plantation en milieu municipal sont passées de 0,1 m ≥ à la fin des années '60 à 3,4 m ≥ en 1996. Pour augmenter le volume de la fosse, plusieurs matériaux ont été introduits en mélange avec le sol afin de permettre aux racines de s'étendre sous le pavage. Trois méthodes sont possibles pour introduire le matériel sous la surface pavée. Au cours des cinq dernières années, plus de 800 arbres ont été plantés dans plus de 30 sites avec ces matériaux et ces méthodes d'insertion. Chacune de ces méthodes a ses avantages et ses inconvénients. Aucun problème sérieux imputable à la capacité de support des matériaux ou au soulèvement par le gel n'a été rapporté.

Zusammenfassung. In Dänemark wird seit den 80ger Jahren das Problem der armseligen Wachstumsbedingungen der Stadtbäume erkannt. 1996 fand eine Studie heraus, das die durchschnittliche Größe die kommunalen Baumscheiben vom 0,1 m³ in den späten 60ger bis zu 3,4 m³ angestiegen ist. Um das Volumen der Pflanzgruben zu vergrößern, wurden verschiedene Materialien eingeführt, um im Mix mit dem Boden Wurzelwachstum zu ermöglichen. Es sind drei Methoden zur Einbringung von Materialien unter der Bepflasterung durchzusetzen. Während der letzten 5 Jahre wurden mehr als 800 Bäume an mehr als 40 Standorten gepflanzt, die diese Nachteile. Es wurden keine größen Schwierigkeiten wegen der Ladekapazität oder Frostverwerfungen gemeldet.

Watson & Himelick ISA 1997

each other and the soil from sun and winds. Below ground, roots can spread over a larger area. Though not much additional soil is available for each tree, the larger shared root space provides a more consistent environment for the roots. Soil temperature, moisture, and other factors will be less affected by the container walls.

Soil specifications

When soil volume is restricted, soil quality becomes very important. Too often, trees are planted in whatever soil is present when the pits are created. Whether it is new construction or openings cut in existing pavements, the soil is often of very poor quality and should be replaced. Soils for planting pits and planters should contain (measured by weight) less than 27 percent clay, at least 50 percent medium (1 mm) sand, and 5 percent organic matter (20-35 percent organic matter by volume) (Patrick Kelsey and Phillip Craul, personal communications).

Planting pit design

Traditional planting pits have been openings in the pavement as small as 2 ft (60 cm) square, covered with an open grate. In recent years, the need for larger root spaces has begun to be recognized and better designs have been adopted. A larger pit with a larger grate is a simple way to enlarge the root space, but not always the most effective. Trees need an area of soil that is two ft (60 cm) deep within the dripline of the expected mature size of the tree, or the equivalent in a slightly different shape (50,52).

Many designs provide additional root space underneath the pavement. Planting pits can often be large enough to become shared root spaces, especially for linear plantings along streets. Vaulted systems suspend the pavement above the soil in order to provide an aeration pathway to the soil surface as well as to reduce or prevent compaction of the soil. Drainage and irrigation systems are usually installed as well (Figure 3-9).

Soils designed to support pavement without settling are often called load-bearing soils. To expand planting pits under pavements, the soil must also provide a favorable environment for root growth while supporting the pavement. The first soil of this type was developed in Amsterdam, Netherlands. Amsterdam Tree Soil specifications call for 91-94 percent medium coarse sand, 4-5 percent organic matter, and 2-4 percent clay (by weight). Phosphorous and potassium are added as necessary. The organic matter provides a source of nitrogen (39). The soil mix is carefully compacted to a specific density when installed, and aeration is provided through spaces in the pavers placed over the soil (Figure 3-10). This system has been shown to be effective in providing vigorous trees and stable pavements for many years.

More recently, other load bearing soils have been tested. Usually, large stones are used to create a network of interconnected spaces that can be filled with soil for root growth (43). Testing is still in the early stages in the United States, and engineers must be satisfied with the system before it will be used widely. Similar systems have been used successfully in European countries for several years.

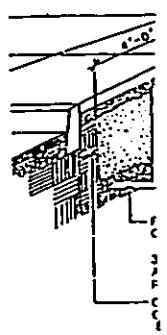


FIGURE 3-9. Vault

Root barriers

When pavements

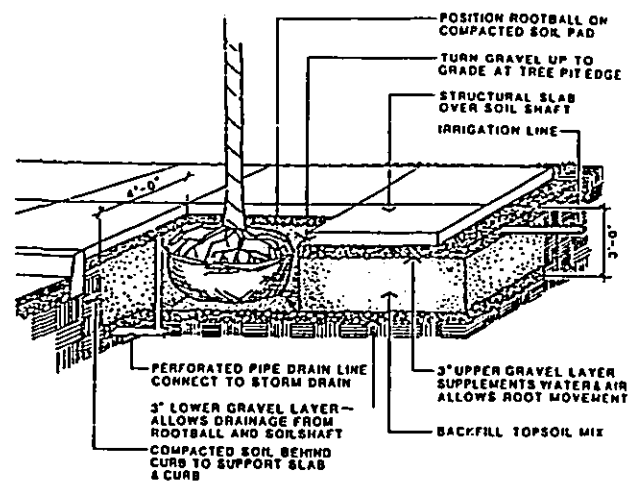


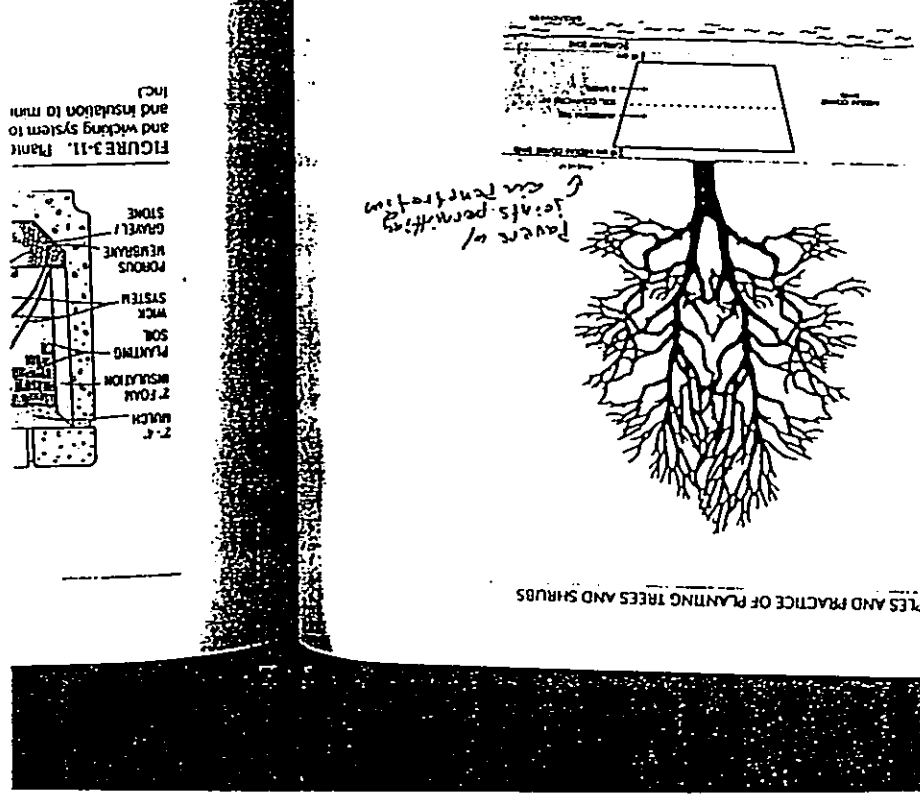
FIGURE 3-9. Vault systems can provide high quality root space underneath pavements. (Drawing courtesy of J. Urban)

Root barriers

When pavements are laid on a compacted soil base, roots often grow between the pavement and the compacted soil. Roots enlarge and can eventually lift the pavement. Barriers are sometimes installed to force roots to grow deeper. Barriers have been constructed from plastic, metal screening, and geotextile impregnated with herbicide. Most are effective at blocking roots between the surface and the bottom of the barrier. When roots grow under the barrier, they often grow back toward the surface, especially in poorly drained soils (42,62). In well-drained and well-aerated soils, the roots may not return to the surface so quickly, or at all (33,34).

Barriers reduce overall root development of trees (33,42,63). On sites with very poor aeration, the roots may not be able to grow deep enough to go under the barrier. The limited root system on one or more sides could result in poor vigor or instability.

When pavements were laid on a 12 in (30 cm) base of coarse brick rubble or gravel, roots did not grow directly under the pavement (51). The rubble was apparently not a suitable environment for root growth without soil in the spaces in between, and the roots grew in the deeper soil underneath the rubble.



IGURE 3-10. Underground tree pit design in Amsterdam. The medium coarse sand
rrounding the Amsterdam Tree Soil is compacted to >90% Proctor Density. Note that
e tree pit is extended underneath the pavement. (Drawing courtesy of E. Couenberg)

bovegground planter design

n downtown areas, sidewalks and courtyards may be built over basements,
nderground parking, or subway systems. In situations like these, trees must be
anted in aboveground planters. The decision to plant a tree in a planter must
clude a permanent commitment for intensive maintenance. The limited amount
moisture held in the extremely small soil volume can be depleted very quickly.
equent, but monitored, irrigation is required. If the drainage system becomes
ogged, excess water will cause damage to roots. Extremes in temperature,
pecially extremely low temperatures in winter, can cause extensive root injury
iding to the death of the plant. The use of larger planters helps to reduce these
oblems

Planting success depends on good root growth. Good root growth depends
a good quality environment. Without adequate site preparation, the plant
ll not grow vigorously on the new site and reach its full potential in the land-
pe.

FIGURE 3-11. Planters designed for the City of Milwaukee provide a water reservoir and wicking system to lengthen the irrigation cycle, drainage to prevent waterlogging, and insulation to minimize temperature extremes. (Drawing courtesy of Wausau Tile Inc.)

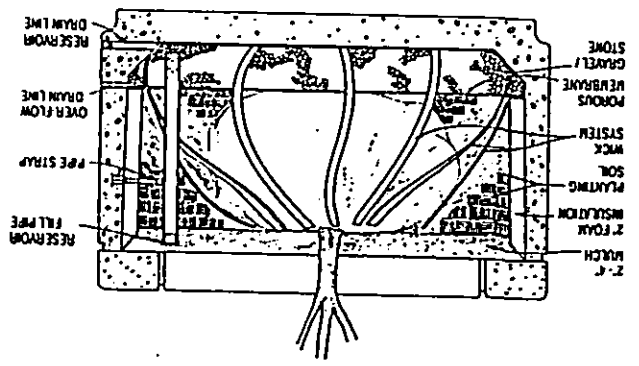


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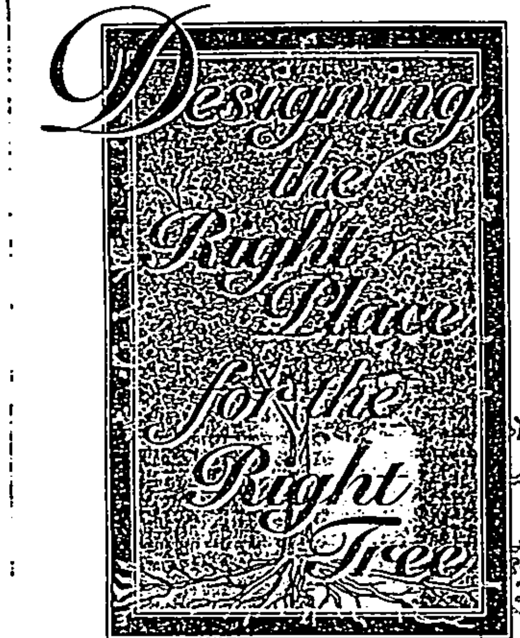
FIGURE 3-11. Planters designed for the City of Milwaukee provide a water reservoir and wicking system to lengthen the irrigation cycle, drainage to prevent waterlogging, and insulation to minimize temperature extremes. (Drawing courtesy of Wausau Tile Inc.)



Designing the Right Place for the Right Tree

David N. Gamstetter
Greenspace Manager, Cincinnati Park Board

The concept of plant the right tree in the right place is well known to tree care professionals. Planting the right tree in the right place ensures that the tree will not outgrow its site and interfere with surrounding utilities or structures and its aesthetic and functional assets perfectly complement the site. Most urban sites do not provide the physical characteristics required to grow desirable species or to allow the tree to reach its desired size and life span.

Cincinnati's Year 2000 Master Plan includes a Central Business District (CBD) street tree plan which establishes a guide for tree planting decisions. By designing development projects to accommodate the right tree, a team of urban foresters, design and construction engineers, and architects can create a streetscape which is low maintenance and conducive to tree growth.

However, good design and construction practices do not eliminate the need for maintenance. Hardware such as grates, guards, and holiday tree lights require proper installation and periodic maintenance—often a confusing, difficult, and expensive procedure.

Introduction

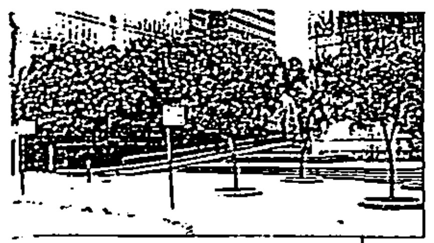
Created in 1986, the Cincinnati Year 2000 Plan was recognized as the blueprint for all street tree planting in the CBD. The plan provided a conceptual base for planting that identified large sections of the CBD based on use and only assigned general characteristics for the trees to be planted. While written with good intention, the plan resulted in disparate clusters of homogeneous tree populations rather than beautiful tree lined streets. The problem was compounded by a streetscape design which specified 4 feet by 4 feet tree wells (tree coffins) covered by a tree grate. The design did not allow for adequate root space and it limited planting options.

The plan was revised in 1993 with the intention to establish a guide for planting decisions. Plan objectives included increasing species diversity, reinforcing major travel corridors, selecting functionally appropriate species, and improving aesthetics. The revision applied specific tree selections to street segments within the CBD. As did the original plan, the revision considered the [illegible] designated historic districts and changes between residential, commercial, and office districts. For example, honeylocust *Gleditsia triacanthos* and ginkgo *Ginkgo biloba* are used in commercial and office districts [illegible]. Large broadleaf shade trees such as London planetree *Platanus × acerifolia* are used in residential districts to provide shade [illegible].

[illegible] the entire length of major streets to emphasize continuity. Tree species were chosen primarily for aesthetic and functional properties plus tolerance to wet sites [illegible].

A 1993 survey of North American cities indicated that a street tree planted in a downtown area has an average life span of 13 [illegible] years compared to 32 years for suburban sites. (1) The primary reason for poor tree performance in downtown environments is a lack of growing space for root systems. Most researchers agree that in natural settings, tree root systems often spread two to four times the width of the canopy. The standard 4 foot by 4 foot tree well design formerly used in Cincinnati provided only 48 cubic feet of root space; research conducted by Urban and Associates (2) indicates that a 20 foot by 20 foot (1,200 cubic feet) area is necessary to sustain a 25-foot diameter tree. Because Cincinnati's CBD is cramped, trees must compete with sidewalks, parking meters, doorways, and utilities for limited right-of-way space. Large tree wells were almost an impossibility.

To beautify the City with large, healthy shade trees, the Park Board's foresters worked closely with City architects and engineers to design adequate space for tree roots in streetscape projects. The design process created five opportunities for expanded root growth areas:



Sophora trees *Sophora japonica*. Trees in background have shared root systems in adequate root space. Trees in foreground are in 5 foot planters. All trees were planted at the same time and receive the same maintenance.

few seasons. In 1995 Cincinnati inventoried all 1,598 tree grates in the City. Of 1,598 grates, 1,282 (80 percent) needed to be replaced or repaired. The City Solicitor's Office determined that because tree grates are part of the walkable sidewalk surface, their maintenance is covered by the City Code governing and funding the sidewalk program in the Public Works Department. The cost of the work was $160,000. There is currently an agreement between Public Works and The Park Board that the street tree program will pay 50 percent of future repair costs.

Tree grates are often necessary to maintain walkable sidewalk surface. In areas with ample sidewalk surface, they should never be used unless maintenance money is set aside in advance and an agency is authorized to maintain them.

Tree grate size and type should be standardized to ease replacement of broken units. When new grates are installed, the joint between the two sections should always be parallel to the curb so that if a vehicle leaves the road and runs over the grate, only one half will be broken.

Tree guards have been used in the United States since the late 1890s. In 1903 William F. Fox, Superintendent of the State Forests for the State of New York strongly recommended using tree trunk guards. Fox stated that "the necessity for some such protection is readily apparent on

Tree grates require constant maintenance. The aperture in this grate is enlarged to accommodate an ever growing tree. Tree grates are inventoried and inspected every five years.

examining trees from the curbstone side, an observing the large number on which the bark has been gnawed by horses" (4). While Mr. Fox's observations were relevant in 190[illegible], today most municipalities have related [illegible] problems. Cincinnati no longer uses tree guards. They are expensive to install, difficult and expensive to maintain, and girdle and kill trees if not removed. If they are used, they should be endowed with a maintenance fund to pay for their removal after a few growing seasons.

Tree lights such as holiday lights are often installed by the abutting property owner. If improperly installed, these lights can injure

or kill a tree by girdling. The lights can turn a simple pruning job into a tangled mass of frustration for arborists (but not for cluppers!) In Cincinnati, holiday lights must be attached to the tree with screw eyes. Screw eyes are screwed into the trunk at intervals of 4 feet. The electrical wire is then attached to the screws with bands or twist ties. When the wire is above branching height, it is draped throughout the tree.

This attachment method is based on National Arborist Association standards for cabling a tree. Horticulturally, the damage to the tree trunk is minor and the tree can generally compartmentalize the damage. This method is superior to using tape or wire for attachment. Such fasteners can girdle the tree when not removed.

Results

Large shade trees along crowded inner-city streets do not just happen. Opportunities for large trees exist but must be designed and integrated into the surrounding infrastructure. By determining the right tree for a given street, the right planting place can be created. The growth requirements of the right tree must drive the surrounding infrastructure improvements. This concept is accepted in Cincinnati, and all of the methods outlined in this article are used to create viable streetscapes. The overriding factors in determining which method(s) to use are existing infrastructure and costs.

Of the five methods, the parking lot beautification program is the least expensive, most cost effective, and most dramatic. While the parking lot owner may lose a few parking spaces and associated revenue, the trees gain thousands of cubic feet of root area and parking lot users and pedestrians gain beauty and relief from the hot summer sun. Typically the cost to reconfigure and landscape an average lot is less than $10,000.

The cost to create a 4 foot by 4 foot (48 cubic feet) tree well with a tree grate and frame is $1,740 (not including tree costs). An expanded growth vault measuring 6 feet by 12 feet (288 cubic feet) with nearly six times the amount of root space is $2,270, a difference of only $530. If the expanded growth area can be incorporated into an existing basement encroachment, the cost is only $1,800, or $60 more than a standard tree well. It is difficult to determine the cost of the large shared root vaults because they are part of the total infrastructure of the site. It is believed that the shared growth planters provide the best growth opportunity because they allow trees to share root area and root systems.

The structural soil mix is the most useful and the least expensive of the expanded growth area techniques. The mix is easily adjustable to most locations, easy to install, and inexpensive. The mix of local materials tested by City consultants costs only $30 per cubic yard. In many situations, the structural soil mix is less expensive than structural fills used in the past.

Large, healthy trees are important in our cities. Do not settle for "the right tree in the right place." Determine the perfect tree, then design the right place.

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A hillside view of the city.

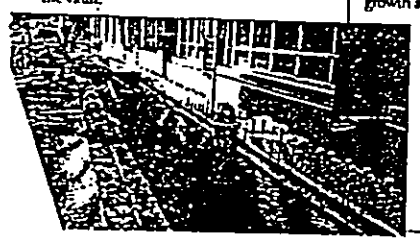
1. Individual vaults beneath the sidewalk, covered by a structural slab
2. Shared root space vaults, covered by a structural slab.
3. Basement vaults.
4. Sidewalks built on structural soil.
5. Parking lot beautification.

Vaults in New Streetscapes

The City of Cincinnati builds tree vaults when new buildings and their corresponding streetscapes are constructed. The vaults have poured concrete or concrete block walls which support a reinforced concrete structural slab. The reinforced concrete slabs are designed to be strong enough to support a fully loaded fire truck. The vault provides adequate root space when filled with planting soil. The Park Board uses a special mix comprised of 60 percent sand, 25 percent topsoil, and 15 percent organic material such as composted leaves.

The size of the vault is determined by the root area required by the tree at maturity as calculated by Urban and Associates (2). Individual vaults, built for one tree, are constructed when trees are spaced more than 40 feet apart or when existing utilities cannot be relocated to accommodate larger vaults. Shared root space vaults, built for more than one tree, are constructed when new buildings and subsequent right-of-way development require extensive excavation and relocation of existing utilities. Shared root space vaults are typically one third to one half of a block long and accommodate four to six trees. These vaults are constructed as part of the utility infrastructure with fire hydrants, pole foundations, and water lines built into the poured concrete vault walls. Capped feeder tubes are inserted through the structural slab to allow for watering and fertilization away from the tree grate.

Shared root system vault. Utilities such as water lines and fire hydrants are built into the vault.



Basement Vaults

Opportunities exist for expanded growth areas in existing streetscapes or areas under renovation. In Cincinnati, many old buildings have basements which extend below the sidewalk and encroach into the public right-of-way. This was a common practice before elevators were invented. It created useable space without adding additional floors with additional steps to climb. Typically these encroachments were used for coal bins and storage. The City eliminates basement encroachments due to safety and liability issues. By walling off the basement at the property line and filling the walled off portion in the right-of-way with a combination of low density fill and a vault filled with soil, an expanded growth area can be created at a nominal cost.

Structural Soil Mix

A structural soil mix is used to create root growth area when there is no opportunity for vaults. This structural planting soil is a 2.7 to 1 by volume ratio mix of stone aggregate to a soil/organic filler. The stone aggregate is capable of supporting a sidewalk while the pores between the aggregate contain the organic filler. Research (3) indicates that the structural mix, even when compacted, retains properties necessary for root growth. This method requires very little disturbance of the surrounding streetscape. The area is excavated to a depth of 30 inches, the soil mix installed and compacted, and new sidewalk poured, leaving a grate covered hole for the tree.

Parking Lot Beautification

Cincinnati's Economic Development Department has an aggressive parking lot beautification/screening program. Under this program, parking lots are re-striped and configured to allow enough space to construct a 10 to 12 foot wide planting bed located just behind the sidewalk off of the public right-of-way. Asphalt and underlying aggregate base are removed, and planting mix is installed. Often the mix is formed into a berm 1 to 3 feet high to provide additional screening of the lot. The CBD Street Tree Plan is used to determine the tree species to be planted so that the parking lot trees match the street trees. The lot owner then assumes responsibility for maintenance.

Creating Problem to Guard Against

Good streetscape design can minimize maintenance. However, maintenance is an essential part of any successful streetscape. The most common'y ignored maintenance items are tree grates and guards. Tree grates have been popular streetscape amenities for decades because they are attractive and increase the amount of walkable sidewalk surface. They are erroneously perceived as low maintenance because they supplant the need for mulch and, when backfilled with gravel, suppress weed growth.

Tree grates are labor intensive and expensive to maintain. They must be periodically reset or replaced when offset or broken. Depending on the size of the center opening, fast growing trees can be girdled after just a

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Nina Bassuk
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Urban Horticulture Institute
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nlb2@cornell.edu

Checks payable to Cornell University

Thank you.

STRUCTURAL SOIL MATERIAL FOR STREET TREE PLANTINGS

PART 1: GENERAL

The object of this document is to initiate discussions between urban foresters, engineers and architects for future project consideration. This material is experimental. It has only been tested on two stone sources and one soil at the time of this writing. There is no data available on long term rooting of trees in compacted profiles of these materials. The longest plant experiment to date lasted two growing seasons. While the material is initially of high bearing strength, there is no data, nor has there been any type of study which can predict the impacts of encouraging tree root proliferation below the pavement structure wearing surface. As experience and further testing of materials continues, a more comprehensive mixing protocol may be developed. Experiments and extensive study of root systems in paved settings will be necessary before any pavement design changes can be recommended to account for the presence of expanding tree roots below paved structures. Organic matter levels in the system have not been tested in any form to date. Mixing technique, placement and compaction are also under study for usage and testing guidelines.

1.01 DESCRIPTION: The work of this section consists of preparing and placing and compacting Structural soil materials on a prepared subgrade.

1.02 SUBMITTALS:

A: Submit soil and stone test analysis reports for the topsoil and the aggregate to be used from an approved soil testing laboratory.

1. The testing laboratories shall have a minimum of 5 years experience with the test protocols of the United States Golf Association -,Green Section and the American Association of State Highway and Transportation Officials (AASHTO).

2. Provide a physical analysis of the soil to include the following:

a. Particle size distribution
b. pH
c. Dry bulk density of soil as it is delivered to the mixing plant
d. Specific gravity
e. Percent organic content by weight
f. Nutrient levels including nitrogen, phosphorus, and potassium.

Fine sand	5 - 10%
Very fine sand	10 - 30%
Silt	20 - 40%
Clay	25 - 40%

C. Provide a minimum of three particle size analysis tests from samples obtained randomly throughout the source stock pile of field.

D. The pH value shall be between 6.0 and 7.0.

E. Nutrient levels in pounds per acre:

Nitrogen	(standard soil spec levels)
Phosphorus (Bray P1)	"
Potassium	"

F. Maximum soluble salts "

2.02 STONE

A. Stone meeting the local DOT size designation equivalent to AASHTO size #4 \ ASTM size #4. Preferably a crushed stone.

1. Stone shall be clean and be certified to meet local DOT aggregate soundness requirements for use in road construction.

2. Stone of high angularity will be preferred over washed gravel.

3. Stone dimension aspect ratio should approach 1:1:1 with a maximum of 2:1:1 average length:width:depth.

4. Particle size distribution shall meet the local DOT size designation equivalent to AASHTO size #4 \ ASTM size #4. A single sized stone near one inch will be preferred to a wider size distribution or smaller single sized stone fitting the general size description.

5. Submit at least three, five pound samples of different aggregate sources and the physical analysis from section 1.02-A-3 for review and selection.

2.03 HYDROGEL:

A. Gelscape® as manufactured by Amereq Corp., Congers, NY 10920 or approved equal.

2. Place the stone into the mixing hopper and set into motion.

3. Add the water-hydrogel slurry and allow to uniformly wet the stone.

4. Add the soil and mix (experience and testing will establish some initial guidelines).

5. Deposit the material.

6. Do not over-mix. If the clay begins to pelletize and separate from the stone, discard the batch.

- Remote mixing and storage in a dryer state and hydration after placement is under consideration.
- Pugging technology is also under consideration for large applications. This system would account for soil moisture while mixing and can mix by a pre-programmed metered weight ratio.

PART 3: EXECUTION

3.01 MIX DESIGN

A. Prepare sample structural mixes for testing and approval.

1. Test the topsoil and stone. Submit the test results and the samples, with their respective analyses for approval. Based on the samples and the analysis, the Contracting Officer and the contractor will jointly determine up to three different mix ratios for each Structural Soil Material to be tested for conformance with the requirements of the specifications

2. The contractor shall prepare the samples of the proposed mix ratio options and obtain test results Submit the samples of the mixes with the testing results.

3. Develop a standard moisture-density curve per AASHTO T 99 for each proposed mix.

4. If desired, conduct permeability and California bearing ratio (CBR) tests on compacted samples when compacted to peak density. Soaked CBR should be a minimum of 40 at peak standard density. Permeability expectations have not been developed at time of

yards of material produced. The sample stone-soil ratio will be checked by splitting a known weight of material on a #4 sieve. The percentage of soil should not be greater than 2% from the target ratio. The mean stone-soil ratio for the stock pile will be calculated and included.

NOTE: This takes time, and can be run quickly on low organic mixes by pan frying the mix, weighing, washing off the soil over the sieve, pan frying the stone and calculating soil percentage. "Speedy moisture" kits or microwaves could also be used for slightly longer drying times on organic materials, or oven methods which can take up to two days.

E. In the event that the average stone-soil ratio varies significantly from the approved sample, as determined by the Contracting Officer, make adjustments to the mixing ratios and procedures. Re-mix and re-test any lot of soil that fails to meet the correct analysis after the adjustment has been made.

F. After completion of the mixing and prior to the installation, protect the Structural Soil Material stockpile from rain and mix separation through erosion.

1. Cover the stockpile at all times with tarps or store in a covered structure.

3.03 UNDERGROUND UTILITIES AND SUBSURFACE CONDITIONS:

A. Notify the Contracting Officer of any subsurface conditions which will effect the contractor's ability to complete the work.

B. Locate and confirm the location of all underground utilities prior to the start of any excavation.

C. Repair any underground utilities or foundations damaged by the contractor during the progress of this work. The cost of all repair shall be at the contractor's expense.

3.04 SITE PREPARATION:

A. Excavate to the proposed subgrade to depths as shown on drawings.

B. Confirm that the subgrade is at the proper elevation and compacted as required. Subgrade elevations shall slope parallel to the finished grade and\or toward the subsurface drain lines as shown on the drawings.

URBAN HORTICULTURE INSTITUTE
Cornell University

October 1995

PROGRESS ON THE DEVELOPMENT OF AN URBAN TREE SOIL SPECIFICATION

Jason Grabosky and Nina Bassuk

The objective of this material is to provide a load-bearing pavement base material which will also provide a rooting medium for street trees. The stone-soil mix described below produces an extremely gap-graded material which provides rapid drainage and air movement. The strength of the material is fundamentally that of the stone when the mix is not produced with excessive soil. Defining the point where soil could be considered excessive has not been thoroughly defined for all stone and soil types, but one tested system is described as an example.

The original premise was to form a rigid stone matrix to meet loading requirements for a maintained light traffic pavement (sidewalks and possibly parking areas). Between the stones would be continuous voids which roots could grow through. A soil would be introduced to fill only a portion of those voids. A tackifier was used to "glue" the soil to the stone to prevent aggregate separation during the mixing, placement and compaction of the material.

The material is intended to be used as a pavement base which will also be expected to sustain street trees and their water use demands. For this reason, it is desired to have a deep base profile of 24 to 36 inches. The additional cost is in excavation, but in some construction and infrastructure repair projects, this cost may already be accounted for

The Materials

The stone tested to date has conformed to NYSDOT §703-02 sizing specifications for a size #2 stone. This corresponds roughly to a material which passes a one inch sieve and is retained on the one-half inch sieve. The preferred aggregate would be a crushed stone (such as NYSDOT §703-0201) which meets local DOT aggregate stability requirements for pavement base materials. More angular aggregates are preferred. The length to width ratio (flakiness index) of the preferred aggregate has not yet been established. A non-limestone based aggregate would likely expand the street tree species selection opportunities since the pH of the final mix would be lower than a limestone-based mixture.

The only hydrogel tested in this system to date is Gelscape® from Amereq Corporation 50 North Harrison Ave. Congers, NY 10920.

The only soil tested to date has been a clay loam (USDA textural triangle classification for a soil with 35% clay, 40% silt, and 25% sand by weight). Soils with high percentages of sand are discouraged to ensure a gap-graded material. A relatively high clay content has been desired in the preliminary studies to maximize the nutrient holding ability of the limited soil reserves in the mix. Based on the research completed to date, any specification would call for a clay loam

A possible mixing ratio could then be:

Stone:	100	
Soil:	20	UNITS OF WEIGHT
Hydrogel	0.03	
Total Moisture	10	

Installation notes

Two large scale installations have been completed in Ithaca, NY. From these two experiences several observations were made.

- The material can be over-mixed causing the soil to pelletize in the mixing hopper.
- The material can be mixed in seven cubic yard batches in a concrete truck.
- Batching the material is preferable if a staging area is present
- Drainage is essential if excess water is entering the site (such as washing out of trucks and tools as concrete is installed).
- The material should be compacted as any other pavement base material and subjected to the same quality control measures on site.
- The stone to soil dry weight ratio fluctuates as much as 15% within one mixing load. Placement of the material evened this out, but the soil component was observed to fluctuate by 20% within one project of 400+ cubic yards. Minimal quality controls could substantially decrease this variation.
- As a factor of safety, the specified ratio should not be set at the point of failure, but at a point where the variation of the mixing process will not cause potential problems.

Final note

We have produced this "pre-specification" with the idea in mind that discussion between engineers, contractors, landscape architects, and city foresters can begin. As we continue to test these materials, we anticipate a working specification within 18 months.

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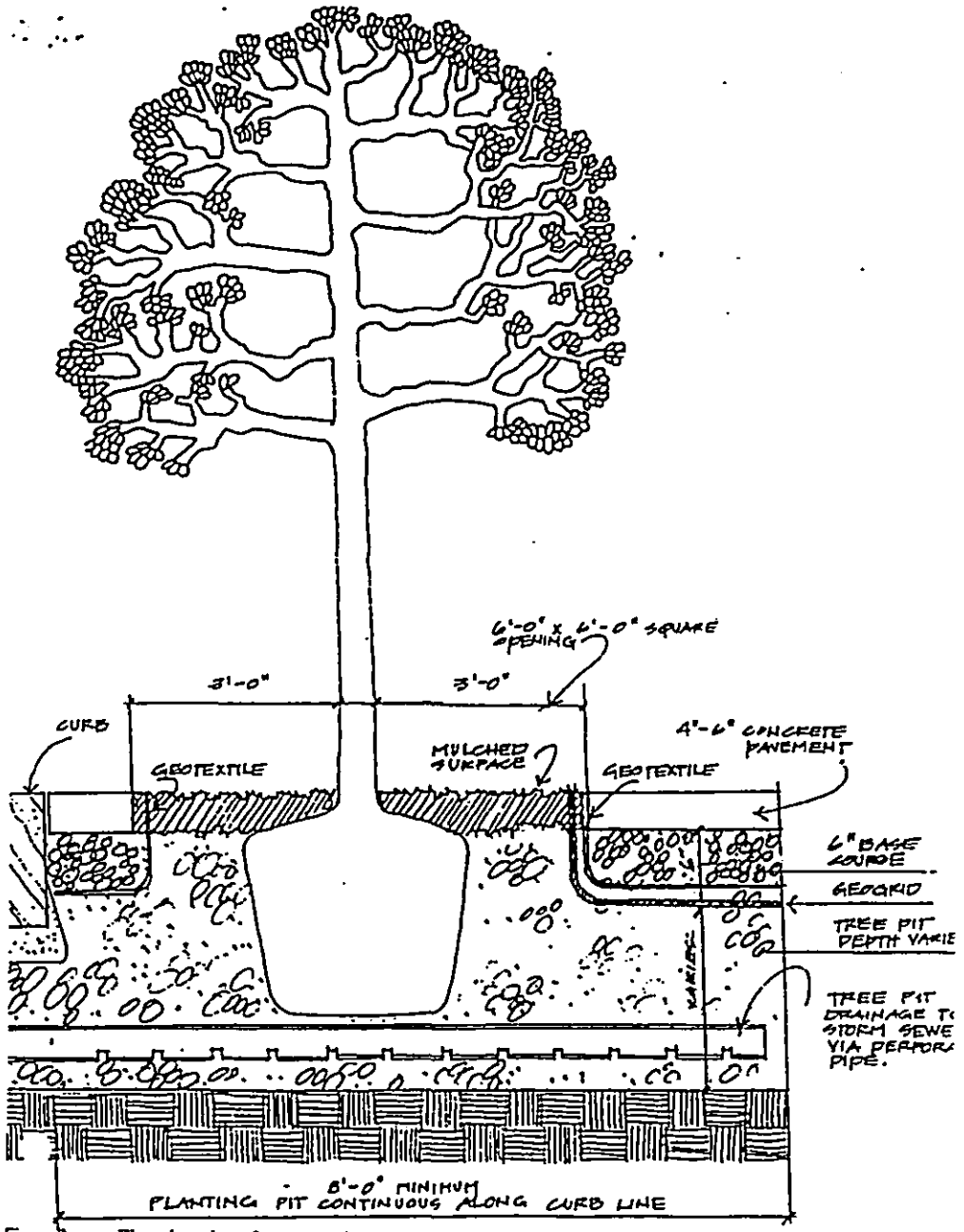


Figure 2: Elevation plan of a proposed structural soil pavement profile using the sub-base as the rooting zone.

SECTION 755

STRUCTURAL SOIL

1.01 GENERAL

The work of this Section consists of all Structural Soil work and related items as indicated on the Drawings or as specified herein and includes, but is not limited to, the following:

A. Structural Soil.

1.02. RELATED WORK SPECIFIED ELSEWHERE

A. The following items of Work are specified and included in other Sections of the specifications:

1. Unclassified Excavation
2. Grading
3. Site Pavements and Curbs
4. Site Improvements
5. Landscape Irrigation
6. Topsoil and Planting Mix
7. Seeding
8. Planting
9. Culvert, Storm Drains and Sewer Pipes

1.03 REFERENCES AND STANDARDS

A. The following references are used herein and shall mean:
1. ASTM: American Society of Testing Materials.
2. USDA: United States Department of Agriculture.
3 AASHTO: American Association of State Highway and Transportation Officials.
4. Standard Specifications: *Regional or Municipal Standard Specifications Documentation for the location of proposed usage*
5. AOAC: Association of Official Agricultural Chemists

compliance with ASTM D422 after destruction of organic matter by hydrogen peroxide.

3. Submit a chemical analysis, performed in accordance with current AOAC Standards, including the following:

a. pH and Buffer pH.
b. Percent organic matter as determined by the loss of ignition of oven dried samples. Test samples shall be oven dried to a constant weight at a temperature of 230 degrees F, plus or minus 9 degrees.
c. Analysis for nutrient levels by parts per million including nitrate nitrogen, ammonium nitrogen, phosphorus, potassium, magnesium, manganese, iron, zinc, calcium and extractable aluminum. Nutrient test shall include the testing laboratory recommendations for supplemental additions to the soil as calculated by the amount of material to be added per volume of soil for the type of plants to be grown in the soil.
d. Analysis for levels of toxic elements and compounds including arsenic, boron, cadmium, chromium, copper, lead mercury, molybdenum, nickel, zinc and PCB. Test results shall be cited in milligrams per kilogram.
d. Soluble salt by electrical conductivity of a 1:2 soil/water sample measured in Millimho per cm.
e. Cation Exchange Capacity (CEC).
f. Carbon/Nitrogen Ratio.

4. Submit 5 point minimum moisture density curve AASHTO T 99 test results for each Structural Soil sample without removing oversized aggregate.

5. Submit California Bearing Ratio test results for each Structural Soil sample indicating a soaked CBR minimum of 50 at peak standard density.

6. Submit Clay Loam-Crushed Stone ratio by splitting a known weight of oven dried material on a #4 sieve for each Structural Soil sample.

7. The approved Structural Soil samples shall be the standard for each lot of 500 cubic yards of material.

8. All testing and analysis shall be at the expense of the Contractor.

D. Maintenance Instructions: Prior to the time of Final Acceptance of the Work, submit maintenance instructions for the use, removal and replacement of Structural Soil for the Department's use. The instructions shall be reviewed by the Engineer as a pre-condition for Final Acceptance of the Work.

E. Submit to the Engineer for review a proposed plan and vertical section layout of all Structural Soil.

F. Submit one cubic foot sample per each 500 cubic yards of required material and for each sample, the following analysis for all Crushed Stone. The soil testing laboratory shall be approved by the Engineer.

A. All areas to receive Structural Soil shall be inspected by the Contractor before starting work and all defects such as incorrect grading, compaction and inadequate drainage etc. shall be reported to the Engineer prior to beginning this work.

B. The Contractor shall be responsible for judging the full extent of work requirements involved, including but not limited to the potential need for temporary storage and staging of soils, including moving soil stock piles at the site to accommodate scheduling of other work and the need to protect installed soils from compaction, erosion and contamination.

1.07 QUALITY ASSURANCE

A. Qualifications of Landscape or Pavement Material Contractor: The work of this section shall be performed by a Landscape Contracting firm which has a minimum of 5 years experience successfully installing planting mix of a similar quality, schedule requirement and construction detailing to this project. Proof of this experience shall be submitted as per paragraph, SAMPLES AND SUBMITTALS, of this Section.

MATERIALS

2.01 CLAY LOAM

A. Clay Loam shall be a "clay loam" based on the "USDA classification system" as determined by mechanical analysis (ASTM D-422) and it shall be of uniform composition, without admixture of subsoil. It shall be free of stones greater than one-half inch, lumps, plants and their roots, debris and other extraneous matter over one inch in diameter or excess of smaller pieces of the same materials as determined by the Engineer. It shall not contain toxic substances harmful to plant growth. It shall be obtained from naturally well drained areas which have never been stripped or top soil before and have a history of satisfactory vegetative growth. Clay Loam shall contain not less than 2% nor more than 5% organic matter as determined by the loss on ignition of oven-dried samples. Test samples shall be oven-dried to a constant weight at a temperature of 230 degrees F., plus or minus 9 degrees.

B. Mechanical analysis for Clay Loam shall be as follows:

Textural Class	% of total weight
Gravel	less than 5%
Sand	25 - 30%
Silt	20 - 40%
Clay	25 - 40%

C. Chemical analysis: Meet or be amended to meet the following criteria.

1. pH between 5.5 to 6.5
2. Percent organic matter 2 -5% by dry weight.
3. Nutrient levels as required by the testing laboratory recommendations for the type of plants to be grown in the soil.
4. Toxic elements and compounds below the United States Environmental Protection Agency Standards for Exceptional Quality sludge or local standard; whichever is more stringent.

B. Acceptable aggregate dimensions will not exceed 2.5:1.0 for any two dimensions chosen.
C. *Statement of angularity or % rounded edges*
D. Results of the Aggregate soundness loss test will not exceed 18%.
E. Losses from L.A. Abrasion tests will not exceed 40%.

2.07 HYDROGEL

A Hydrogel shall be a potassium propenoate-propenamide copolymer Hydrogel as manufactured by Geiscape by Amereq Corporation.

2.08 WATER

A. The Contractor shall be responsible to furnish his own supply of water to the site at no extra cost. All work injured or damaged due to the lack of water, or the use of too much water, shall be the Contractor's responsibility to correct. Water shall be free from impurities injurious to vegetation.

2.09 STRUCTURAL SOIL

A. A uniformly blended mixture of Crushed Stone, Clay Loam and Hydrogel, mixed to the following proportion:

MATERIAL	UNIT OF WEIGHT
Crushed Stone	100 dry weight
Loam	As determined by the test of the mix (Approx. 16 +/-)
Hydrogel	0.03 dry weight
Total moisture	10 (AASHTO T-99 optimum

B. The initial mix design for testing shall be determined by adjusting the ratio between the Crushed Stone and the Clay loam such that the volume percent of Clay Loam in the mix is less than 80% and more than 60% of the percent of voids in the Crushed Stone as determined from the stone rodded unit weight (1.04 F 3) and the bulk density of the soil. Adjust final mix dry weight mixing proportion to decrease soil in mixture if CBR test results fail to meet acceptance (CBR>=50).

CONSTRUCTION METHODS

3.01 MIX DESIGN

A. Prepare sample Structural Soil mixes to determine the ratio of mix components. Submit for approval.

1. Submit samples and the test results of each mix component for approval. Based on samples and the analysis of the mix components, the Engineer and the Contractor will jointly determine a mix ratios to be tested for conformance with the requirements of the specifications. For Structural Soil quantities greater than 500 cubic yards, test the mix ratio for each Clay

e. Auger out to stocking pile or transport vehical (or into pit it using a portable pugging operation).

4. Add soil amendments to alter soil fertility including fertilizers and pH adjustment at the time of mixing at the rates recommended by the soil test.

a. soil pH shall be adjusted to fall within a rate of 5.5 and 6.5 two months after mixing if the material is stored. Unless mixing with a high pH stone. Once pavement is layed, no adjustment should be imposed.

b. Soil component Carbon / nitrogen ratio shall be adjusted to be less than 1:33 within two months after mixing.

B. The Contractor shall mix sufficient material in advance of the time needed at the job site to allow adequate time for final quality control testing as required by the progress of the work. Structural Soil shall be stored in piles of approximately 500 cubic yards and each pile shall be numbered for identification and quality control purposes. Storage piles shall be protected from rain and erosion by covering with plastic sheeting.

C. During the mixing process, the Contractor shall take two - one cubic foot quality control samples per 500 cubic yards of production from the final Structural Soil. The samples shall be taken from random locations in the numbered stockpiles as required by paragraph 1.04.B of this specification. Each sample shall be tested for particle size analysis and chemical analysis as described in Paragraph 1.04. C.2 and 3 above. Submit the results directly to the Engineer for review and approval.

D. The quality control sample Clay Loam-Crushed Stone ratio's shall be no greater or less than 2% of the approved test sample as determined by spitting a known weight of oven dried material on a #4 sieve. In the event that the quality control samples varies significantly from the approved Structural Soil sample, as determined by the Engineer, remix and retest any lot of soil that fails to meet the correct analysis making adjustments to the mixing ratios and procedures to achieve the approved consistency.

3.03 UNDERGROUND UTILITIES AND SUBSURFACE CONDITIONS

A. Notify the Engineer of any subsurface conditions which will effect the Contractor's ability to complete the work.

B. Locate and confirm the location of all underground utility lines and structures prior to the start of any excavation.

C. Repair any underground utilities or foundations damaged by the Contractor during the progress of this work. The cost of all repair shall be at the Contractor's expense.

3.04 SITE PREPARATION

A. Do not proceed with the installation of the Structural Soil material until all walls, curb footings and utility work in the area has been installed. For site elements dependent on Structural Soil for foundation support, postpone installation until immediately after the installation of Structural Soil.

C. Install first 6 inch lift of Structural Soil material without damage to Filter Fabric at bottom and sides of trenches.

3.06 INSTALLATION OF STRUCTURAL SOIL MATERIAL

A. Install Structural Soil in 6 inch lifts and compact each lift.

B. Compact all materials to not less than 95% of peak dry density from a standard AASHTO compaction curve (AASHTO T 99). No compaction shall occur when moisture content exceeds maximum as listed herein. Delay compaction 24 hours if moisture content exceeds maximum allowable and protect Structural Soil during delays in compaction with plastic or plywood as directed by the Engineer.

C. Bring Structural Soils to finished grades as shown on the Drawings. Immediately protect the Structural Soil material from contamination by toxic materials, trash, debris, water containing cement, clay, silt or materials that will alter the particle size distribution of the mix with plastic or plywood as directed by the Engineer.

D. The Engineer may periodically check the material being delivered and installed at the site for color and texture consistency with the approved sample provided by the Contractor as part of the submittal for Structural Soil. In the event that the installed material varies significantly from the approved sample, the Engineer may request that the Contractor test the installed Structural Soil. Any soil which varies significantly from the approved testing results, as determined by the Engineer, shall be removed and new Structural Soil installed that meets these specifications.

3.07 FINE GRADING

A. After the initial placement and rough grading of the Structural Soil but prior to the start of fine grading, the Contractor shall request review of the rough grading by the Engineer. The Contractor shall set sufficient grade stakes for checking the finished grades.

B. Adjust the finish grades to meet field conditions as directed.

1. Provide smooth transitions between slopes of different gradients and direction..

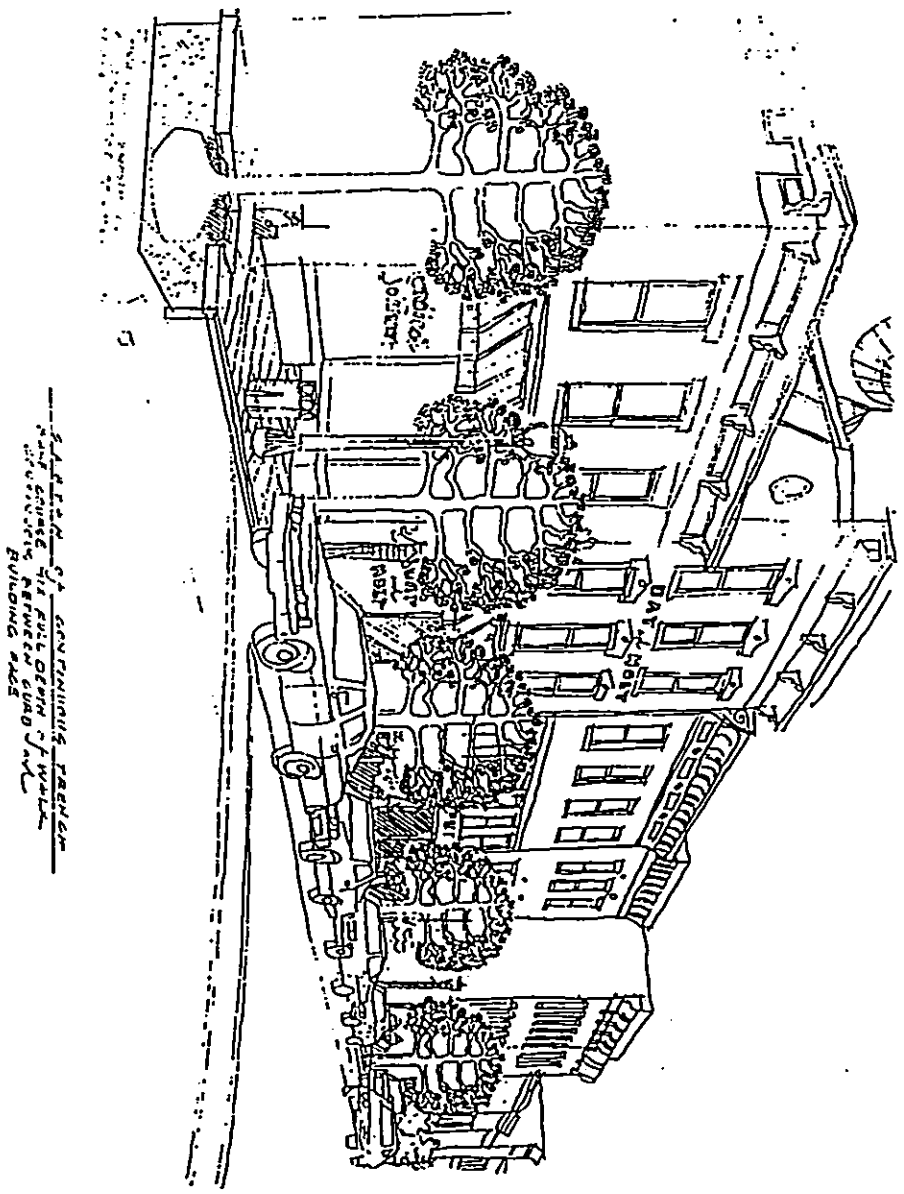
2. Fill all dips and remove any bumps in the overall plane of the slope.

a. The tolerance for dips and bumps in Structural Soil areas shall be a 2" deviation from the plane in 10'.

3. All fine grading shall be inspected and approved by the Engineer prior to the installation of other items to be placed on the Structural Soil.

C. The Engineer will inspect the work upon the request of the Contractor. Request for inspection shall be received by the Engineer at least 10 days before the anticipated date of inspection.

3.08 ACCEPTANCE STANDARDS



'RECIPE'

I. Materials

Stone: Angular Crushed Stone or gravel, sized as uniformly as possible between 0.75 and 1.5 inches in diameter. No fine grained contaminants.

Soil: Screened soil falling under the following parameters:

Gravel	< 5%	
Coarse to medium sand	< 5%	Falling under the USDA
Fine sand	5-10%	soil classifications
Very fine sand	10-30%	loam, silt loam or clay loam
Silt	20-60%	
Clay	20-35%	

Hydrogel: Gelscape® or approved equal

Amereq Inc. (914) 634-2400
19 Squadron Blvd (800) 832-8788
New City, NY 10956

II Determination of a mixing ratio

A. Make two or three test batches

i. 15%soil, 85%stone by weight
ii. 18%soil, 82%stone by weight
iii. 20% soil, 80% stone by weight

Hydrogel rate is constant for each blend at 30grams (1oz) dry powder hydrogel per 100 kilograms (210 lb) of stone.

B. Calculate ratio of stone to soil

i. Weigh out 25kg (55 lb)of dry stone (absorbency of stone material should be low <<1% so air-dry stone is acceptable for the mixing)
ii. Determine dry weight of soil

a.	Take a small representative sample of soil from the stock pile (40-50g) (1.4-1.8 oz)	48 grams (1.69 oz)
b.	Dry sample to a constant weight (about 48 hours) at 60C or 110 F	40 grams (1.41 oz)
c.	Weight the dry soil	

Send the 3 sample material blends to a soils engineering laboratory to run the following diagnostic tests.

- Standard Proctor Density curve: AASHTO T-99 to anchor your compaction specification should the material be used. This will also provided optimum moisture level for compaction.
- Strength testing as required by the project engineer. We have used a minimum criteria of California Bearing Ratio (96 hour soak) of 50. Even if the engineer is willing to accept a lesser strength material, we would strongly suggest this minimum CBR of 50 to meet both root growth and strength requirements.

When the results come back:

15% should give you acceptable strength.
IF 18% is at CBR = 50, reduce the soil in mixture to 15% (to allow for mixing variations)

- 20% may or may not give you acceptable strength. IF 20% is at CBR = 50, then reduce soil to 18% (again to account for mixing variation)

-or- graph the results of CBR against soil percentage in mix. Choose 2% less soil than level where line crosses CBR = 50

MIXING

Scale the mixing process to match the equipment available.

Mixing "on the flat" on a paved surface with a front end loader (shovel)

Spread a known weight of dry stone onto the flat surface in a thin layer. This requires knowing the unit weight of stone per loader bucket.	1000kg (2204.6 lb) stone in layer
Spread dry hydrogel evenly over the stone layer at the 30 units hydrogel per 100,000 units stone rate.	300grams (10.58 oz) hydrogel
Converting weight to volume of soil component:	A) 176 kg (388 lb) dry soil is needed for a 15% soil mix
Weigh one bucket load of soil moist	B) 105 kg (231.5 lb) moist soil per bucket in this example
Take 5 representative samples from the soil stock pile 2 days prior to mixing and tarp soil pile to minimize changes in the moisture content. Determine average soil moisture content as described earlier. NOTE: a Speedy® moisture kit could provide on site moisture content measurement Available	C) soil moisture was calculated at 20% in the previous example 100x(105 ÷ (100+%moisture in bucket load)) = weight of dry soil per bucket
water added in soil	17.5 kg (38.5 lb)(per bucket *2 buckets = 35 kg (77 lb) water
water needed to hit target moisture	106 kg - 35 kg = 71 kg water ----- 71 liters water 156.5 lb water ----- 18.75 gallons

If mixing the material in large quantities is expected, stockpile mixed material in 200-400 cyd batches.

For quality control, take a minimum of three 5 kg (11 lb) samples to be tested for:

- % moisture (if to be immediately used)
- particle size ratio stone to soil

To quickly measure ratio stone to soil

	Example
Collect sample and obtain moist weight	6.00 kg (13.2 lb)
Dry the stockpile sample and obtain sample dry weight	5.50 kg (12.1 lb)
Determine mixture moisture content	6 - 5.5 = 0.5 (13.2-12.1 = 1.1) 0.5 ÷ 5.5 = 0.091 = moisture content (1.1+12.1= 0.091)
Submerge the sample in water and wash the stone free of soil	
Pass the material through a #40 seive, while washing any residual soil away. Retain and collect all stone from the sample	
dry the stone and obtain sample stone dry weight	4.68 kg (10.3 lb) stone
calculate the percentage of stone in the stone	4.68 kg stone ÷ 5.5 kg sample dry weight = 0.851 (10.3+12.1 = 0.851) 0.851 * 100 = 85.1 Target mixture @ 85.0
Remember 95% of the stone should be retained on a 0.75 inch seive, now could be a good time to double check if stone is in question	

Installation

February 23, 1999

Mr. Charles Jencks, Director
County of Maui
Department of Public Works and
Waste Management
200 South High Street
Wailuku, Hawaii 96793

Dear Mr. Jencks:

The Monkey Pod trees growing on South Kihei road in front of Kauhale Makai condominium were discussed at the February 10, 1999 Maui County Arborist Committee meeting. A meeting of the Tree Concerns subcommittee was scheduled on site for February 23rd. The Arborist Committee requested that following this meeting a letter be sent to you with suggestions on how to deal with the root/sidewalk impact.

Because the trees provide a great deal of welcomed shade to an other wise hot area, there is community support for keeping the street trees. The tree concerns subcommittee inspected the trees and sidewalk beginning from the North end at Village by the Sea condominium.

Observations:

Some of the trees have large exposed surface roots and others do not. This may be due to a shallow soil. Some Kihei developers used large rocks as fill and then covered them with soil prior to planting a landscape. We did not excavate to verify what occurred here. Nonetheless this would not solve the present concerns. We learned that the trees are about 20 years old.

1. Monkey Pod #1. Large surface roots. No sidewalk lifting. Recommend that the sidewalk be curved towards the curb to provide the tree with a larger space for trunk and root growth. This method has been observed in mainland communities.

2. Monkey Pod # 2. No sidewalk impact.
3. Monkey Pod # 3. Same as tree number 1.
4. Monkey Pod # 4. No sidewalk impact.
5. Monkey Pod # 5. Same as tree # 1.

Entrance into Luana Kai Condominium.

6. Monkey Pod # 6. There is some sidewalk lifting at the ramp. Some root pruning occurred in the past. Solve by providing more growing space as in tree # 1.
7. Monkey Pod # 7. Provide an enlarged growing space at base of the tree as recommended in tree # 1.
8. Monkey Pod # 8. No sidewalk impact.
9. Monkey Pod # 9. Provide more growing space as recommended in tree # 1.
10. Monkey Pod # 10. Provide more growing space as recommended in tree # 1.
11. Monkey Pod # 11. Roots have impacted with the sidewalk. Provide more growing space as in tree # 1.
12. Monkey Pod # 12. Same as tree # 1.

Entrance to parking lot.

13. Monkey Pod trees # 13, 14, and 15. These three trees have raised the sidewalk the most. Provide more growing space by elevating the sidewalk as discussed below. Sidewalk repair in any other method will probably require root pruning. This is not a recommended practice.

Possible Solutions:

1. Elevating the sidewalk: Move the entire sidewalk towards the curb and elevate it by adding 3-4 inches of soil and 3-4 inches minimum of crushed blue rock on top of it. Compact the blue rock some. Pour a new sidewalk reinforced with steel. The curb may need to be raised to level the elevated

sidewalk with it. A railing could be installed between the sidewalk and the curb instead. Fill between the sidewalk and trees with top soil.

The soil and blue rock will provide more space for expanding roots and the steel will lessen any future lifting by the roots. This technique should provide some years of impact free growth.

2. Provide an enlarged growing space for trees # 1, 3, 5, 6, 7, 9, 10, 11, and 12 by curving the sidewalk towards the curb. The new sidewalk should be steel reinforced and tied into the existing sidewalk sections. For trees number 13, 14, and 15, because the distance is only about 40 feet and each tree is raising the sidewalk it is recommended that a new sidewalk be constructed as proposed in solution # 1.

3. Do number 2 without steel reinforcements or blue rock base. This will fix the problem but not provide long term correction.

Other Suggestions:

1. Do not prune the roots because this practice affects tree stability and opens up sites for root decay.

2. The Arborist Committee has learned of new creative methods for building underground spaces for improved root growth that lessens root/sidewalk and curb impact. We have shared a video from Cornell University with the Planning Department and would like to offer it for your department's review. However, these methods are used prior to planting and not to correct an existing problem.

We are interested in using this technique, or some other one, for street/parking lot tree planting in a private or public project. If you are aware of a project where such an experiment could be conducted, please bring it to our attention. We are interested in changing the way we plant trees to provide better growth and lessen root impact with hardscapes.

We hope these suggestions will help you resolve the Monkey Pod's impact with the sidewalk in Kihei. We all want to keep the trees and yet make the area safer for walkers.

Thank you for your assistance on this matter. If you have any questions please contact Sue Kiang at the Volunteer Action Program at 243-7325.

Sincerely,

ERNEST H. REZENTS
Chairman

c: Elaine Malina, Tree Concerns Subcommittee
David Sakoda, County Arborist

c:\arbcom\jencks3(er)

MAUI COUNTY ARBORIST COMMITTEE

375 UHU STREET · KAHULUI · HAWAII 96732 · (808) 243-7325 · FAX (808) 243-7953

ERNEST H. REZENTS, CHAIRMAN
KEOKI FREELAND
JEFF GRAY
LEINAALA KIHM
ELAINE MALINA
ROSLYN MORESH
VIVIENNE ROMANCHAK
KEVIN TANAKA
GENE THOMPSON

February 3, 2000

TO: Laura, Wilson Okamoto & Associates
FROM: Sue Kiang, Maui County Arborist Committee
Sue

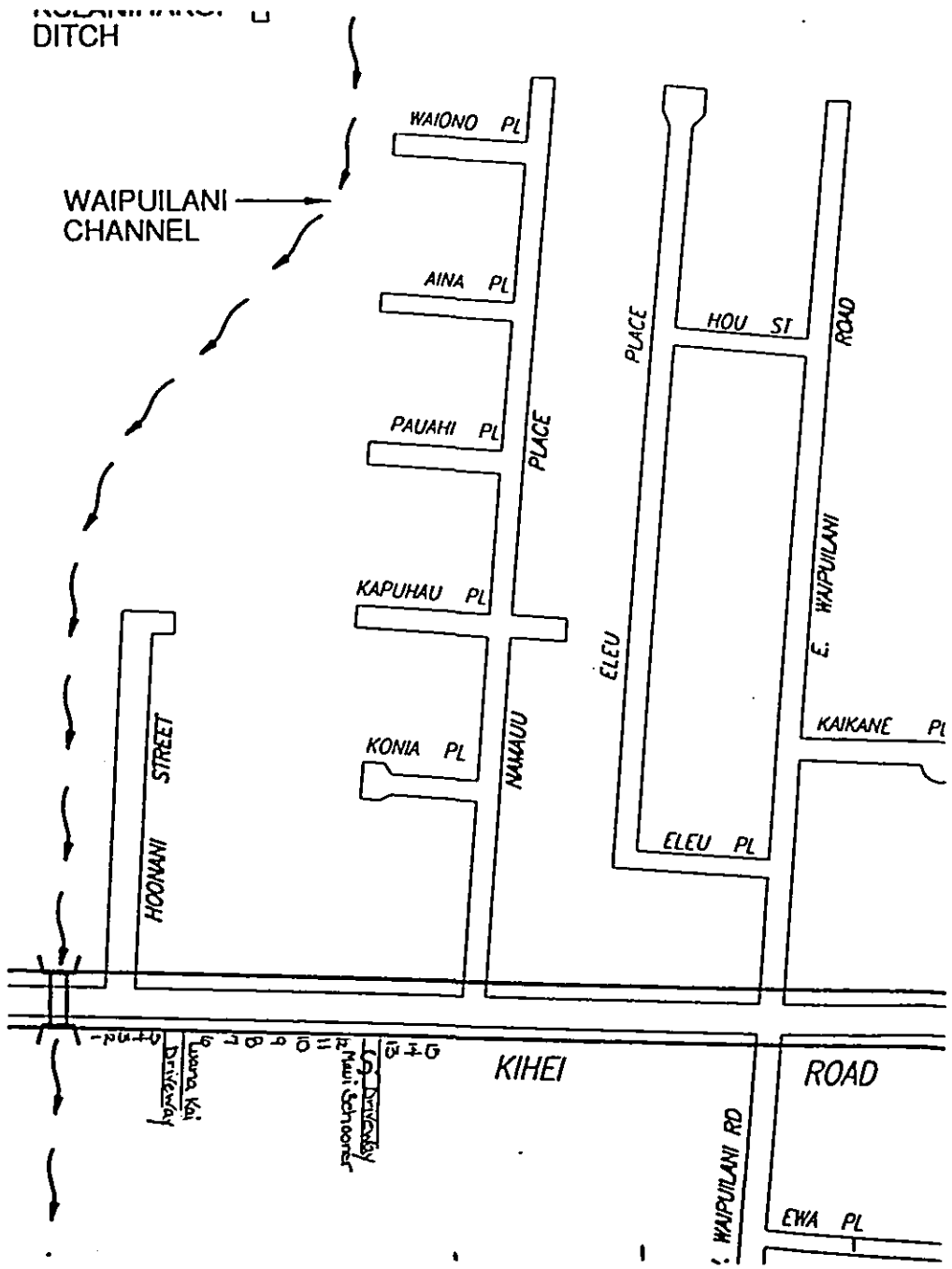
LM

Here is a blow-up of the map of South Kihei Road that reflects the area of concern to the Committee regarding the beautiful, mature Monkeypod trees. I am also including the earlier letter as a convenient reference. I numbered the trees according to the letter and tried to place them accordingly.

As you may know, Kihei is in a very hot and dry community. The shade provides a welcome respite in the neighborhood. Hopefully, some of the technical information that Ernest Rezents sent with the follow-up letter for the Environmental Impact Assessment could be included in the construction plans. If these trees cannot be saved during the road improvements, maybe a better job can be done creating subsurface growing vaults for newly-planted trees.

If I can be of further assistance, please call. Again I apologize for the delay in my offer to map this. I had misunderstood your needs and thought I had missed my "window of opportunity."

[The hard copy will follow in tomorrow's mail, in case the facsimile is of poor quality.]



JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
Director

DAVID C. GOODE
Deputy Director

TEL. (808) 270-7745
FAX (808) 270-7975

COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
AND WASTE MANAGEMENT
ENGINEERING DIVISION
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

RALPH NAGAMINE, L.S., P.E.
Land Use and Codes Administration

RONALD R. RISKA, P.E.
Wastewater Reclamation Division

LLOYD P.C.W. LEE, P.E.
Engineering Division

ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

March 3, 2000

Mr. Ernest Rezents, Chair
Maui Arborist Committee
c/o County of Maui
Department of Parks and Recreation
275 Uhu Street
Kahului, Hawaii 96732

Attention: Ms. Sue Kiang

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII
FAP NO. STP-3100(11)

Dear Mr. Rezents:

We have received your letters dated November 22, 1999 and February 3, 2000 commenting on the subject Drat EA.

As discussed with Ms. Sue Kiang on February 16, 2000, we will consider replanting trees within the new right-of-way to the extent possible, and provide root barriers to prevent damage to the new sidewalks. The Department is also considering transplanting trees at various county parks. In particular, the South Maui Parks Division of the Department of Parks and Recreation has indicated a need for shade trees at the old Kalama Park located approximately 1 mile south of Lipoa Street. The disposition and treatment of any transplanted trees will be coordinated with Mr. David Sakoda, County Arborist.

We appreciate the information you provided regarding the various methods and techniques for tree planting as well as the assistance of Ms. Kiang in providing the accompanying map for the Monkey Pod tree assessment. The information will be considered in the project's design.

Thank you for your participation during the EA review process.

Sincerely,

pp LLOYD LEE
Engineering Division Chief

LL:lk:c:(ED00-360)

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.

Kihei Community Association

Planning and Development Review

RYF-

Project	South Kihei Road Improvements
Location	Kulanihakoi Street to Lipoa Street
Owners	County of Maui Department of Public Works and Waste Management
Architect/Consultants	Wilson Okamoto & Associates, Inc. Engineers and Planners 1907 South Beretania Street-Suite 400 Honolulu, Hawaii 96826
Cost Estimate	Not available

Proposal Improve approximately 5,100 feet of roadway - 1,000 feet to be restriped, 300 feet will remain as is, and 3,800 feet to be widened from 50 to 60 feet to 60 to 70 feet with 2 travel lanes, bike lanes, a parking lane, turning lanes, sidewalks, curbs, and gutters. Travel lanes would be 12 foot wide, bike lanes - 5 foot wide, sidewalks - 6 foot wide.

Comments 1. The Planning and Development Committee of the Kihei Community Association and the residents of South Maui have not be had an opportunity to meet with the planners of this project to provide their questions, comments, and concerns. 2. The plan provided does not show a roadway profile. It appears from the written copy that the proposed parkway between the sidewalk and curbs and gutter will be less than the recommended 4 foot. We recommend a 4 foot parkway with the reduction in sidewalk width to 4 or 5 foot, if necessary.

3, We recommend that where parkway trees do not exist, they be added for the entire length of the proposed roadway. These will reduce the levels of noise produced by the use of Kihei Road and provide a parkway appearance to a common road. 4. We recommend that reclaimed water supply lines and localized irrigation lines be installed for the trees, ground cover, and or grass in the parkways. 5. We recommend that Condominiums located along the project be permitted to tie into the reclaimed water supply for their irrigation.

a. Revenues from the sale of reclaimed water to the condominiums should provide significant income to offset any added construction costs.

b. 50% or more of the current domestic water used by the condominiums will become available for other users.

6. Future conversion to a 4 lane roadway without bike lanes is strongly opposed by the community. If this is to be county policy, the added right of way required should be acquired now on a immediate or delayed possession basis.

Pending	SMA Approval
Date	January 2000

JAMES "KIMO" APANA
Mayor

CHARLES JENCKS
Director

DAVID C. GOODE
Deputy Director

TEL. (808) 270-7745
FAX (808) 270-7975

COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
AND WASTE MANAGEMENT
ENGINEERING DIVISION
200 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

March 3, 2000

RALPH NAGAMINE, L.S., P.E.
Land Use and Codes Administration

RONALD R. RISKA, P.E.
Wastewater Reclamation Division

LLOYD P.C.W. LEE, P.E.
Engineering Division

ANDREW M. HIROSE
Solid Waste Division

BRIAN HASHIRO, P.E.
Highways Division

Kihei Community Association
P. O. Box 662
Kihei, Hawaii 96753

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA)
SOUTH KIHEI ROAD IMPROVEMENTS
KULANIHAKOI STREET TO LIPOA STREET
TAX MAP KEYS: (2) 3-9-1, 2, 7, 8, 22, 34, 46, 52: VARIOUS
KIHEI, MAUI, HAWAII
FAP NO. STP-3100(11)

Dear Sir or Madam:

We have received your letter dated January 2000 commenting on the subject Draft EA and offer the following response to your comments:

1. The Department plans to conduct a public informational meeting to apprise the community and discuss any concerns regarding the project. We invite your attendance and will notify you once arrangements for the meeting have been made. In addition, a public hearing required in conjunction with the Special Management Area permit process, which was recently initiated, will provide additional opportunity for pubic input.

2. Attached for your information are typical road sections for the project, which illustrate the improvements within the new right-of-way which will vary from 60 to 70 feet. The proposed improvements call for a 6-foot wide sidewalk between the curb and gutter and the new right-of-way. While we concur that a parkway would be desirable, provisions for a parkway cannot be accommodated within the new right-of-way. The inclusion of a parkway would require the acquisition of additional land area. The current proposal will require the acquisition of 40,540 square feet, or 0.93 acres of land distributed among 49 private parcels. As we are striving to minimize land acquisition costs and associated impacts to adjacent landowners, a parkway will not be included as part of the proposed project.

3. Currently, there are no plans to plant trees where none exist, however, we are considering replanting trees which may be displaced to the extent possible. We have consulted with the County Arborist Committee and will coordinate with the County Arborist regarding the disposition and treatment of any transplanted trees.

4. & 5. We concur with the use of reclaimed water for irrigation purposes, however, there are no immediate plans to connect the reclamation system to the project site. The nearest possible connection points within the existing transmission system are located along the North-South Road, approximately 1/2-mile east of the project site, and near Kalama Park, approximately 1 mile south of Lipoa Street. The construction cost for the transmission system is approximately $1 million per mile, and as such, is deemed cost prohibitive for the Department to consider at this time.

6. The Department has no immediate plans for converting the roadway into four lanes.

Thank you for your participation during EA review process.

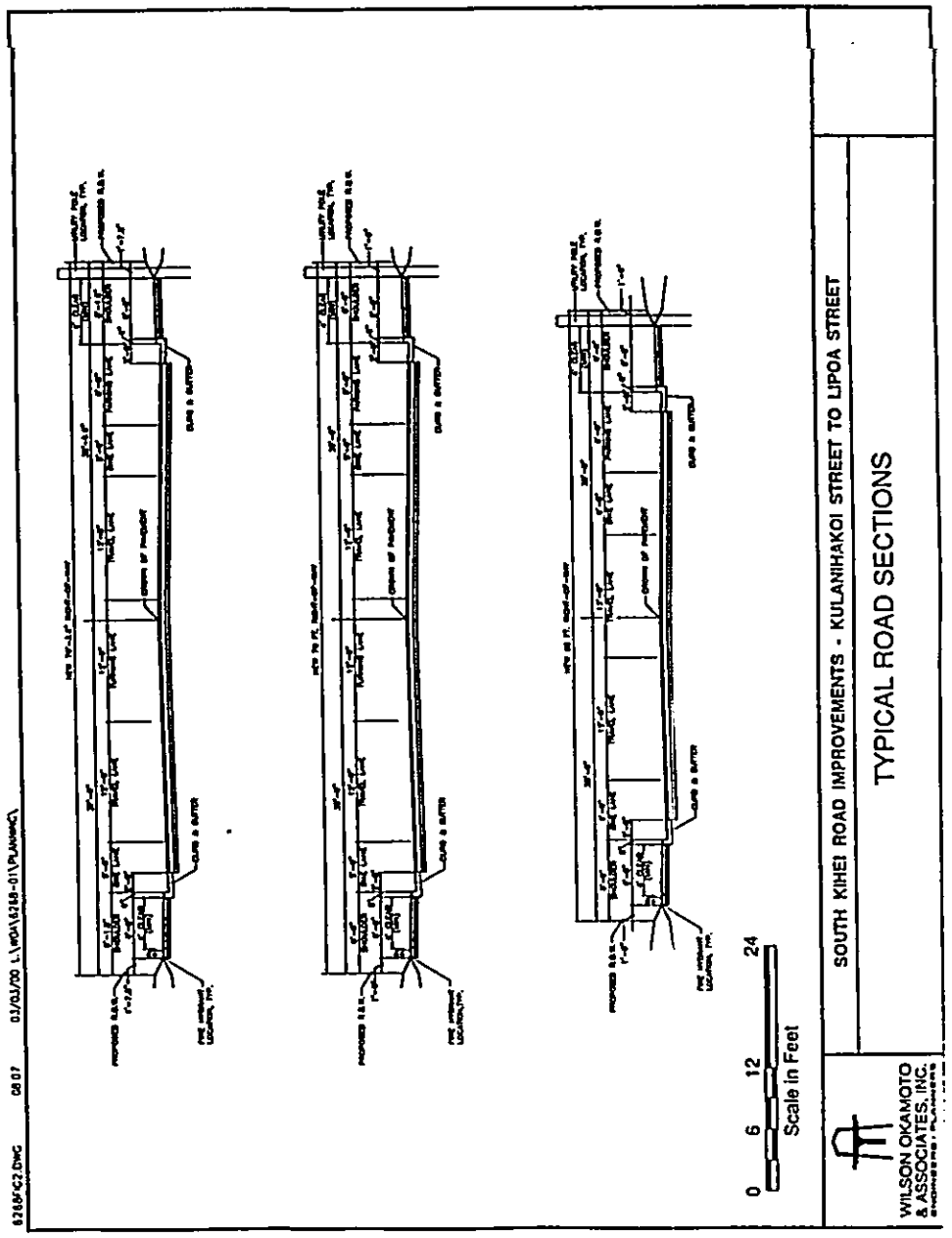
Sincerely,

LLOYD LEE
Engineering Division Chief

LL/JK:c(ED00-359)
A:\LETTERS\ltrp.hca.wpd

Enclosure

xc: Rodney Funakoshi, Wilson Okamoto & Associates, Inc.



10. REFERENCES

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Appendix A

Botanical Survey Report for South Kihei Road Improvements Kulanihakoi Street to Lipoa Street

Prepared By Botanical Consultants
October 1999

BOTANICAL SURVEY REPORT FOR SOUTH KIHEI ROAD IMPROVEMENTS

KULANIHAKOI STREET TO LIPOA STREET, KIHEI, MAUI HAWAII

PREPARED
FOR
WILSON OKAMOTO AND ASSOCIATES, INC.
1907 SOUTH BERETANIA STREET, SUITE 400
HONOLULU, HAWAII 96826

PREPARED
BY
EVANGELINE J. FUNK, PHD.
BOTANICAL CONSULTANTS
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OCTOBER 1999

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INTRODUCTION

A botanical survey of an approximately .95 mile long and 70 - foot wide section of South Kihei Road (from Lipoa Street to Kulanihakoi Street, Kihei, Maui) was conducted in October 1999. The purpose of the survey was to describe the vegetation within this corridor and to determine the presence of any candidate, proposed, listed threatened or endangered plant species, as set forth in the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543). The results of the survey are presented below.

BOTANICAL HISTORY OF THE SITE

South Kihei Road, from Kulanihakoi Street to Lipoa Street, passes through an urbanized area where houses, small apartment complexes and commercial activities can be found. There are seven vacant lots and one undeveloped site along this right-of-way.

From 1985 to the present, ten negative declarations (ND) or findings of no significant impact (FONSI) have been filed for various projects proposed for the area. In most of these documents the botanical resources have been described as non-existent (RTMC 1996) or as exotic or introduced species (Dept. of Public Works 1995a, 1995b, 1996).

METHODS

A walk through survey of the proposed road improvements site was carried out by one botanist. Both sides of South Kihei Road from Kulanihakoi Street to Lipoa Street were surveyed in October 1999. All plant species found within the seventy foot right-of-way were recorded and those findings are presented in the attached species list.

THE VEGETATION

A variety of cultivars (horticultural species) have been planted along the South Kihei Road alignment for landscaping purposes. The vacant lots have mostly been grubbed and the one undeveloped lot supports a moderately dense stand of kiawe trees (*Prosopis pallida* Kunth) with an understory of buffel grass (*Cenchrus ciliaris* L.) Interestingly, three very commonly found native species, 'akulikuli (*Sesuvium portulacastrum* (L.) L.), kou (*Cordia subcordata* Lam., and 'ae'ae (*Bacopa monnieri* (L.) Wettst.) are found thriving in the landscaped areas.

WETLANDS

The wetlands that at one time were found along this corridor between Lipoa street and Waipuilani Road have all been filled during earlier development. No wetlands or wetland indicators were found within the 70 – foot corridor during this survey.

ENDANGERED SPECIES

No candidate, proposed, or listed threatened or endangered species as set forth in the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543) are known from this site and none were found during this survey.

SPECIES LIST OF PLANTS FOUND ALONG THE SOUTH KIHEI ROAD FROM KULANIHAKOI STREET TO LIPOA STREET, KIHEI, MAUI

The plant families in the following species list have been alphabetically arranged within two groups, Monocotyledons and Dicotyledons. The genera and species are arranged alphabetically within plant families. The taxonomy and nomenclature follow that of Wagner, Herbst, and Sohmer (1990) and Neal (1965).

For each taxon the following information is provided:

1. An asterisk before the plant name indicates a plant introduced to the Hawaiian Islands since Cook or by the aborigines.
2. The scientific name of the plant.
3. The Hawaiian name of the plant or the most widely used common name of the plant.
4. Abundance rating are for this site only and they have the following meanings:

Uncommon = a plant that was found less than five times.

Occasional = a plant that was found between five and ten times.

Common = a plant considered an important part of the vegetation.

Locally abundant = plants found in large numbers over a limited Area. For example plants found in grassy patches.

This species list is the result of an extensive survey of this site during a very dry season (October 1999) and it reflects the vegetative composition of the flora during a single season. Changes in the vegetation will occur due to introductions and losses and a slightly different species list would result from a survey conducted during a different growing season.

Scientific Name	Common Name	Abundance
MONOCOTYLEDONS		
ARACEAE – Aroid Family		
**Epipremnum pinnatum* (L.) Eng.	Pothos	Locally abundant
ARECACEAE – Palm Family		
**Cocos nucifera* L.	Coconut	Uncommon
CYPERACEAE – Sedge Family		
**Cyperus rotundus* L.	Nut grass	Locally abundant
LILIACEAE – Lily Family		
**Aloe vera* L.	Aloe	Locally abundant
**Mondo japonicum* Farw.	Mondo grass	Locally abundant
POACEAE – Grass Family		
**Cenchrus ciliaris* L.	Buffel grass	Locally abundant
**Cynodon dactylon* (L.) Pers.	Bermuda grass	Locally abundant
**Eleusine indica* (L.) Gaertn.	Wiregrass	Locally abundant
**Paspalum conjugatum* Bergius	Hilo grass	Locally abundant
DICOTYLEDONS		
AIZOACEAE – Fig-wort Family		
Sesuvium portulacastrum (L.) L.	Akulikuli	Locally abundant
AMARANTHACEAE – Amaranth Family		
**Alternanthera pungens* Kunth	Khaki weed	Common
**Amaranthus spinosus* L.	Spiny amaranth	Common
**Amaranthus viridis* L.	Slender amaranth	Occasional
ANACARDIACEAE – Mango Family		
**Mangifera indica* L.	Mango	Occasional
**Schinus terebinthifolius* Raddi	Christmas berry	Occasional

Scientific Name	Common Name	Abunoance
APOCYNACEAE – Dogbane Family		
**Cascabela thevetia* (L.) Lippell	Be-still tree	Uncommon
**Catharanthus roseus* (L.) G. Don	Periwinkle	Occasional
**Plumeria* spp.	Plumeria	Occasional
**Nerium oleander* L.	Oleander	Occasional
ASTERACEAE – Sunflower Family		
**Bidens alba* (L.) DC	Bidens	Occasional
**Bidens pilosa* L.	Spanish needle	Occasional
**Calyptocarpus vialis* Less.		Common
**Eclipta alba* (L.) Hassk	False daisy	Occasional
**Emilia coccinea* (Sims) G. Don	Flora's paintbrush	Occasional
**Pluchea indica* (L.) Less.	Indian fleabane	Common
**Sonchus oleraceus* L.	Pualele	Occasional
**Synedrella nodiflora* (L.) Gaertn.	Nodeweed	Locally abundant
**Wedelia trilobata* (L.) Hitchc.	Wedelia	Locally abundant
BATACEAE – Saltwort Family		
**Batis maritima* L.	Pickleweed	Locally abundant
BORAGINACEAE – Borage Family		
Cordia subcordata Lam.	Kou	Uncommon
**Heliotropium curassavicum* L.	Seaside heliotrope	Common
Casuarinaceae – She-oak Family		
**Casuarina equisetifolia* L.	Ironwood	Locally abundant
CHENOPODIACEAE – Goosefoot Family		
**Atriplex semibaccata* R. Br.	Australian saltbush	Common
**Bassia hyssopifolia* (Pall.) Kuntze		Uncommon
**Chenopodium murale* L.	Aheahea	Uncommon
CONVOLVULACEAE – Morning glory Family		
Ipomoea pes-caprae (L.) R. Br.	Beach morning glory	Locally abundant

Scientific Name	Common Name	Abundence
EUPHORBIACEAE- Spurge Family		
**Chamaesyce hirta* (L.) Millsp.	Hairy spurge	Occasional
**Chamaesyce hypericifolia* (L.) Millsp.	Graceful spurge	Occasional
**Codiaeum* spp.	Croton	Common
FABACEAE – Bean Family		
**Delonix regia* (Bojer ex Hook) Raf.	Poinciana	Occasional
**Erythrina indica* Lam.	Haole wiliwili	Occasional
**Leucaena leucocephala* (Lam.) deWit	Koa haole	Common
**Prosopis pallida* Kunth	Kiawe	Common
**Samanea saman* (Jacq.) Merr.	Monkey pod	Occasional
GUTTIFERAE – Mangosteen Family		
**Clusia rosea* Jacq.	Copey	Uncommon
LYTHRACEAE – Crepe Myrtle Family		
**Cuphea hyssopifolia* Kunth	False heather	Occasional
MALPIGHEACEAE – Malpighia Family		
**Galphimia glauca* Cav.	Galphimia	Occasional
MALVACEAE – Mallow Family		
**Abutilon grandifolium* (Willd.) Sweet	Hairy abutilon	Occasional
**Hibiscus* spp.	Hibiscus	Common
**Hibiscus rosa-sinensis* L.	Red hibiscus	Common
**Malvastrum coromandelianum* Garcke	False marrow	Occasional
**Sida rhombifolia* L.	Cuba jute	Occasional
**Thespesia populnea* Sol x Correa	Milo	Locally abundant
MORACEAE – Mulberry Family		
**Ficus microcarpa* L. fil.	Banyan	Occasional
MYRTACEAE – Myrtle Family		
Melaleuca quinquenervia Blake	Paperbark	Occasional

Scientific Name	Common Name	Abundance
NYCTAGINACEAE – Four-o'clock Family		
**Boerhavia Coccinia* Mill.	Boerhavia	Uncommon
**Bougainvillea* spp.	Bougainvillea	Common
**Mirabilis jalapa* L.	Four o'clock	Uncommon
PORTULACACEAE – Purslane Family		
**Portulaca oleracea* L.	Pigweed	Occasional
RUBIACEAE – Coffee Family		
**Gardenia taitensis* DC	Tiare	Uncommon
SCROPHULARIACEAE – Figwort Family		
Bacopa monnieri (L.) Wettst.	'Ae'ae	Locally abundant
Sterculiaceae = Cacao Family		
**Waltheria indica* L.	'Uhaloa	Uncommon

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Appendix B

Archaeological Assessment for South Kihei Road Improvements Lipoa Street to Kulanihakoi Street Waiohuli Ahupua`a (Kihei) Kula, Maui

Prepared by Cultural Surveys Hawaii
November 1999

ARCHAEOLOGICAL ASSESSMENT FOR SOUTH KĪHEI ROAD IMPROVEMENTS, LĪPOA STREET TO KŪLANIHĀKO'I STREET, WAIOHULI *AHUPUA'A*, (KĪHEI) KULA, MAUI

For

WILSON OKAMOTO & ASSOCIATES

By

Hallett H. Hammatt, Ph.D.

and

David W. Shideler, M.A.

Cultural Surveys Hawai'i

November, 1999

ABSTRACT

An archaeological assessment for a proposed South Kīhei Road improvements project (County of Maui Job No. 97-33) was conducted by Cultural Surveys Hawai'i, Inc. for Wilson Okamoto and Associates on behalf of the County of Maui, Public Works and Waste Management Department, Highways Division.

No evidence of pre-contact cultural or agricultural activity within the project area *per se* was uncovered. Our historical analysis points out that there was a major Hawaiian community at Kalepolepo just to the north of the project area probably from pre-contact times. The community at Kalepolepo appears to have prospered between 1820 and the mid 1870s in response to demands from whalers and California gold miners for agricultural goods but this did not appear to affect the project area. The presence of four fish ponds along the coast in the immediate area does indicate some permanent Hawaiian coastal settlement at Waiohuli and Kēōkea but the archaeological evidence suggests that permanent habitation in these *ahupua'a* was overwhelmingly in upland areas above 2,000' elevation. Field reconnaissance and observations of soil borings gave no indication of archaeological resources under or adjacent to this stretch of South Kīhei Road. The absence of cultural use of the vicinity of the project area is suggested to be because of its low elevation above the water table and propensity to flood (with ten documented flooding events in the area this century) and because of the low rainfall (lowest on the island) and poor soils in the area.

In light of the above conclusions, full time monitoring is not indicated within this phase of the South Kīhei Road improvements project.

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I. INTRODUCTION

An archaeological assessment for a proposed South Kīhei Road improvements project (County of Maui Job No. 97-33) was conducted by Cultural Surveys Hawai`i, Inc. for Wilson Okamoto and Associates on behalf of the County of Maui, Public Works and Waste Management Department, Highways Division.

Project Area Description

The project area consists of a relatively straight, approximately 1.53 kilometer (0.95 mile) long segment of South Kīhei Road between Kūlanihāko`i Street (on the north) and Lipoa Street (on the south). This stretch of South Kīhei Road parallels the coast approximately 350 m inland at an elevation of approximately 1-2 m amsl. The project area lies entirely within the *ahupua`a* of Waiohuli, in the traditional Kula District of Maui Island. The project area is understood to include South Kīhei Road and the shoulders on either side to a distance of 5 m from the asphalt. Typically a much wider swath was examined for any evidence of cultural resources.

Scope of Work

The scope of work for this project was agreed upon in a meeting on October 8, 1999 at the offices of Wilson Okamoto & Associates which included Dr. Ross Cordy of the State Historic Preservation Division. The agreed upon scope of work for the archaeological investigation is as follows:

1. Background research consisting of examination of historic maps, archival documents including Land Commission Award documents, historical accounts, and previous archaeological research in the area. Also the files of the State Historic Preservation Division were consulted for previously recorded archaeological sites and possible historic buildings in the area.

2. Field work consisting of survey of the road and adjacent areas to determine existing conditions, and record archaeological sites adjacent to the road, as well as potential areas of archaeological and/or historical interest. This field work was to coordinate with the subsurface testing of Geolabs Inc. to develop data on subsurface deposits for potential insight into potential archaeological resources.

3. Preparation of a report to detail the results of the background research and field work. This report describes all sites found with significance assessments and recommendations for mitigation.

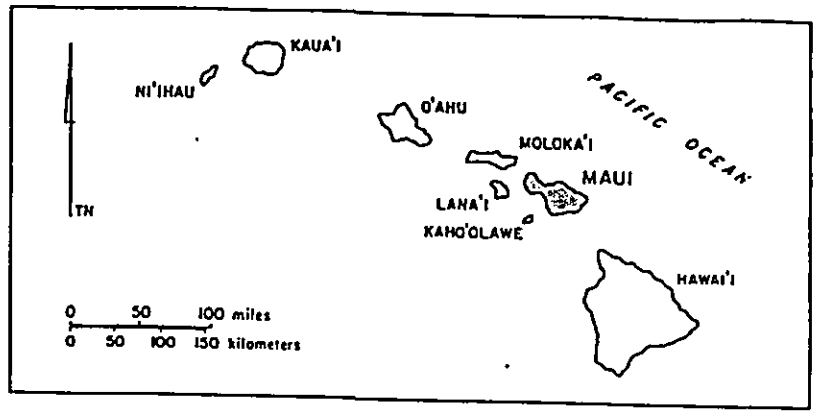

FIGURE 1
Map of the State of Hawai'i

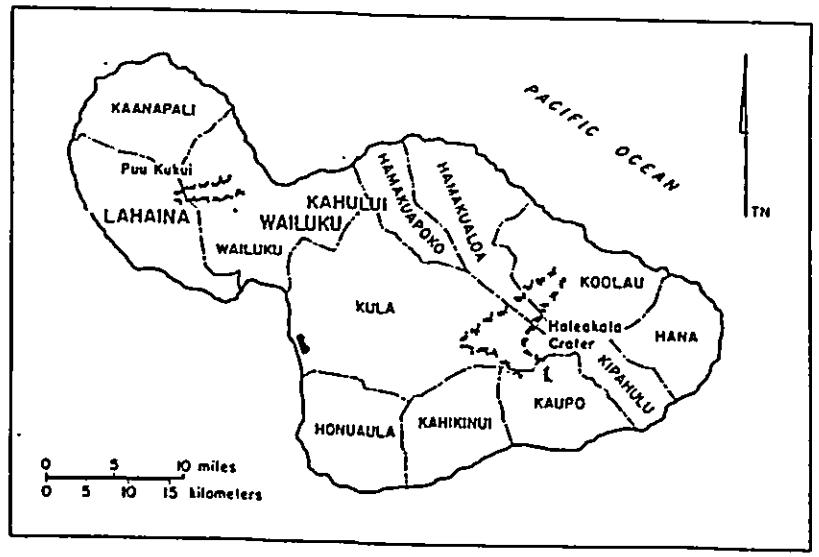

FIGURE 2
General Location Map, Maui Island

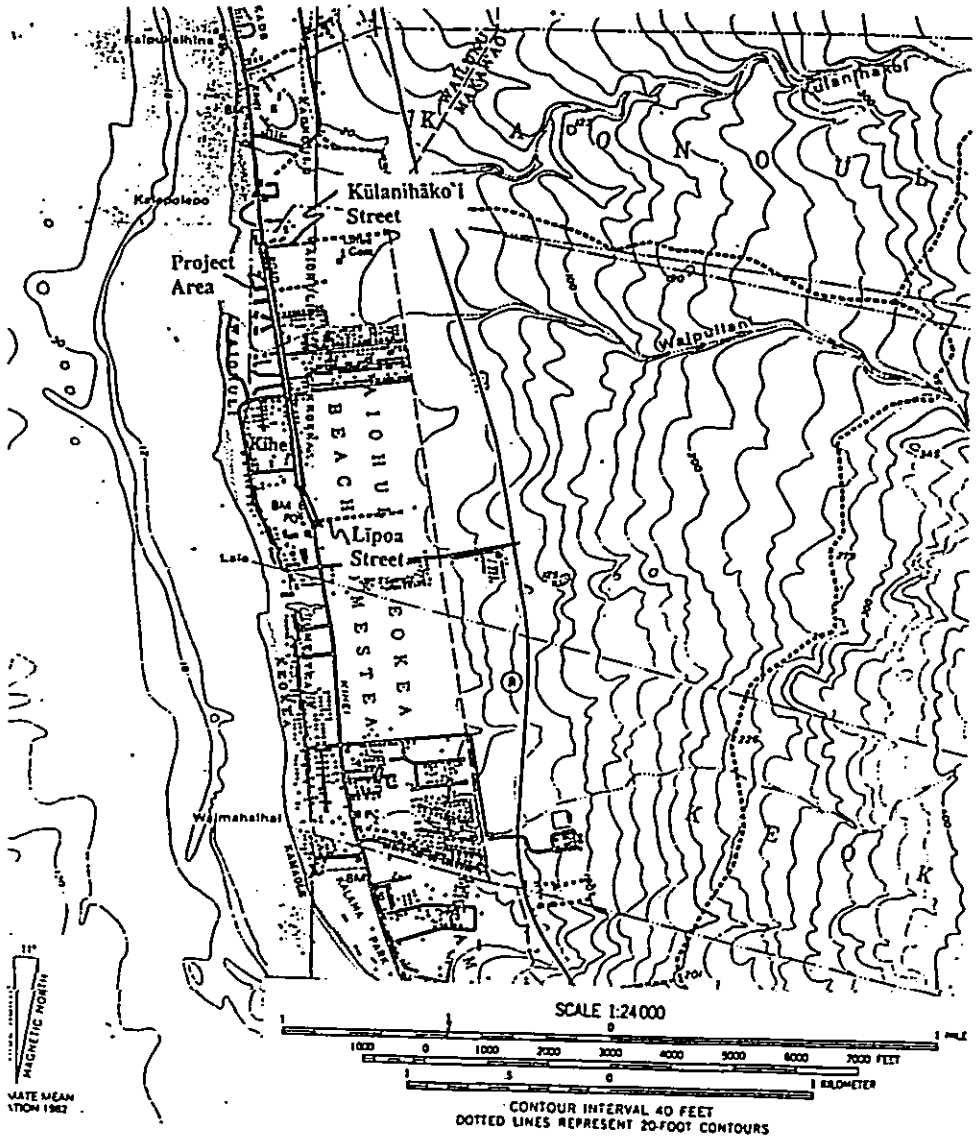

Figure 3 Portions of USGS 7.5 Minute Series Mā'alaea and Pu'u-o-Kali Quadrangles, Showing Project Area

II. NATURAL HISTORY

Geology

The *ahupua'a of* Waiohuli in which the project area lies is located on the western slope of Haleakalā Volcano. The underlying lava flows are known as the Honomanū Volcanic Series of the Tertiary system. These ancient lavas are exposed in only a few localities: along the north and northeast shore sea cliffs and in Ke'anae Valley (Macdonald *et al.* 1983:388).

In the project area, the Honomanū Series lavas are covered by the Kula Volcanic Series of the Pleistocene epoch. Lavas of the Kula Series consist mostly of 'a'ā. Eruptions were explosive to the extent that many large cinder cones were formed and beds of ash are common. These cones are present mostly on the summit and northern slopes of the mountain but also occur on the western slope in the vicinity of the project area (Pu'u o Kali, Pu'u Ōla'i). The Kula flows are relatively thick, averaging from twenty feet thick near the summit of Haleakalā to fifty feet thick at the coast. Much of the Kīhei coastline is comprised of lithified dunes of the Pleistocene epoch (Macdonald *et al.* 1983:383). The southern two-thirds of the project area is reported as Jaucas sand and the northern third is Alae sandy loam (Foote *et al.* 1972)

Geography

The Kīhei area receives less than 400 mm. of rainfall annually (ranging from 5 mm. to 50 mm. monthly), making it the minimum rainfall area on Maui (Giambelluca *et al.* 1986:14). Most of the rain in this area comes during winter storms. Giambelluca *et al.* indicate that "the Kīhei minimum is part of a broad area of low rainfall covering the saddle of the island and extending along the leeward coast from Mākena to Kā'anapali. The aridity of this region results from the rain-shadow effects of the island's two large volcanoes" (Giambelluca *et al.* 1986:16). Typically, Kīhei is sunny and dry with an average temperature of 77°F with occasional variations ranging from the low 60s to the high 80s.

Vegetation on adjacent undeveloped parcels consists of *kiawe* and lowland shrubs including *koa haole*, finger grass, and *pili* grass (Armstrong 1973:64). The majority of the margins of South Kīhei Road are landscaped with a variety of exotic ornamental plants. Wildlife consists of native water birds and upland game birds (Foote *et al.* 1972:8).

Flooding

Kīhei has historically been prone to flooding due to three different factors: tsunami, runoff inundation, and heavy surf. The tsunami of 1906 ran up to a height of 3.6 m at Mā'alaea where it did damage (Dept of the Army, 1971:6). The 1946 tsunami waters rose to a height of 9 feet (2.7 m) at Kīhei (Shepard *et al*, 1950:435). The tsunami of 1960 also caused inundation and damage at Kīhei (Dept of the Army, 1971:26). Runoff inundation at Kīhei is documented for 1916, 1951, 1955, 1967 and 1971 (Dept of the Army, 1971:24). In 1971 "the Kīhei flood plain was inundated up to 6 feet deep." (Dept of the Army, 1971:24). Heavy surf in 1959 and 1963 also caused flooding at Kīhei. The low elevation of the project area (1 to 1.7 m above the water table) and ten documented flooding events this century are suggested to be partial explanations for the relative dearth of archaeology in the vicinity.

III. HISTORIC BACKGROUND

Historic Setting

The project area lies in the inland edge of the "coastal zone" defined by Cordy as a 1/4-mile wide band along the shore (Cordy 1977:3). Previous research on prehistoric occupation in Kula District (Kolb *et al.* 1997) has favored a bimodal model of permanent residence on the coast and in the uplands (with an intermediate barren or transition zone) or a "transhumance" model emphasizing seasonal migrations of Hawaiian families from the uplands to the coast. A reconstruction of the coastal and archaeological landscape of Kula (Figure 4) underscores the importance of the uplands as a focus of habitation. Hawaiian traditions and the presence of four fishponds, however, indicate that Kalepolepo and environs on the coast were also foci of settlement in the region.

Mythological and Traditional Accounts

Mythology regarding the Kīhei area is relatively scarce. Place name analysis can sometimes yield insight into patterns of life in an area. Literal translations of several of the place names for land areas and divisions near to the project area are listed below. Unless otherwise noted, the translations are taken from Pukui *et al.* (1974).

Place Names in the Vicinity

ʻIliʻiliholo	meaning uncertain
Kaipukaihina	"Hina's meat dish"
Kalaepōhaku	"the stone promentory
Kalama Beach Park	named for Samuel E. Kalama
Kalepolepo	"the dirt"
Kalialinui	meaning uncertain
Kaluaihākōkō	"the pit [for] wrestling" Hākōkō is said to have been the name of a chief
Kamahale	"house child"
Kamaʻole	"childless" (or "barren"--Fredericksen, *et al.* 1994:3)
Kaʻonoʻulu	"the desire [for] breadfruit"
Kawililīpoa	meaning uncertain perhaps līpoa seaweed twist
Keawakapu	"the sacred (or forbidden) harbor"
Kēōkea	"the white sand"
Kīhei	"cape, cloak"
Kōheo	"to show off or to twirl"
Koʻieʻie (fishpond)	"a plaything for floating in the rapids", ancient name of Kalepolepo (Fornander 1919, V:2 235-236)
Kula (district)	"plain"
Kūlanihākoʻi	"agitated heaven that stands"
Lāʻie	"*ie* leaf"
Liʻilioholo	meaning uncertain

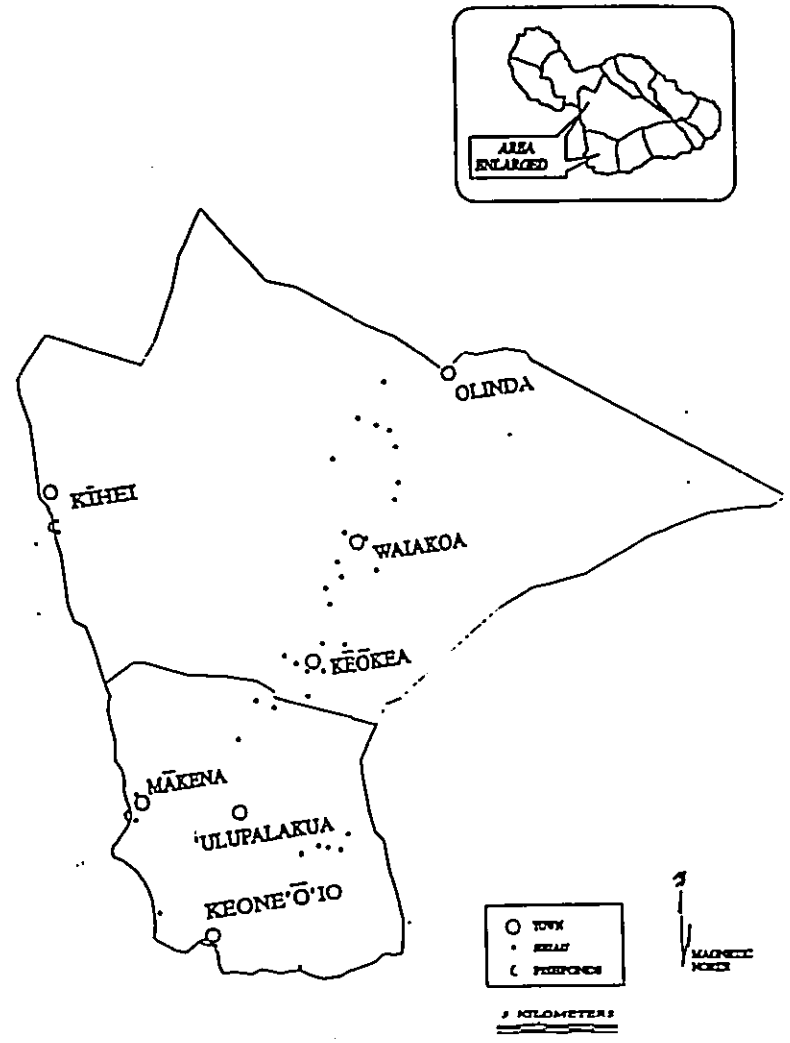

Figure 4 Map of Major Archaeological Sites in Kula District (Adapted from Kolb *et al.* 1997:29)

Makawao (district)	"forest beginning" (or "Watchful eyes of Wa-o" (timeless or eternity)--Wong Smith in Donham 1990b:B-1)
Mai poina ʻoe iʻau	"Forget me not" Beach park dedicated in 1956 to the memory of WWII servicemen
Nāʻalae	"the mudhens"
Nāwāwaeoʻ Alika	"the feet of Alex" or "the feet of Arctic"
Paeahu	"row [of] heaps"
Puʻu-o-kali	"hill of waiting"
Waiakoa:	"water [used] by warrior"
Waimāhaʻihaʻi	"broken water"
Waiohuli	"water of change"
Waipuʻilani	"waterspout"

Place names such as Kamaʻole and Kalepolepo suggest a relative barrenness. References to ʻieʻie (*Freycinetia arborea*) and breadfruit (*ulu*) suggest an upland focus where such plants might grow. The place name "Kaipukaihina", located a kilometer north of the project area, suggests that area was particularly good for fishing. The relative dearth of recorded coastal place names is consistent with a small coastal population.

Traditional Accounts

Kamakau (1961) provides references to Kīhei involving the ruling chiefs of Maui and Hawaiʻi and their warfare during the 1730s:

> Alapaʻi sailed from Kohala on Hawaiʻi...But when he landed at Mokulau in Kaupō (Maui) and heard that Ke-kau-like was dying, he gave up all thought of war and wished only to meet Ke-kau-like and his (half) sister Ke-kuʻi-apo-iwa-nui...He landed at Kīheipukoa with all his chiefs and fighting men...While he was at Kīhei, Alapaʻi heard that the ruling chief of Oahu was making war upon Molokai. Most of the chiefs of Molokai...were of Hawaiʻi...Alapaʻi's sympathy was aroused, for these were his own brothers and children (relatives), and he made ready to go to their help on Molokai. (1961:70)

Kamakau (1961:142) relates an account of a lesser chief on Maui during the 1780s, with references to Kula, Wailuku, and Kamaʻole:

> During this period there were disturbances among the country people, not only on Oahu but also on Maui. The trouble arose through one of the lesser chiefs (*kaukauali'i*) named Kū-keawe, a favorite (*aikāne*) of Ka-hekili to whom Ka-hekili had given the privilege of letting his pigs run over the land of Kula and roasting them as he needed them. But he seized also the pigs belonging to the country people of Kula, Honuaʻula, and Kahikinui, as far as Kaupō, and went with a large party to rob them of their wealth even with violence. This was the cause of the uprising of the country people called the "Battle of the pig-eating of Kū-keawe" (*ʻAipuaʻa-a-Ku-keawe*). When the

> plundering party reached Kaupō they were surprised by some fighting men of Kahikinui, Honuaʻula, Wailuku, and Waiheʻe...they climbed the mountain of Haleakalā in order to descend to Kamaʻole in Kula...Here they were surrounded by Ka-wehena's men, Kū-keawe was killed, and his body stuck up like an image toward the sea of Palauea.

A second reference to Kamaʻole, regarding the coastal place name Kaluaihākōkō, is recorded by Kamakau in an account of the ruling chief ʻUmi (1961:230):

> ...ʻUmi came from a humble family, yet when he became ruling chief the people bowed to him...But Kiha-Pīʻilani despised ʻAihākōkō and Kū-malae, the children of his sister Piʻi-kea-a-Pīʻilani, because they were born to ʻUmi. ʻAihākōkō was brought to Maui, but Kiha treated him with contempt and killed his favorite *kahu*; and ʻAihākōkō died of grief for him and was buried at Kapaʻahu where is the burial cave of ʻAihākōkō. The young people are mistaken in giving the name Ka-lua-ʻAihākōkō to the coconut grove at Koa-kanu on the seacoast of Kama-ʻole in Kula...

Early Historic Period

Kīhei was one of the locations visited by Captain George Vancouver. A monument at Mai Poina ʻOe Iaʻu Beach Park in Kīhei commemorates Vancouver's on-shore expedition in 1792, when he first met the ruling chief Kahekili. With its sheltered coastline and easy access to upcountry resources over a vast slope, Kīhei would continue to be a common stop for visiting ships. For details on the history of whaling, the Irish potato industry, the Chinese presence, ranching, and sugar cultivation in the vicinity the reader is referred to Helen Wong Smith's research as presented in Brown and Haun (1989:Appendix C). However, a general overview of these subjects is provided in the following sections along with supplemental information not covered by Wong Smith.

In 1820, the whaling industry was introduced in Hawaiʻi. Although the whaling centered around Lahaina and mainly effected the Kula/Kīhei area with its agricultural demands, Clark (1980:47) notes that "From the 1840s to the 1860s a small whaling station was maintained at Kalepolepo [Kīhei]."

The introduction of whaling to the Maui community brought with it an increased demand for foodstuffs and in particular the long-lasting Irish potato. As a result, after 1830 dryland agriculture in the old Kula District expanded particularly focusing on Irish potatoes. The California Gold Rush of 1849 intensified this demand as a California-Hawaii potato trade began to flourish. Kula became the area of highest potato production and came to be known as "the potato district" (the area between 2000 and 5000 ft. amsl). Potato production thrived in Kula from 1830-1850 until successful potato cultivation and production in California and Oregon resulted in a decline in the Hawaiʻi trade (Burgett and Spear 1995:6-7). Donham (1992:5) notes that the inundation of land clearing and cultivation associated with the Gold Rush resulted in "deforestation [which] adversely affect[ed] the amount of rainfall in the district, and periods of drought became more common."

Around 1849 John Halstead built the Koa House at Kalepolepo in Kīhei. The building, part store and part residence, thrived on the whaling industry and the resultant potato industry. The store also served as a gathering place for the whaling sailors. During the Gold Rush years, the store became "an emporium for Irish potatoes." Halstead ran his store until 1876, closing shop when the potato industry diminished and moving to Ulupalakua (Janion 1977:25-31). David Malo created a balance for this boisterous whaling crowd by constructing a church at Kalepolepo circa 1852.

The increase in agricultural production associated with the potato industry encouraged many Hawaiians to venture into cash-cropping (Speakman 1984:116) and attracted Chinese immigrants to Kula in the 1840s. During the subsequent 30 to 40 years the Chinese created a thriving community in the uplands (Burgett and Spear 1995:7). According to Speakman (1984:140), even though the Kula land was hard, with scattered rains and common droughts, "the Chinese who lived and worked around Kēōkea enjoyed the healthiest climate to be found almost anywhere; they also enjoyed themselves and became good friends and neighbors of the Hawaiians living there." During this time period sugar cultivation and ranching were established in the Kula region. Sugar was present prior to 1846, with six sugar producers operating on the slopes of Haleakalā (Wong Smith in Brown and Haun 1989:C-7). As Wong Smith points out (Brown and Haun 1989:C-6), ranching was present in the area prior to the 1840s. Much of the produce, sugar and livestock moved down the Kalepolepo and Kekuawahaʻulaʻula Trails to the landing at Kalepolepo.

Mid-1800s (Land Commission Awards)

Settlement Pattern in Kula as shown by LCAs

Kula was famous for its upland *ʻuala* (sweet potato) "plantations" (Handy and Handy 1972:511). The combination of good soil developed in volcanic ash, cool temperatures and frequent clouds to lower evapo-transpiration and bring moisture as fog drip, and rainfall distributed fairly evenly throughout the year would also have allowed for taro cultivation for subsistence by Hawaiians living in the uplands of Kula on a permanent basis. In contrast, water was notably scarce along much of the coast.

Informants for Handy and Handy (*Ibid.*) in the 1930s place a "considerable population" on the "lower westward slopes of Haleakalā." This information is supported by the findings in the uplands of Kēōkea and Waiohuli of numerous archaeological sites of prehistoric age (Brown and Haun 1989). Additional support for this is an abundance of *heiau* - 33 total recorded in the archaeological survey of Maui by Winslow Walker (1931) - in the district of Makawao between roughly the 2000 ft. to 3000 ft. elevation contours (see Figure 4). This provides an image of extensive agricultural fields across open land in prehistoric times, much as Kula appears today. Jarves (in Kuykendall 1980:313) describes the Kula area in July 1846 in the midst of the cash cropping boon of Irish potatoes there.

> It ranges along the mountain (Haleakalā) between 2000 and 5000 feet elevation, for the distance of 12 miles. The forest is but partially cleared, and the seed put into the rich virgin soil.

This would seem to suggest that prehistoric occupation in Kula was dispersed and with possibly *swidden* type agriculture practiced. Substantial forest clearing does not appear to have occurred until the mid-1800s for commercial agriculture, especially potatoes and sugar cultivation throughout most of Kula during the *Māhele* period.

The Land Commission Awards (LCAs) in Kula occur primarily in a narrow horizontal band around 3,000' elevation along the old Kula road where there is sufficient natural rain and where it is cool enough for tuber crops. This contrasts sharply in design with the typical valley systems elsewhere where awardees frequently claimed agricultural land *mauka* along the alluvial valley terraces and house lots and *kula* land at the coast.

Some claimants appear to be of high chief status, *e.g.* Keaweamahi, Koehokaole, and Namauu. Some are important personages such as Kaawai, the land commissioner of Maui, and Hewahewa (the son of the famous high priest). These persons appear to have claims in many places. There are, however, also claimants who appear to be commoners from elsewhere (Wailuku, Waikapu, Lahaina), who, along with the chiefs, are raising sweet potatoes and Irish potatoes for trade with the seagoing vessels or for the California gold miners. Higher status claimants, living elsewhere on other parts of Maui and even on other islands, came into Kula at this time to grow potatoes.

Of greatest interest for the present project area is the occupation at Kalepolepo Landing. The town of the 1850s was largely focused on the "koa house" emporium of John Halstead next to the southern edge of Kalepolepo Fishpond (Figure 5). Numerous land awards were granted directly inland of the fishpond and in the area to the southeast between the fishpond and the church and graveyard. As near as we can tell, Kalepolepo Town did not extend into the present study area. The Land Commission claims for Kalepolepo and vicinity (Figure 5 and Table 1) indicate that many of the residents of the coastal town had agricultural interests inland.

By the time John Halstead closed shop (1876), the boom years of Kalepolepo were through. By 1880 the government survey of the Kula area (RM 913) shows very few Land Commission Awards left and even shows those who received awards as having replaced the award with grants. Many homestead sections were opened up before 1880 and many new names appear on this map.

Late 1800s

By the 1880s lower Kula consisted primarily of pasture land for ranching (Wong Smith in Donham 1990b:B-6). Kennedy (1992:7) notes that at this point *kiawe* was imported to feed cattle and provide wood. Maps from late 1800s/early 1900s indicate that several ranching companies owned and operated land in Kula. The land of Kēōkea, particularly the lowland/coastal portion, was historically used for ranching activities by Haleakala Ranch Company (Donham 1990b:6).

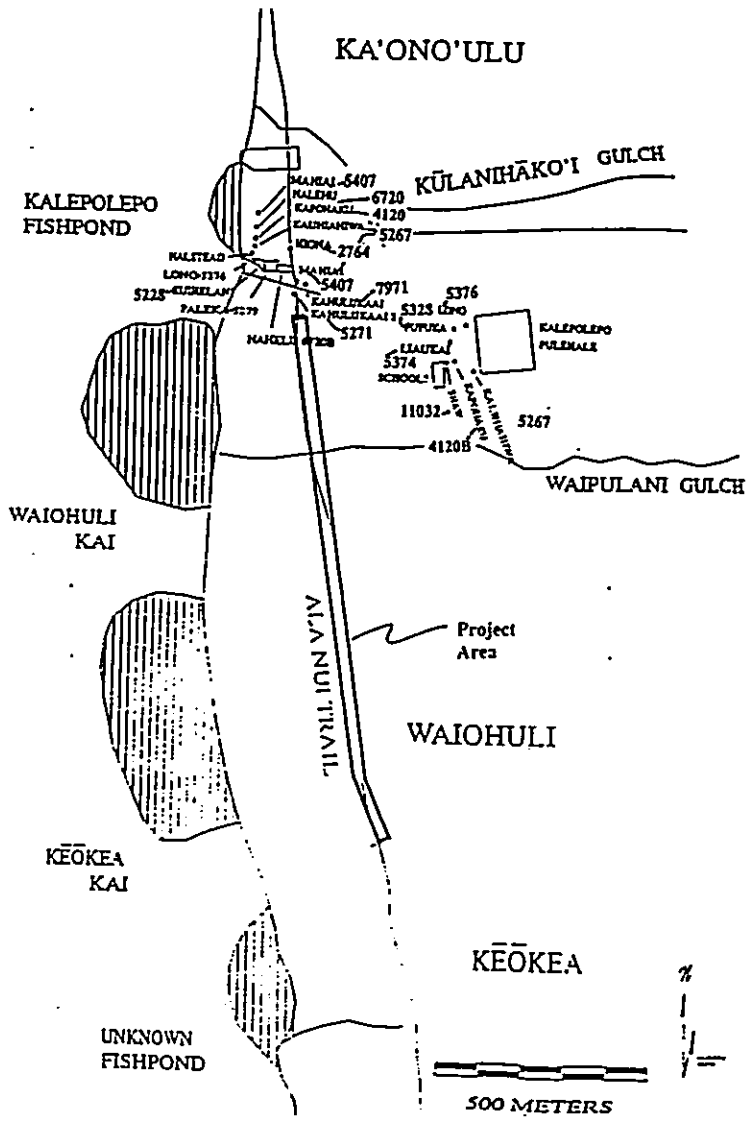

Figure 5 Map Showing the Relationship of the Project Area to the Land Court Awards at Kalepolepo Town and the Fishponds

Table 1: Land Commission Claims in Kalepolepo and Vicinity

Ahupua'a	'Ili/Ahupua'a, Award	Land Use	Claimant	Claim #	Acreage / not awarded (na)	TMK located, Other comments
Kaonoulu	Kupulaia	lr. potato mala(s)	Nahiona	2764	na	
Kaonoulu	Kapukahawai, aw Kupalaia, aw Kaonoulu	1 potato patch potato patch & land house lot	Kuihelani	5228	1 ap. 28 Acs 1 ap. 1.8 Acs	
Kaonoulu	Kaukaulua, aw	(no significant text?)	Kauaua	5267B	1 ap. 4.5 Acs	
Kaonoulu	Kupalaia, aw Puuokuhihewa, aw	kula, 2 mala lr. potatoes kula	Pupuka	5328	1 ap. 2.04 Acs 1 ap. 5.14 Acs	
Kaonoulu	Kalepolepo, aw Kaonoulu, aw	house lot kula	Lono	5376	1 ap. .022 Acs 1 ap. 2.17 Acs	
Kaonoulu	Kaonoulu, aw Kalepolepo Kupalaia	small house lot on kuapa 3 lr. potatoes	Mahiai	5407	2 ap. 3 491 Acs	
Keokea	Walluku Molokai Maunakilowaa, aw Piimoo, aw Puaiea Kalepolepo, aw (Puuokeokeo[, aw	pasture pasture taro taro 2 pastures house site [not given]	Kapohaku	4120B	 1 ap. 2 9 Acs 1 ap. 11.7 Acs 1 ap. .25 Ac 1 ap. 3 04 Acs	TMK 2-2-03 ap. 4 TMK 2-2-03 ap. 1 ap. 3 ap. 2? 3 003 acs
Keokea	Kupuni	2 kulas of lr.	Kahulukaeiopio	5271	na	
Keokea	Kalepolepo, aw Paliku, aw Walluku, aw (2 ap.) Piimoo Puaiea	house site taro taro pasture	Kapelekai / Palekai	5279	1 ap .09 Ac. 1 ap. 10 4 Acs 2 ap. 2.75 Acs	TMK 2-2-03 ap 1, 2 TMK 2-2-04 ap 4 ap. 1 1± Ac. ap 2 1.44 Acs TMK 2-2-02 Ap 5 5± Acs
Keokea	Keokea	lr. potatoes	George Shaw*	11032	na	
Waiohuli	Kahuihanau Kahilinanaenaena	kula kula	Nahelu	6720B	na	

Sugar companies began operating in the Makawao area in the late 1800s. In 1899 the Kīhei Plantation Company (KPC) was founded and began sugar operations in Kīhei and the plain above. This plantation was absorbed by the Hawaiian Commercial and Sugar Company in 1908. The best KPC fields continued to be cultivated (some are still productive), while the remaining plantation lands became cattle pasture (Cox 1976:14-15).

Early 1900s To The Present

Sugar production continued into the twentieth century, with Hawaiian Commercial and Sugar Company cultivating sugar in the Kīhei and Wailuku area, particularly during the 1940s to 1960s (Sinoto and Pantaleo 1992:5). A 1922 USGS Kīhei Quad map (Figure 6) shows only a half a dozen houses near the project area but extensive fencing for pasturage.

While World War I had little impact on Maui, World War II brought with it a significant military presence. Speakman (1984:166-176) provides a detailed review of the Marines on Maui, particularly Camp Maui in Kokomo and training maneuvers held on Kaho'olawe and at Ma'alaea Bay, along its beach and in the *kiawe* groves to the east of the Bay. Allen (1971:230) notes that the Marines conducted amphibious landing training at Ma'alaea Bay. Allen (*Ibid.*) also gives an extensive account of the Navy presence on Maui, which included the Combat Demolition Training Station at Kama'ole and two naval air stations, one at Pu'unene and the other at Kahului. The training station at Kama'ole was responsible for research work at Kīhei as early as 1940.

Burgett and Spear (1995:8) discuss the introduction of ranching ventures into the uplands of Kula in the early 1900s. TMK maps (sections 2-2 and 2-3) list the following landholders: Haleakala Ranch Co., Ulupalakua Ranch, Inc., Kaonoulu Ranch Co., Ltd., Maui [Land and] Pineapple Co., Ltd., the James Campbell Estate, the State of Hawai'i, and Hawaiian Homes Lands. As discussed by Wong Smith (Brown and Haun 1989:C-7), agriculture and cattle raising would continue to be important activities in the Kula area. During the 1970s, Kula produced the majority of Hawai'i's locally grown produce; livestock ranches comprised most of the remaining land use. At present, non-residential areas are still in use as centers of agricultural production, particularly in the "potato district" of Kula (Donham 1992:5). Haleakala, Ulupalakua and Kaonoulu Ranches are also still in operation.

Kihei underwent a rapid residential and commercial development beginning in the 1970s. Clark (1980:49) notes that the groundwork for this development was established in the late 1950s when investors began purchasing coastal property. However, the construction boom of high rise apartments, hotels, and condominiums and corresponding shopping centers, restaurants, and real estate offices didn't occur until the 1970s. Speakman (1984:188) notes that along with the condominiums and "classy" hotels (Maui's "hallmark") came the construction of millionaire homes in the dry hills overlooking Kihei and the view beyond of Kaho'olawe and Moloka'i. He comments on the congestion and overcrowding which resulted from this development (Speakman (1984:188-189): "It was partially blamed on the fact that Kihei was owned by many proprietors or speculators, each with individual plans uncoordinated with general planning, and partly on the failure of the County planners to hold the line against the runaway development. Kihei became the model for the wrong way to go about expansion." Pi'ilani Highway was constructed to ease the congested Kihei traffic which resulted from this development and expansion of the tourist industry.

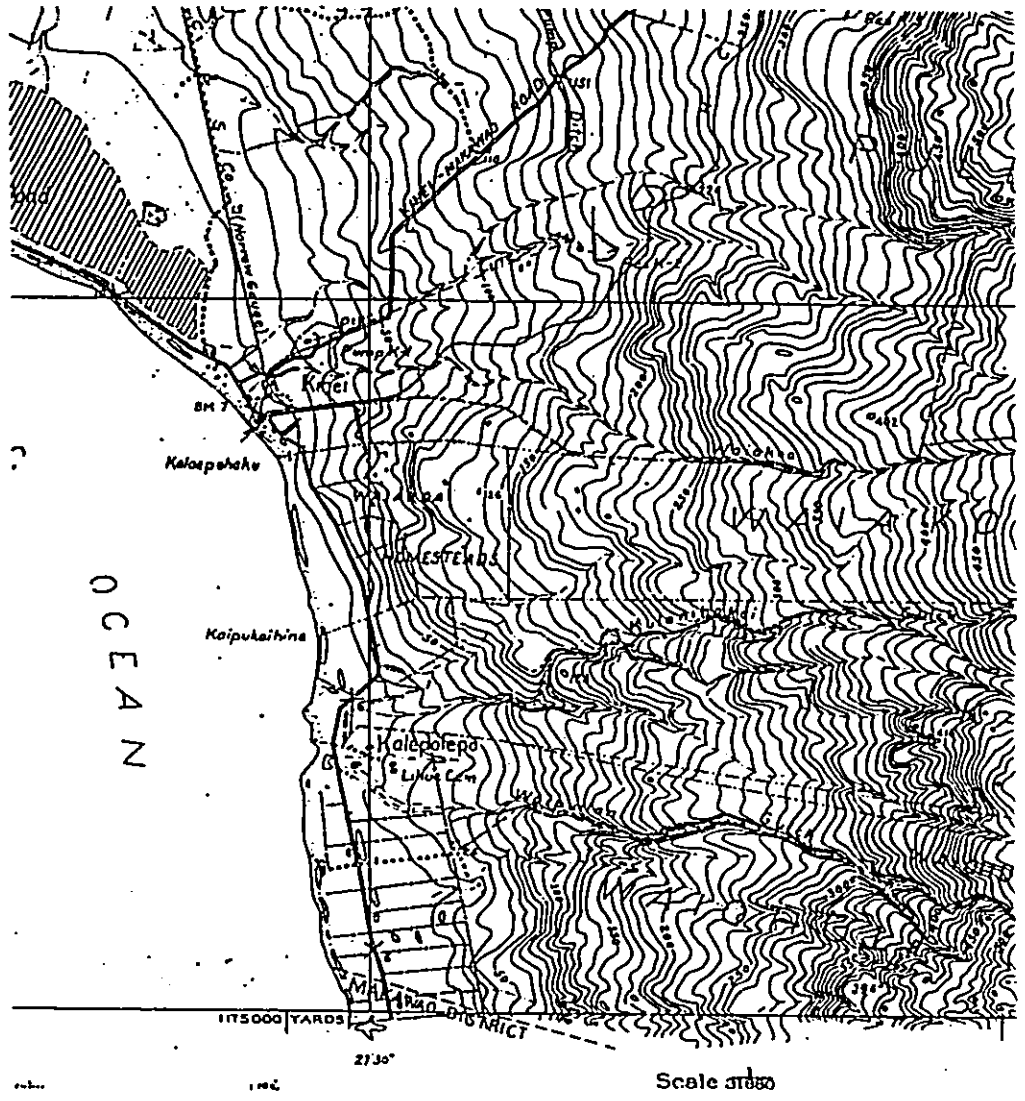

Figure 6 Portion of 1922 USGS Kihei Quad Map Showing Only Half a Dozen Houses and Fencing for Pasturage Near the Project Area

Summary

Mythology regarding this portion of Maui is relatively scarce and traditional accounts focus on political activities. Accounts record the struggles and activities of Maui and Hawai'i chiefs in the 1700s, including Ke-kau-like, Alapa'i, Ka-hekili, Ku-keawe, 'Umi, and also British Captain Vancouver.

During the early historical period Kula's agricultural role was expanded as the introduction of whaling in 1820 and the California Gold Rush of 1849 created a demand for the Irish potato, which was cultivated in the uplands. The traditional *'uala* planting grounds were now also used for the Irish potato, and the area became known as the "potato district." Immigrants from China came to Makawao during this time and created a thriving community in Kula. Sugar cultivation and ranching were also introduced into Makawao in the early 1800s.

Many of the people who had claims in Kula had the status of chiefs which allowed them to actively engage in the international economy, which was potatoes for cash. Kalepolepo flourished as a major entrepot in the period from the 1830s to the mid 1870s.

The late 1800s were marked by the continuation of ranching and sugar in Makawao. Lower Kula consisted primarily of pasture land by the end of the century. By the late 1800s, Hawaii Commercial and Sugar Company became a major presence in Makawao with its absorption of other neighboring operations.

During the twentieth century sugar, pineapple, agriculture, and ranching activities would continue while military operations associated with World War II and residential and commercial development would be introduced. Hawaii Commercial and Sugar Company and Maui Land and Pineapple Company continued their operations in the area. The military established itself on Maui during WWII with a Navy Combat Demolition Training Station at Kama'ole. Agriculture and ranching continued in the area, with Kula providing a major source of produce for Hawai'i in the 1970s and ranches constituting much of the remaining land use. Kula continues to provide local produce, including vegetables and flowers. Haleakala, Ulupalakua, and Kaonoulu Ranches continue to operate at this time. Residential and commercial development were initiated in the 1950s, with a construction boom beginning in the 1970s. The focus of this development was Kihei, an area now known for its resorts and retail ventures. Pi'ilani Highway was constructed in the late 1970s to ease the Kihei traffic which became congested as a result of this development and the expansion of the tourist industry on Maui.

IV. PREVIOUS ARCHAEOLOGICAL RESEARCH

Numerous archaeological studies have been conducted in the Kihei area (Table 2 and Figure 7). However, despite the massive development on both the seaward and inland sides of South Kihei Road, there appear to have been only two archaeological studies adjacent to this project area. Walter and Demaris Fredericksen (1990a & b) conducted monitoring studies at the Longs Drugs Project (TMK 3-9-02:30) and Azeka Place Commercial Center (TMK 3-9-02:28, 80) located adjacent and inland of South Kihei Road just north of Lipoa Street in Waiohuli *Ahupua'a*. These studies documented no cultural remains at all. Because of the paucity of studies in the immediate area, it seemed appropriate to examine studies throughout Waiohuli *Ahupua'a* and in adjacent *ahupua'a* (Kaonoulu and Waiakoa to the north and Kēōkea and Kama'ole to the south. Germane studies are summarized in the following table and are briefly discussed below.

Table 2: Previous Archaeological Studies in the Vicinity

Date	Author	Ahupua'a	Nature of Study	Findings
1931	W. Walker	Entire Island	Reconnaissance	three *heiau* in the *ahupua'a* of Waiohuli above 3,000' elevation
1971	P. Kirch	Palauea	Survey & Excavations	Documents a coastal settlement and settlement patterns
1973	W. Kikuchi	State-wide fishpond survey	Fishpond survey	Notes 3 fishponds in the Kalepolepo area
1976	D. Cox	Pulehunui to Kama'ole	Surface Survey	Identified 6 sites
1977	R. Cordy	Pulehunui to Paeahu	Reconnaissance	Identified 38 sites: 3 in Waiohuli, 0 in Kaonoulu and 8 in Kēōkea
1978	A. Sinoto	Coastal Kama'ole	Reconnaissance	No significant archaeological findings
1981	R. Hommon	Coastal Waiakoa	Reconnaissance	No archaeological findings
1981 (a)	C. Keau	Coastal Kama'ole	Reconnaissance	No archaeological findings
1981 (b)	C. Keau	Coastal Kaonoulu	Reconnaissance	Notes historic features & significance of area

1982	M. Miura (R. Bordner & D. Cox)	Coastal Waiohuli & Kēōkea	Reconnaissance	Reports 9 sites
1982 (a)	E. Neller	Coastal Kama'ole	Reconnaissance	Relates report of "large number of burials"
1982 (b)	E. Neller	Coastal Kaonoulu	Reconnaissance	No archaeological findings but relates history on pond & graves
1986	W. Kam	Waiohuli & Kēōkea 2100' to 2700' elevation	Field Inspection	2 possible pre-contact house sites & walls
1986 a	J. Kennedy	Coastal Kēōkea	Reconnaissance	No archaeological features were located
1986 b	J. Kennedy	Coastal Waikapu	Reconnaissance	Notes mounds (discounted in 1988a)
1986 c	J. Kennedy	Coastal Waiohuli	Reconnaissance	No archaeological sites were found
1987	M. Riford	Uplands (1800' to 3000') of Waiohuli & Kēōkea	Monitoring & Reconnaissance Survey	Identified 113 sites mostly pre-contact
1987	F. Watanabe	Uplands (280' to 380') of Waiohuli	Reconnaissance	No archaeological sites were found
1988	A. Estioko-Griffin	Uplands (2680') of Kēōkea	Field Inspection	Notes human remains in a cave site
1988	A. Haun	Kama'ole	Reconnaissance	Identified 33 sites, mostly military, revisited by Mayberry & Haun 1988
1988 (a)	J. Kennedy	Coastal Waikapu	Testing & Monitoring	No archaeological findings
1988 (b)	J. Kennedy	Coastal Kaonoulu	Reconnaissance	No archaeological findings
1988 (c)	J. Kennedy	Coastal Waiohuli	Reconnaissance	No archaeological Findings
1988	J. Mayberry & A. Haun	Coastal Kama'ole	Reconnaissance	Identified 33 sites

1989	R. Brown	Upland (1800' to 3000') Kēōkea and Waiohuli	Inventory Survey	Identified 159 sites (part of this area was studied by Riford in 1987)
1989	R. Brown & A. Haun	Kēōkea and Waiohuli	Inventory Survey	A more detailed study of the same parcels described by Brown 1989
1989	T. Donham	Waiohuli	Inventory Survey	Identified 4 sites in a portion of the Miura 1982 study area and recommended data recovery
1989	W. Fredericksen *et al.*	Coastal Kama'ole	Inventory Survey	No archaeological findings
1989	H. Hammatt & D. Shideler	Coastal Kama'ole	Reconnaissance	Identified 8 sites
1989 (a)	J. Kennedy	Coastal Kama'ole	Survey	No archaeological findings judged significant
1989 (b)	J. Kennedy	Coastal Kama'ole	Reconnaissance	No archaeological findings
1989 (c)	J. Kennedy	Coastal Pulehu	Inspection	No archaeological findings
1989	H. Leidemann	Coastal Kama'ole	Reconnaissance	No archaeological findings, area extensively bulldozed
1989	A. Sinoto	Coastal Kama'ole	Surface Survey	Identified 8 sites
1990 (a)	T. Donham	Coastal Waiohuli	Data Recovery	Site 2475 was excavated
1990 (b)	T. Donham	Coastal Kēōkea	Inventory survey	Part of Miura 1982 study area. 16 sites were identified
1990 (a)	W. Fredericksen & D. Fredericksen	Coastal Kēōkea	Monitoring	No archaeological findings

1990 (b)	W. Fredericksen & D. Fredericksen	Coastal Kēōkea	Survey & Monitoring	No archaeological findings
1990	W. Fredericksen *et al.*	Coastal Kama'ole	Inventory Survey	No archaeological findings
1990	H. Hammatt & D. Shideler	Coastal Kama'ole	Reconnaissance	No archaeological findings
1990 a	J. Kennedy	Coastal Waiakoa	Survey	No archaeological findings
1990 b	J. Kennedy	Kama'ole, 300' elevation	Archaeological Inventory Survey	No archaeological findings
1990 (a)	A. Sinoto	Coastal Waiakoa	Survey & Testing	No archaeological findings (other than 2 pieces of midden)
1990 (b)	A. Sinoto	Coastal Kama'ole	Reconnaissance	No archaeological findings
1991	T. Donham	Upland (3200') Kaonoulu	Field Inspection	Study of the Wonderland Mushroom House (1933-1936) historic structures
1991	W. Fredericksen *et al.*	Coastal Kama'ole	Subsurface Inventory Survey	No significant archaeological findings (2 modern dog burials and a modern trash pit)
1991	J. Kennedy	Coastal Kama'ole	Reconnaissance	No archaeological findings
1991	J. Kennedy & M. Breithaupt	Coastal Kēōkea	Inventory survey	No archaeological findings
1991	L. Rotunno-Hakuka & J. Pantaleo	Coastal Kama'ole	Surface Survey	No archaeological findings

1992	H. Hammatt & D. Shideler	Coastal Kama'ole	Survey & Testing of H. Hammatt & D. Shideler 1989 study area	Identified 2 probable *koa* (fishing shrines) among 8 sites
1992	J. Kennedy	Coastal Kama'ole	Inventory survey	Identified 4 sites including a permanent pre-contact habitation/religious site
1992	J. Kennedy *et al.*	Coastal Kama'ole	Inventory survey wt Subsurface Testing	Identified 4 sites all believed to be historic; two military and 2 ranching
1992	Sinoto & Pantaleo	Coastal Pulehunui	Inventory Survey	No archaeological findings other than a bridge foundation (site -3131)
1993	D. Fredericksen *et al.*	Coastal Waiohuli	Inventory Survey/Data Recovery	A rock shelter excavation yielded lithic artifacts, midden and a date of A.D. 1560 to 1800
1994	D. Frederick-sen *et al.*	Coastal Kama'ole	Inventory Survey	2 sites were identified including a midden scatter & a concrete slaughterhouse foundation
1994 a	E. Frederick-sen *et al.*	Kama'ole	Inventory Survey	Radiocarbon date reported as AD 1520 to 1570
1994	M. Kolb et al.	Upland Waiohuli and Kēōkea	Settlement Survey	Archaeological & historical settlement survey
1995	Burgett & Spear	Upland Kaonoulu (3100' elevation)	Archaeological Inventory Survey	6 post contact sites were identified
1995 a	E. Frederick-sen & D. Frederick-sen	Waiohuli	Inventory Survey	one rock shelter site was identified as a pre-contact temporary habitation site
1995 b	E. Frederick-sen & D. Frederick-sen	Waiohuli	Data Recovery	Four carbon dates were obtained suggesting late pre-contact use.

1995 a	D. Hibbard	Coastal Kēōkea	Environmental Assessment	Determined Phase III South Kihei Road Improvements project would have "no effect"
1995 b	D. Hibbard	Coastal Kēōkea	Historic Preservation Review	Determined Phase II South Kihei Road Improvements project would have "no effect"
1995	Moore and Kennedy	Upland Koheo and Kaonoulu (2600' elevation)	Archaeological Inventory Survey	8 sites were identified (3 historic ranching, 5 possibly pre-contact ag.
1996	E. Frederick-sen et al.	Upland Kaonoulu (3060' to 9700' elevation)	Archaeological Inventory Survey	4 sites were identified including 2 rock shelters and 2 historic sites
1997	Chaffee et al.	Waiohuli (120' elevation)	Archaeological Inventory Survey	3 sites were identified, all interpreted as agricultural
1999	Erik and Demaris Fredericksen	Kama'ole (170' elevation)	Archaeological Inventory Survey	3 sites were identified including 5 small enclosures and a rock pile

Winslow M. Walker conducted a walk-through archaeological reconnaissance of the vicinity in 1931 recording only two coastal sites (Walker sites 198, Kalaihi *Heiau* and 199 Kealalipoa *Heiau* at Ko'ie'ie also known as Kalepolepo) along the entire coastline from Ma'alaea to Makena. These coastal *heiau* were located adjacent to Ko'ie'ie Fishpond approximately 200 m and 400 m northwest of the northernmost terminus of the present project area. Walker recorded three *heiau* in the uplands of the *ahupua'a* of Waiohuli including Kaumeheiwa *Heiau*(?) (Walker site 212), Kaimupe'elua *Heiau* (Walker site 213), and Pauhu *Heiau* (Walker site 214) but these were all located up around the 3,000-foot elevation.

From 1969 to 1971, Kirch (1971) conducted a survey and subsequent excavations at Palauea, south of K1 and K2 termini at Pi'ilani Highway. Through his analysis of coastal sites 50-50-14-1028 and 50-50-14-1029, Kirch concluded that settlement patterns in this area were characterized by transient coastal habitation involving the use of ocean resources with permanent settlements and agricultural activities in the upland region.

In his Ph. D. dissertation (1973) William (Pila) Kikuchi identified three fishponds in the area including Kalepolepo (also called Kaonoulukai), Kēōkeakai and Waiohulikai. They are all of the *loko kuapā* type. The first two are said to have been built under Kikau, a contemporary of 'Umi-a-Līloa.

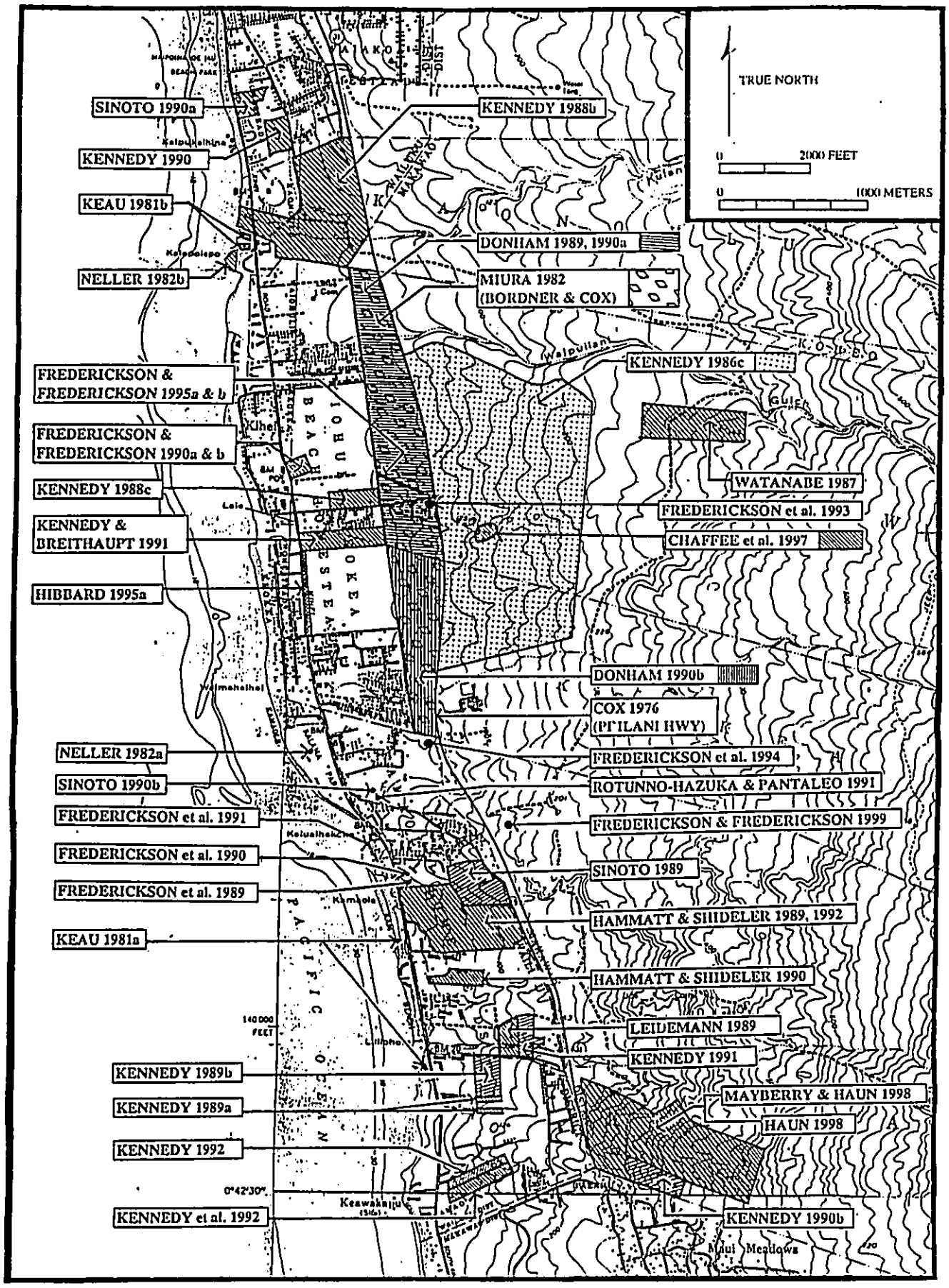

Figure 7 Previous Archaeological Studies in the Vicinity of the Project Area

Cox (1976) carried out contract archaeology for the State Department of Transportation's proposed Pi`ilani Highway project. This right-of-way corridor was located approximately 610 m (2000 feet) inland from South Kīhei Road. The corridor was approximately 61 m (200 feet) wide and 7.24 kilometers (25,560 feet) long for a total of approximately 117 acres. Six sites were identified within this corridor. No sites were identified in Waiohuli, Kaonoulu or Waiakoa but one site, # 223 consisting of two C-shapes believed to be pre-contact temporary shelter, was identified in neighboring Kēōkea *Ahupua`a* and one site, # 224 a cave shelter, was identified in Kama`ole *Ahupua`a* to the south. No excavation or dating was undertaken.

Cordy (1977) conducted an archaeological reconnaissance for a flood control project focused on nine drainage gullies and an inland corridor between Kealia Pond and Wailea, traversing seven *ahupua`a*. He identified three sites in Waiohuli *Ahupua`a* including a collapsed frame house of modern construction (1703), a wall extending off-shore interpreted as a fishpond (1704), and a wall incorporating fence posts (1705). The survey (1977:32) noted extensive land alteration in relation to housing. No sites were found in adjacent Kaonoulu *Ahupua`a* to the north but eight sites, most of which were understood as temporary housing, were identified in Kēōkea *Ahupua`a* to the south. Cordy (1977:56) comments on the difficulty of constructing settlement patterns given the extent of destructive activities in the vicinity. Cordy did conclude that the fishpond at Waiohuli *Ahupua`a* indicated permanent occupation on the coast.

Robert Hommon (1981) conducted an archaeological reconnaissance of a thirty-acre parcel adjacent to the seaward side of Kīhei Road to the north in Waiakoa *Ahupua`a* but found no evidence of any archaeology. He notes (1981:1-2) the extensive human disturbance and erosion in the area.

Charles Keau (1981a) conducted an archaeological reconnaissance of Kamaole Beach Parks I and III to survey storm damage but observed no significant archaeology.

Charles Keau (1981b) conducted an archaeological reconnaissance of two Maui County owned Kaonoulu Beach lots which flank the Federal facility at Kaonoulu. He notes three historic structures in addition to Kalepolepo Fishpond and recommends further archaeological work. The general historic significance of the area is noted.

Miura (1982) reported an archaeological reconnaissance (carried out by Richard Bordner and David Cox) on a 190-acre parcel on the seaward side of Pi`ilani Highway in Waiohuli and Kēōkea *Ahupua`a*. Nine sites were located. The eight sites reported in Kēōkea *Ahupua`a* included alignments, walls, C-shapes, modified outcrops, and enclosures interpreted as agricultural and habitation sites. The one site reported in Waiohuli *Ahupua`a* (site 50-50-10-2476) was a possible alignment. It is noted that the land alteration in Waiohuli was greater than in Kēōkea.

Earl Neller (1982a), then of the State Historic Preservation Office, conducted a reconnaissance of Kalama County Beach Park and reports the find of a burial there in 1981. No details were available but he relates "It has also been reported that a large

number of burials were disturbed during construction of the existing playing field several years ago..." Neller investigated a reported image (*ki`i*) but concluded it was a natural basalt stone. He notes that old maps show a *heiau* and other structures in the vicinity of Waimāha`iha`i (Kama`ole). Noting the depth of apparent alluvium at Kama`ole Beach Park, Neller posits that "the coastal areas around Kama`ole contain a number of archaeological sites buried under five feet of alluvium. This might explain the small number of known archaeological sites in the Kīhei area."

Earl Neller (1982b), then of the State Historic Preservation Office, conducted a reconnaissance of Kaonoulu County Beach Park. He reports no archaeological findings but offers historical accounts and a map pertaining to Kalepolepo Fishpond and burials just seaward of South Kīhei Road.

Wendell Kam (1986) conducted a field inspection of Department of Hawaiian Homes lands in Waiohuli *Ahupua`a* between 2100' and 2700' elevation, identifying two possible pre-contact house sites and numerous stone walls. The location of four named *heiau* in the vicinity is shown. An archaeological survey is called for.

Joseph Kennedy (1986b) conducted an archaeological reconnaissance at a Kīhei Village (coastal Waikapu) lot noting some mounds.

Joseph Kennedy (1986c) conducted a surface archaeological reconnaissance of an approximately 160-acre proposed golf course in Waiohuli, just inland from South Kīhei Road. No archaeological features were located.

Mary Riford (1987) carried out monitoring and reconnaissance survey of 800 acres in two parcels of Department of Hawaiian Homes Lands in the uplands (1800' to 3,000' elevation) of Waiohuli and Kēōkea. A total of 113 archaeological sites composed of more than 252 features were identified. Thirteen sites contained historic period building materials but the vast majority were thought to be pre-contact agricultural, habitation and religious sites.

Farley Watanabe (1987) conducted an archaeological survey reconnaissance of three areas as part of a strategic defense initiative including a parcel in the uplands (approximately 280' to 350' elevation) of Waiohuli *Ahupua`a*. The parcel including access roads ran to approximately 3 acres. No archaeological sites were identified.

Agnes Estioko-Griffin (1988) of DLNR State Parks visited a cave site ("T45" identified by Riford in 1987) on Department of Hawaiian Home Lands and noted the presence of human remains.

Alan Haun (1988) carried out an archaeological reconnaissance of 147 acre parcel in Kama`ole Ahupua`a identifying 33 sites of which 20 were thought to be military related.

Joseph Kennedy (1988a) reported on 1987 testing and conducted archaeological monitoring at the Kīhei Village (coastal Waikapu) lot studied in 1986 finding remnants of a modern dump but no significant cultural remains.

Joseph Kennedy (1988b) conducted a reconnaissance of Kaonoulu Subdivision, an approximately 102 acre parcel in Kaonoulu *Ahupua'a* extending from South Kihei Road to the sea. No significant cultural remains were observed on the surface. No subsurface testing was undertaken but it was recommended in this study.

Joseph Kennedy (1988c) conducted a reconnaissance of an approximately 10-acre parcel on the north side of Lipoa Street inland from South Kihei Road. However the entire property had already been subjected to grubbing and grading and no cultural materials were observed.

Mayberry and Haun (1988) conducted an archaeological reconnaissance of a 147-acre parcel (Maui Palisades) at Kama'ole located just inland from Pi'ilani Highway. The thirty-three sites identified included C-, U- and L-shape alignments, enclosures, terraces, cairns, mounds and modified outcrops which were interpreted as serving military, temporary habitation, transportation marker and agricultural functions. Twenty of the sites (including 48 structures) were regarded as modern military-related sites, two were associated with historic roads and eleven were understood as possibly pre-contact in age. Only two of these sites were regarded as temporary habitations (T4 and T27), however there was some question in both cases as to whether they were in fact prehistoric and whether they were habitation features. All of these sites were rather modest and were recommended as significant for information content only.

Roderick Brown (1989) conducted an inventory survey on 1,025 acres in two parcels of Department of Hawaiian Home Lands in the uplands (1800' to 3000') in Kēōkea and Waiohuli *Ahupua'a*. Most of these lands were the subject of Riford's 1987 study. Some 159 sites were identified.

Roderick Brown and Alan Haun (1989) present a fuller account of an inventory survey on 1,025 acres in two parcels of Department of Hawaiian Home Lands in the uplands (1800' to 3000') in Kēōkea and Waiohuli reported on by Brown 1989. Fifteen radiocarbon dates are presented with the oldest date range AD 680 to 1157. Most of these lands were the subject of Riford's 1987 study. Several burial and possible burial sites are noted.

Theresa Donham (1989) conducted an archaeological inventory survey of a parcel in coastal Waiohuli just seaward of Pi'ilani Highway that was previously studied by Miura (1982) She identified four sites including two new sites. Data recovery was recommended and was reported by Donham in 1990.

Walter Fredericksen *et al.* (1989) carried out an archaeological inventory survey on a 1-acre parcel at Kama'ole just inland from South Kihei Road. No archaeological sites, midden or cultural materials were observed.

Hammatt and Shideler (1989) conducted an archaeological reconnaissance of a 54-acre parcel at Kama'ole adjacent and inland from South Kihei Road. While virtually the entire project area was previously bulldozed and impacted by WWII military and ranching activity; eight sites were identified including a historic ranch structure and seven probable

pre-contact sites. Survey and testing were recommended (reported by Hammatt and Shideler 1992).

Joseph Kennedy (1989a) conducted a survey of two small parcels in Kama'ole *Ahupua'a* approximately midway between South Kihei Road and Pi'ilani Highway. He reports a low rock wall and a mound but concluded they were part of a jeep road and a bulldozer pile respectively. No archaeological site numbers were given and no midden or other cultural materials were observed.

Joseph Kennedy (1989b) conducted a reconnaissance of a sixteen-acre parcel in Kama'ole *Ahupua'a* approximately midway between South Kihei Road and Pi'ilani Highway. No archaeological sites, midden or cultural materials were observed.

Joseph Kennedy (1989c) conducted an inspection of a small site in coastal Pulehu *Ahupua'a* near Uwapo Road. No archaeological sites, midden or cultural materials were observed.

Helen Leidemann (1989) of the B. P. Bishop Museum conducted a reconnaissance of a 9.5-acre parcel in coastal Kama'ole *Ahupua'a* located about midway between South Kihei Road and Pi'ilani Highway. No archaeological sites, midden or cultural materials were observed but extensive clearing and bulldozing were noted.

Aki Sinoto (1989) conducted a surface survey of a 24-acre parcel in Kamaole *Ahupua'a* just seaward of Pi'ilani Highway, identifying 8 archaeological sites. These included thee walls, two midden scatters, two rectangular enclosures and a rock shelter mostly concentrated along a central gulch. Further archaeological work was recommended.

Theresa Donham 1990(a) conducted archaeological data recovery of previously identified (Donham 1989) Site 2475 and concluded it was an agricultural terrace complex. This parcel was first studied by Miura (1982). No midden or dates were obtained in the data recovery. Only one artifact (a basalt flake) was recovered.

Theresa Donham 1990(b) conducted an archaeological inventory survey on a 74-acre parcel in coastal Kēōkea that was part of the Miura 1982 study area. She identified 16 sites mostly on the top and upper slope areas of low to prominent knolls along the edges of natural terraces. These included terraces, low enclosures, midden scatters, modified outcrops and a platform which were understood as having habitation and or agricultural functions. Midden and artifacts were minimal and no dates were obtained. Data recovery was recommended. It appears that one set of SIHP numbers was given to the Miura (1982) sites and a second set was given to the Donham recorded sites (some of the sites were one and the same)

Walter and Demaris Fredericksen (1990a & b) carried out surface survey and archaeological monitoring projects at two contiguous approximately 5-acre parcels at Kēōkea *Ahupua'a* just inland from South Kihei Road. No significant archaeological sites, midden or cultural materials were observed in either lot.

Walter Fredericksen *et al.* (1990) carried out an archaeological inventory survey on a 8.5-acre parcel at Kama'ole just inland from South Kihei Road. The project area had been heavily disturbed by bulldozing and other construction activities and no archaeological sites, midden or cultural materials were observed.

Hammatt and Shideler (1990) conducted an archaeological reconnaissance on a 4-acre parcel at Kama'ole just inland from South Kihei Road. No archaeological sites, midden or cultural materials were observed.

Joseph Kennedy (1990a) conducted a survey of an approximately 15-acre parcel in southern Waikoa *Ahupua'a* approximately midway between South Kihei Road and Pi'ilani Highway. No archaeological sites, midden or cultural materials were observed.

Joseph Kennedy (1990b) conducted an archaeological inventory survey of an approximately 15-acre parcel on the southern edge of Kama'ole *Ahupua'a* at approximately the 300' elevation. No archaeological sites, midden or cultural materials were observed.

Aki Sinoto (1990a) of the B. P. Bishop Museum reported on archaeological survey and subsurface testing of three contiguous parcels (total approximately 7.3 acres) in Waiakoa *Ahupua'a* adjacent on the inland side of South Kihei Road. No archaeological sites, only two pieces of midden and no other cultural materials were observed. Archaeological monitoring of construction was recommended.

Aki Sinoto (1990b) of the B. P. Bishop Museum reported on a surface survey of a 3.2-acre parcel in Kama'ole located just inland from South Kihei Road. The project area had been disturbed by bulldozing and other construction activities and no archaeological sites, midden or cultural materials were observed. Archaeological monitoring of construction was recommended.

Theresa Donham (1991) of the SHPD conducted a field inspection of a historic property known as the Wonderland Mushroom House.

Walter Fredericksen *et al.* (1991) conducted an inventory survey with subsurface testing in coastal Kama'ole *Ahupua'a* at a 1/4-acre beachfront lot. Twenty-three test trenches were excavated by backhoe but the only results were two dog burials and a trash pit - all believed to be modern. No significant archaeological sites, midden or cultural materials were observed.

Joseph Kennedy (1991) performed a reconnaissance of a 5.8-acre parcel in coastal Kama'ole *Ahupua'a* located just seaward of Pi'ilani Highway. No archaeological sites, midden or cultural materials were observed. No subsurface testing was conducted.

Joseph Kennedy and Breithaupt Maigret (1991) conducted an archaeological inventory survey on a 20-acre parcel in Kēōkea *Ahupua'a*. No archaeological sites, midden or cultural materials were observed. No subsurface testing was conducted but this study recommends it.

Lisa Rotunno-Hazuka and Jeffery Pantaleo (1991) of the B. P. Bishop Museum conducted a surface survey of a 4.2-acre parcel in coastal Kama'ole *Ahupua'a* located inland of South Kihei Road. No archaeological sites, midden or cultural materials were observed. No subsurface testing was conducted. Monitoring of construction was recommended.

Hammatt and Shideler (1992) returned to the 54-acre parcel reported on by them in 1989 and conducted survey and testing. No new sites were identified. Test excavations were carried out at five sites thought to possibly contain burials but no burials were encountered. Two of these sites were concluded to be probable prehistoric fishing shrines (*koa*).

Joseph Kennedy (1992) conducted an archaeological inventory surface survey of an approximately 10-acre parcel at the south end of coastal Kama'ole *Ahupua'a* just inland from South Kihei Road. Four sites were identified including a historic house complex, a midden scatter thought to be prehistoric, a wall thought to relate to historic agriculture and a terraced hill thought to be a pre-contact permanent habitation and/or religious structure. Further work was recommended (and was conducted by the Fredericksens in 1992).

Joseph Kennedy *et al.* (1992) conducted an archaeological inventory surface survey with subsurface testing at a site in south coastal Kama'ole *Ahupua'a*. They identified 4 sites, all believed to be historic; two military and 2 ranching. Twenty-nine backhoe trenches and twenty-one shovel test units revealed no features or deposits of significance.

Aki Sinoto and Jeff Pantaleo (1992) conducted an archaeological inventory survey of two parcels (total 38.5 acres) in coastal Pulehunui *Ahupua'a*. There were no archaeological findings other than a bridge foundation crossing Waiakoa Stream (site -3131).

Demaris Fredericksen *et al.* (1993) produced a combination inventory survey/data recovery report on a 2-acre parcel in coastal Waiohuli located just seaward of Pi'ilani Highway. This was an exclusion in the Donham (1989, 1990a) work as the school property is owned by the State. A rock shelter was identified and largely excavated (including backhoe testing just outside) yielding an abundance of midden, basalt flakes and modest tools and volcanic glass. A carbon date of A.D. 1560 to 1800 was obtained. Archaeological monitoring in the vicinity was recommended.

Demaris Fredericksen *et al.* (1994) conducted an archaeological inventory survey on a 5.7-acre parcel in north coastal Kama'ole *Ahupua'a*. Two sites were identified including a shallow low density midden scatter and the concrete foundation of a slaughterhouse. Three test excavations and 47 auger tests did not produce any evidence of subsurface cultural deposits.

Erik Fredericksen *et al.* (1994a) conducted an archaeological inventory survey on a 24-acre parcel in coastal Kama'ole *Ahupua'a*. A rock shelter site (3541) yielded a radiocarbon date reported as AD 1520 to 1570.

Michael Kolb *et al.* (1994) conducted an archaeological and historical settlement survey focused on upcountry Waiohuli and Kēōkea. An in-depth synthesis of settlement patterns in Kula District is presented.

Erik and Demeris Fredericksen (1995b) conducted data recovery on a small rock shelter overhang recovering four radiocarbon dates. While all four dates ranged to modern times they were interpreted as falling within a range of AD 1470 to 1700.

Berdena Burgett and Robert Spear (1995) conducted an archaeological inventory survey of a 22.25-acre parcel in the uplands of Kaonoulu *Ahupua'a* around 3100' elevation. Six post-contact sites were identified. No further work was recommended.

The State Historic Preservation Division (Hibbard 1995a & b)reviewed two earlier phases (phases II and III) of South Kīhei Road Improvements. In both cases a determination of "no effect" was rendered. The area between Welakahao and Lipoa Streets "was visually examined by State Historic Preservation Division staff and found to contain no surface evidence of historic sites" (Hibbard 1995a).

James R. Moore and Joseph Kennedy (1995) conducted an archaeological inventory survey in the uplands of Koheo 1st and 2nd, Kaonoulu, and Alae 1st to 4th *Ahupua'a* for a water transmission main running at approximately the 2600' elevation. Eight sites were identified including three ranching sites and five possibly prehistoric agricultural sites. Site 3542, a pair of adjacent platforms near Kaonoulu Gulch, was thought to have a possible burial function.

Erik Fredericksen *et al.* (1996) conducted an archaeological inventory survey of a ductline corridor up Haleakalā largely in Kaonoulu *Ahupua'a* from 3060' to 9700' elevation. They recorded four sites including two rock shelters and two historic agricultural sites, one with an indigenous component.

David Chaffee *et al.* (1997) carried out an archaeological inventory survey on an approximately 15-acre parcel located in Waiohuli *Ahupua'a* at approximately the 120' elevation. Three sites comprising ten archaeological features were designated. All were posited to have an agricultural function. No cultural material of any kind was recovered.

Erik and Demaris Fredericksen (1999) carried out an archaeological inventory survey on an approximately 1.5-acre parcel in Kama'ole *Ahupua'a* just inland from Pi'ilani Highway. Three sites were designated including five enclosures and a rock pile. These were thought to have a pre-contact temporary habitation function.

Summary of Previous Archaeology

As a perusal of the above studies shows, the vast majority of archaeological surveys in Kihei have produced no significant archaeological data at all. While this may be due in large measure to changes on the land associated with ranching, military occupation and resort and housing construction it still seems inescapable that few areas in the Hawaiian

Islands abutting sandy beaches have less in the way of Hawaiian cultural deposits than Kīhei.

It is also clear, however, that the present project area is one of the least studied portions of Kīhei. In particular, the core area of Kalepolepo Village (including the fish pond and Lihue Cemetery) at the northern terminus of the project area has received very little study.

Overview of Burial Patterns in the Vicinity of the Project Area

Kolb *et al.* (1997:182) review burial distribution in their settlement study of Waiohuli and Kēōkea and assert that "there are substantially more burial sites in the coastal sample [than in the uplands], and most of them occur in association with some form of platform."

In the uplands of Waiohuli, at elevations of 2180' to 2770', Riford (1987:33) reports an exposed human burial at temporary site # 34 and five other possible burial sites (temporary site #s 35, 89, 98, 100 and 105).

She also noted three possible burial sites in the uplands of Kēōkea at elevations of 2550' to 2710'(temporary site #s 25, 26 and 32). Human remains were reported from a cave (T45) at 2725' elevation in Kēōkea *Ahupua'a* (Estioko-Griffin 1988:2).

Brown and Haun (1989) conducted an archaeological inventory survey that largely overlapped the study areas of Riford and Estioko-Griffin. From Waiohuli, Brown and Haun report a possible burial function for features at Site 2040 (W11), a complex of walls, mounds and platforms; an isolated exposed human skull fragment which composed Site 2362 (W35, Riford's 105); and a burial cave Site 2384 (W90) containing two historic burials.

From Kēōkea, Brown and Haun (1989:E-2) report an infant burial (2 phalanges) from a rectangular enclosure at Site -2028 (K3); a possible burial function for a mound at Site 2029 (K-6); a probable burial platform at Site 2084 (K-62); a possible lava tube burial at Site 2089 (K71); a possible burial function for a mound and faced platform at Site 2097(K87, Riford's site 25); and Site 2339(K 207, Estioko-Griffin's T45) a very deep sink site containing human bone.

Moore and Kennedy (1995) assigned a possible burial function to two platforms constituting site 3542 in the uplands of Kaonoulu at approximately 2600' elevation.

Along the coast, Kolb *et al.* 1997 cite the report of two burials at coastal Waipao (Cleghorn 1975 and Dobyns 1988), two burials at coastal Paeahu (Rosendahl and Haun 1987), three burials at Palauea (Kirch 1971 and Donham 1990), and an extensive graveyard (a minimum of twenty individuals) at Kalihi *Ahupua'a* (Clark *et al.*). As far as we can determine, no archaeologist has reported encountering a burial in coastal Waiakoa, Kaonoulu, Waiohuli, Kēōkea or Kama'ole *Ahupua'a* - which seems rather extraordinary. Neller (1982) reports the find of a burial (but he didn't see it) in 1981 at Kalama Park approximately 1.6 kilometers south of the southern terminus of the present project area. No details were available but he relates: "It has also been reported that a large number of

burials were disturbed during construction of the existing playing field [at Kalama Park] several years ago...".

Approximately 400 m east of the northern terminus of the project area is Lihue Cemetery adjacent to the site (ruins) of Kilolani Church built in 1853. This was the burial ground of the Halstead and Wilcox families and of whalers who died in Hawai`i.

In short there are no indications of a likelihood of burials along the project corridor.

V. RESULTS OF FIELD INSPECTION

On November 9, 1999, David W. Shideler, M.A., of Cultural Surveys Hawai`i carried out a pedestrian inspection of both sides of the project area. Close to 95% of the adjoining parcels are developed in condominiums and houses. Typically the margins of South Kihei Road in this vicinity are lined with sidewalks, drive ways, parking lots and landscaping. Particular attention was given to the search for surface midden or lithic scatters. In several places, vacant lots or recent grading of parcels on the sides of the road allowed for further inspection. Additionally the entire coastline west of the project area and the extensive dunes to the west of the northern two thirds of the project area were inspected for some sign of pre-contact or early historic cultural activity but no sign of any such cultural activity was observed. Nothing of archaeological significance was seen along the road corridor.

Field inspection was coordinated to coincide with subsurface testing by Geolabs Hawai`i. Geolabs Hawai`i conducted soil testing at six locations as part of soil engineering studies for the proposed road improvements. Testing was conducted with a truck mounted mobile drill rig with a 7-inch diameter auger drill with an internal sampling device. While it was not anticipated that anything of archaeological significance could be determined from the holes *per se* it was anticipated that the soil profiles (drill logs) might provide useful data. Boring holes 1 and 2 were drilled on 11/8/1999 and bore holes 3 to 6 were observed on 11/9/1999. The holes were spaced evenly along the project area. The archaeological import of the soil record was felt to end at the watertable.

Boring 1 was located approximately 60 m to the south of Kulanihakoi Street on the dirt shoulder 4 m to the west (*makai*) of the west side of South Kihei Road. From the surface to the water table at 1 m (3'4") was a brown silty sand with basalt gravel fill, loose to medium dense.

Boring 2 was located 30 m north of Ho`onani Street on the west (*makai*) side of South Kihei Road in the sidewalk. A tan sand with basalt gravel fill extended down to the water table at 1.5 m (5'). At the water table there was still basalt gravel, loose to medium dense.

Boring 3 was located 20 m south of Namauu Place in the middle of busy South Kihei Road. A brown silty pebble and cobble gravel fill extended down to 91 cm (3') at which depth a tan sand graded down to a brown silt at 1.5 m (5'). The water table was encountered at 1.7 m (5'4").

Boring 4 was located 60 m south of Kauha`a Street on the west (*makai*) side of South Kihei Road, 2 m west of the asphalt edge of the road in sand. A tan sand with basalt and calcareous pebble gravel turned at .15 m (6") to a brown silty sand with basalt and calcareous pebble gravel. At 0.9 m (3') this graded to a brown silt with a mild organic odor. The water table was encountered at 0.7 m (2'5").

Boring 5 was located directly west of Longs Drug Store in South Kihei Road, 3 m east of the seaward curb. A brown silty gravel with sand, medium dense continued down to 0.6

m (2') followed by a gray silty sand down to 0.9 m (3'). A tan calcareous sand with coral gravel continued on down to 4.6 m (15'). The water table was encountered at 0.9 m (3').

Boring 6 was located in the middle of busy South Kīhei Road just seaward of Hawai'i National Bank and 50 m north of Lipoa Road. A brown silty gravel extended from 0.15 m (6") to 0.9 m (3'). From 3' (0.9 m) to 1.5 m (5') was a light gray sand turning to a tan sand at 1.5 m (5'). The water table was at 1 m (3'4").

The first observation regarding import for archaeological deposits is that no evidence of cultural occupation (midden, artifacts) or agricultural deposits were observed in the bore holes.

The second observation was the remarkably low elevation of South Kīhei Road. Four of the borings encountered the water table at 1 m or less and the highest ground tested was at 1.7 m above the water table. While we knew the road was low, we did not appreciate how low the road is, and this may well have archaeological implications. The relatively close proximity of the water table may have discouraged burial at such low elevations (the Lihue Cemetery by the old church is notably inland, Figure 5). Furthermore the presumably brackish water may have discouraged the growth of any but the most salt tolerant of plants making coastal residence less pleasant.

The Kīhei area has historically been prone to flooding due to three different factors: tsunami, flood, and heavy surf. The low elevation of the project area (1 to 1.7 m above the water table) and ten documented flooding events this century are suggested to be partial explanations for the relative dearth of archaeology in the vicinity. Undoubtedly the propensity of the Kīhei flood plain to flood was well known to the ancient Hawaiians and this may have significantly discouraged permanent habitation within the flood plain.

The gravels, sand and silty sand observed in the bore hole stratigraphy appeared to be poor agricultural soils.

VI CONCLUSIONS AND RECOMMENDATIONS

Conclusions

No evidence of pre-contact cultural or agricultural activity within the project area *per se* was uncovered. Our historical analysis points out that there was a major Hawaiian community at Kalepolepo just to the north of the project area (see Figure 5) probably from pre-contact times. The community at Kalepolepo appears to have prospered between 1820 and the mid 1870s in response to demands from whalers and California gold miners for agricultural goods but this did not appear to affect the project area. The presence of four fish ponds along the coast in the immediate area does indicate some permanent Hawaiian coastal settlement at Waiohuli and Kēōkea but the archaeological evidence suggests that permanent habitation in these *ahupua'a* was overwhelmingly in upland areas above 2,000' elevation. Our field reconnaissance and observations of soil borings gave no indication of archaeological resources under or adjacent to the stretch of South Kīhei Road constituting the present project area. The absence of cultural use of the vicinity of the project area is suggested to be because of the low elevation above the water table and propensity to flood (with ten documented flooding events in the area this century) and because of the low rainfall (lowest on the island) and poor soils in the area.

Recommendations

In light of the above conclusions we can only recommend that full time monitoring is not indicated for this portion of this project. We cannot rule out the possibility of some isolated find. If a human burial or other significant find is encountered, all work in the immediate area should cease and the State Historic Preservation Division should be immediately notified.

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Photographic Appendix

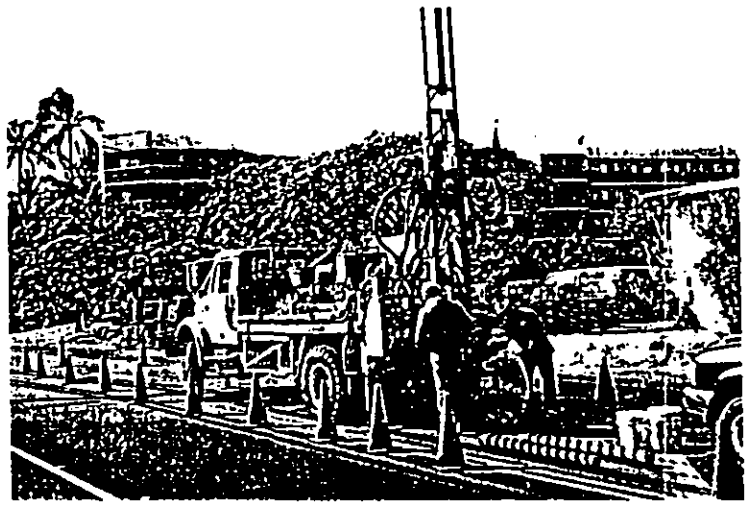

Figure 8 View of Boring Hole # 3 (Just South of Namauu Place) in Progress, View to Southwest

Figure 9 General View of Project Area from North End at Kūlanihāko'i Street, View to South

Figure 10 General View of Central Portion of the Project Area from Waipu'ilani Road. View to South

Figure 11 General View of South Portion of the Project Area from Lipoa Street. View to North

Walter Fredericksen *et al.* (1990) carried out an archaeological inventory survey on a 8.5-acre parcel at Kama'ole just inland from South Kihei Road. The project area had been heavily disturbed by bulldozing and other construction activities and no archaeological sites, midden or cultural materials were observed.

Hammatt and Shideler (1990) conducted an archaeological reconnaissance on a 4-acre parcel at Kama'ole just inland from South Kihei Road. No archaeological sites, midden or cultural materials were observed.

Joseph Kennedy (1990a) conducted a survey of an approximately 15-acre parcel in southern Waikoa *Ahupua'a* approximately midway between South Kihei Road and Pi'ilani Highway. No archaeological sites, midden or cultural materials were observed.

Joseph Kennedy (1990b) conducted an archaeological inventory survey of an approximately 15-acre parcel on the southern edge of Kama'ole *Ahupua'a* at approximately the 300' elevation. No archaeological sites, midden or cultural materials were observed.

Aki Sinoto (1990a) of the B. P. Bishop Museum reported on archaeological survey and subsurface testing of three contiguous parcels (total approximately 7.3 acres) in Waiakoa *Ahupua'a* adjacent on the inland side of South Kihei Road. No archaeological sites, only two pieces of midden and no other cultural materials were observed. Archaeological monitoring of construction was recommended.

Aki Sinoto (1990b) of the B. P. Bishop Museum reported on a surface survey of a 3.2-acre parcel in Kama'ole located just inland from Sputh Kihei Road. The project area had been disturbed by bulldozing and other construction activities and no archaeological sites, midden or cultural materials were observed. Archaeological monitoring of construction was recommended.

Theresa Donham (1991) of the SHPD conducted a field inspection of a historic property known as the Wonderland Mushroom House.

Walter Fredericksen *et al.* (1991) conducted an inventory survey with subsurface testing in coastal Kama'ole *Ahupua'a* at a 1/4-acre beachfront lot. Twenty-three test trenches were excavated by backhoe but the only results were two dog burials and a trash pit - all believed to be modern. No significant archaeological sites, midden or cultural materials were observed.

Joseph Kennedy (1991) performed a reconnaissance of a 5.8-acre parcel in coastal Kama'ole *Ahupua'a* located just seaward of Pi'ilani Highway. No archaeological sites, midden or cultural materials were observed. No subsurface testing was conducted.

Joseph Kennedy and Breithaupt Maigret (1991) conducted an archaeological inventory survey on a 20-acre parcel in Kēōkea *Ahupua'a*. No archaeological sites, midden or cultural materials were observed. No subsurface testing was conducted but this study recommends it.

Lisa Rotunno-Hazuka and Jeffery Pantaleo (1991) of the B. P. Bishop Museum conducted a surface survey of a 4.2-acre parcel in coastal Kama'ole *Ahupua'a* located inland of South Kihei Road. No archaeological sites, midden or cultural materials were observed. No subsurface testing was conducted. Monitoring of construction was recommended.

Hammatt and Shideler (1992) returned to the 54-acre parcel reported on by them in 1989 and conducted survey and testing. No new sites were identified. Test excavations were carried out at five sites thought to possibly contain burials but no burials were encountered. Two of these sites were concluded to be probable prehistoric fishing shrines (*koa*).

Joseph Kennedy (1992) conducted an archaeological inventory surface survey of an approximately 10-acre parcel at the south end of coastal Kama'ole *Ahupua'a* just inland from South Kihei Road. Four sites were identified including a historic house complex, a midden scatter thought to be prehistoric, a wall thought to relate to historic agriculture and a terraced hill thought to be a pre-contact permanent habitation and/or religious structure. Further work was recommended (and was conducted by the Fredericksens in 1992).

Joseph Kennedy *et al.* (1992) conducted an archaeological inventory surface survey with subsurface testing at a site in south coastal Kama'ole *Ahupua'a*. They identified 4 sites, all believed to be historic; two military and 2 ranching. Twenty-nine backhoe trenches and twenty-one shovel test units revealed no features or deposits of significance.

Aki Sinoto and Jeff Pantaleo (1992) conducted an archaeological inventory survey of two parcels (total 38.5 acres) in coastal Pulehunui *Ahupua'a*. There were no archaeological findings other than a bridge foundation crossing Waiakoa Stream (site -3131).

Demaris Fredericksen *et al.* (1993) produced a combination inventory survey/data recovery report on a 2-acre parcel in coastal Waiohuli located just seaward of Pi'ilani Highway. This was an exclusion in the Donham (1989, 1990a) work as the school property is owned by the State. A rock shelter was identified and largely excavated (including backhoe testing just outside) yielding an abundance of midden, basalt flakes and modest tools and volcanic glass. A carbon date of A.D. 1560 to 1800 was obtained. Archaeological monitoring in the vicinity was recommended.

Demaris Fredericksen *et al.* (1994) conducted an archaeological inventory survey on a 5.7-acre parcel in north coastal Kama'ole *Ahupua'a*. Two sites were identified including a shallow low density midden scatter and the concrete foundation of a slaughterhouse. Three test excavations and 47 auger tests did not produce any evidence of subsurface cultural deposits.

Erik Fredericksen *et al.* (1994a) conducted an archaeological inventory survey on a 24-acre parcel in coastal Kama'ole *Ahupua'a*. A rock shelter site (3541) yielded a radiocarbon date reported as AD 1520 to 1570.

Michael Kolb *et al.* (1994) conducted an archaeological and historical settlement survey focused on upcountry Waiohuli and Kēōkea. An in-depth synthesis of settlement patterns in Kula District is presented.

Erik and Demeris Fredericksen (1995b) conducted data recovery on a small rock shelter overhang recovering four radiocarbon dates. While all four dates ranged to modern times they were interpreted as falling within a range of AD 1470 to 1700.

Berdena Burgett and Robert Spear (1995) conducted an archaeological inventory survey of a 22.25-acre parcel in the uplands of Kaonoulu *Ahupua'a* around 3100' elevation. Six post-contact sites were identified. No further work was recommended.

The State Historic Preservation Division (Hibbard 1995a & b)reviewed two earlier phases (phases II and III) of South Kihei Road Improvements. In both cases a determination of "no effect" was rendered. The area between Welakahao and Lipoa Streets "was visually examined by State Historic Preservation Division staff and found to contain no surface evidence of historic sites" (Hibbard 1995a).

James R. Moore and Joseph Kennedy (1995) conducted an archaeological inventory survey in the uplands of Koheo 1st and 2nd, Kaonoulu, and Alae 1st to 4th *Ahupua'a* for a water transmission main running at approximately the 2600' elevation. Eight sites were identified including three ranching sites and five possibly prehistoric agricultural sites. Site 3542, a pair of adjacent platforms near Kaonoulu Gulch, was thought to have a possible burial function.

Erik Fredericksen *et al.* (1996) conducted an archaeological inventory survey of a ductline corridor up Haleakalā largely in Kaonoulu *Ahupua'a* from 3060' to 9700' elevation. They recorded four sites including two rock shelters and two historic agricultural sites, one with an indigenous component.

David Chaffee *et al.* (1997) carried out an archaeological inventory survey on an approximately 15-acre parcel located in Waiohuli *Ahupua'a* at approximately the 120' elevation. Three sites comprising ten archaeological features were designated. All were posited to have an agricultural function. No cultural material of any kind was recovered.

Erik and Demaris Fredericksen (1999) carried out an archaeological inventory survey on an approximately 1.5-acre parcel in Kama'ole *Ahupua'a* just inland from Pī'ilani Highway. Three sites were designated including five enclosures and a rock pile. These were thought to have a pre-contact temporary habitation function.

Summary of Previous Archaeology

As a perusal of the above studies shows, the vast majority of archaeological surveys in Kihei have produced no significant archaeological data at all. While this may be due in large measure to changes on the land associated with ranching, military occupation and resort and housing construction it still seems inescapable that few areas in the Hawaiian

Islands abutting sandy beaches have less in the way of Hawaiian cultural deposits than Kihei.

It is also clear, however, that the present project area is one of the least studied portions of Kihei. In particular, the core area of Kalepolepo Village (including the fish pond and Lihue Cemetery) at the northern terminus of the project area has received very little study.

Overview of Burial Patterns in the Vicinity of the Project Area

Kolb *et al.* (1997:182) review burial distribution in their settlement study of Waiohuli and Kēōkea and assert that "there are substantially more burial sites in the coastal sample (than in the uplands), and most of them occur in association with some form of platform."

In the uplands of Waiohuli, at elevations of 2180' to 2770', Riford (1987:33) reports an exposed human burial at temporary site # 34 and five other possible burial sites (temporary site #s 35, 89, 98, 100 and 105).

She also noted three possible burial sites in the uplands of Kēōkea at elevations of 2550' to 2710'(temporary site #s 25, 26 and 32). Human remains were reported from a cave (T45) at 2725' elevation in Kēōkea *Ahupua'a* (Estioko-Griffin 1988:2).

Brown and Haun (1989) conducted an archaeological inventory survey that largely overlapped the study areas of Riford and Estioko-Griffin. From Waiohuli, Brown and Haun report a possible burial function for features at Site 2040 (W11), a complex of walls, mounds and platforms; an isolated exposed human skull fragment which composed Site 2362 (W35, Riford's 105); and a burial cave Site 2384 (W90) containing two historic burials.

From Kēōkea, Brown and Haun (1989:E-2) report an infant burial (2 phalanges) from a rectangular enclosure at Site -2028 (K3); a possible burial function for a mound at Site 2029 (K-6); a probable burial platform at Site 2084 (K-62); a possible lava tube burial at Site 2089 (K71); a possible burial function for a mound and faced platform at Site 2097(K87, Riford's site 25); and Site 2339(K 207, Estioko-Griffin's T45) a very deep sink site containing human bone.

Moore and Kennedy (1995) assigned a possible burial function to two platforms constituting site 3542 in the uplands of Kaonoulu at approximately 2600' elevation.

Along the coast, Kolb *et al.* 1997 cite the report of two burials at coastal Waipao (Cleghorn 1975 and Dobyns 1988), two burials at coastal Paeahu (Rosendahl and Haun 1987), three burials at Palauea (Kirch 1971 and Donham 1990), and an extensive graveyard (a minimum of twenty individuals) at Kalihi *Ahupua'a* (Clark *et al.*). As far as we can determine, no archaeologist has reported encountering a burial in coastal Waiakoa, Kaonoulu, Waiohuli, Kēōkea or Kama'ole *Ahupua'a* - which seems rather extraordinary. Neller (1982) reports the find of a burial (but he didn't see it) in 1981 at Kalama Park approximately 1.6 kilometers south of the southern terminus of the present project area. No details were available but he relates: "It has also been reported that a large number of

burials were disturbed during construction of the existing playing field [at Kalama Park] several years ago...".

Approximately 400 m east of the northern terminus of the project area is Lihue Cemetery adjacent to the site (ruins) of Kilolani Church built in 1853. This was the burial ground of the Halstead and Wilcox families and of whalers who died in Hawai'i.

In short there are no indications of a likelihood of burials along the project corridor.

V. RESULTS OF FIELD INSPECTION

On November 9, 1999, David W. Shideler, M.A., of Cultural Surveys Hawai'i carried out a pedestrian inspection of both sides of the project area. Close to 95% of the adjoining parcels are developed in condominiums and houses. Typically the margins of South Kihei Road in this vicinity are lined with sidewalks, drive ways, parking lots and landscaping. Particular attention was given to the search for surface midden or lithic scatters. In several places, vacant lots or recent grading of parcels on the sides of the road allowed for further inspection. Additionally the entire coastline west of the project area and the extensive dunes to the west of the northern two thirds of the project area were inspected for some sign of pre-contact or early historic cultural activity but no sign of any such cultural activity was observed. Nothing of archaeological significance was seen along the road corridor.

Field inspection was coordinated to coincide with subsurface testing by Geolabs Hawai'i. Geolabs Hawai'i conducted soil testing at six locations as part of soil engineering studies for the proposed road improvements. Testing was conducted with a truck mounted mobile drill rig with a 7-inch diameter auger drill with an internal sampling device. While it was not anticipated that anything of archaeological significance could be determined from the holes *per se* it was anticipated that the soil profiles (drill logs) might provide useful data. Boring holes 1 and 2 were drilled on 11/8/1999 and bore holes 3 to 6 were observed on 11/9/1999. The holes were spaced evenly along the project area. The archaeological import of the soil record was felt to end at the watertable.

Boring 1 was located approximately 60 m to the south of Kulanihakoi Street on the dirt shoulder 4 m to the west (*makai*) of the west side of South Kihei Road. From the surface to the water table at 1 m (3'4") was a brown silty sand with basalt gravel fill, loose to medium dense.

Boring 2 was located 30 m north of Ho'onani Street on the west (*makai*) side of South Kihei Road in the sidewalk. A tan sand with basalt gravel fill extended down to the water table at 1.5 m (5'). At the water table there was still basalt gravel, loose to medium dense.

Boring 3 was located 20 m south of Namauu Place in the middle of busy South Kihei Road. A brown silty pebble and cobble gravel fill extended down to 91 cm (3') at which depth a tan sand graded down to a brown silt at 1.5 m (5'). The water table was encountered at 1.7 m (5'4").

Boring 4 was located 60 m south of Kauha'a Street on the west (*makai*) side of South Kihei Road, 2 m west of the asphalt edge of the road in sand. A tan sand with basalt and calcareous pebble gravel turned at .15 m (6") to a brown silty sand with basalt and calcareous pebble gravel. At 0.9 m (3') this graded to a brown silt with a mild organic odor. The water table was encountered at 0.7 m (2'5").

Boring 5 was located directly west of Longs Drug Store in South Kihei Road, 3 m east of the seaward curb. A brown silty gravel with sand, medium dense continued down to 0.6

m (2') followed by a gray silty sand down to 0.9 m (3'). A tan calcareous sand with coral gravel continued on down to 4.6 m (15'). The water table was encountered at 0.9 m (3').

Boring 6 was located in the middle of busy South Kīhei Road just seaward of Hawai'i National Bank and 50 m north of Lipoa Road. A brown silty gravel extended from 0.15 m (6") to 0.9 m (3'). From 3' (0.9 m) to 1.5 m (5') was a light gray sand turning to a tan sand at 1.5 m (5'). The water table was at 1 m (3'4").

The first observation regarding import for archaeological deposits is that no evidence of cultural occupation (midden, artifacts) or agricultural deposits were observed in the bore holes.

The second observation was the remarkably low elevation of South Kīhei Road. Four of the borings encountered the water table at 1 m or less and the highest ground tested was at 1.7 m above the water table. While we knew the road was low, we did not appreciate how low the road is, and this may well have archaeological implications. The relatively close proximity of the water table may have discouraged burial at such low elevations (the Lihue Cemetery by the old church is notably inland, Figure 5). Furthermore the presumably brackish water may have discouraged the growth of any but the most salt tolerant of plants making coastal residence less pleasant.

The Kīhei area has historically been prone to flooding due to three different factors: tsunami, flood, and heavy surf. The low elevation of the project area (1 to 1.7 m above the water table) and ten documented flooding events this century are suggested to be partial explanations for the relative dearth of archaeology in the vicinity. Undoubtedly the propensity of the Kīhei flood plain to flood was well known to the ancient Hawaiians and this may have significantly discouraged permanent habitation within the flood plain.

The gravels, sand and silty sand observed in the bore hole stratigraphy appeared to be poor agricultural soils.

VI CONCLUSIONS AND RECOMMENDATIONS

Conclusions

No evidence of pre-contact cultural or agricultural activity within the project area *per se* was uncovered. Our historical analysis points out that there was a major Hawaiian community at Kalepolepo just to the north of the project area (see Figure 5) probably from pre-contact times. The community at Kalepolepo appears to have prospered between 1820 and the mid 1870s in response to demands from whalers and California gold miners for agricultural goods but this did not appear to affect the project area. The presence of four fish ponds along the coast in the immediate area does indicate some permanent Hawaiian coastal settlement at Waiohuli and Kēōkea but the archaeological evidence suggests that permanent habitation in these *ahupua'a* was overwhelmingly in upland areas above 2,000' elevation. Our field reconnaissance and observations of soil borings gave no indication of archaeological resources under or adjacent to the stretch of South Kīhei Road constituting the present project area. The absence of cultural use of the vicinity of the project area is suggested to be because of the low elevation above the water table and propensity to flood (with ten documented flooding events in the area this century) and because of the low rainfall (lowest on the island) and poor soils in the area.

Recommendations

In light of the above conclusions we can only recommend that full time monitoring is not indicated for this portion of this project. We cannot rule out the possibility of some isolated find. If a human burial or other significant find is encountered, all work in the immediate area should cease and the State Historic Preservation Division should be immediately notified.

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Photographic Appendix

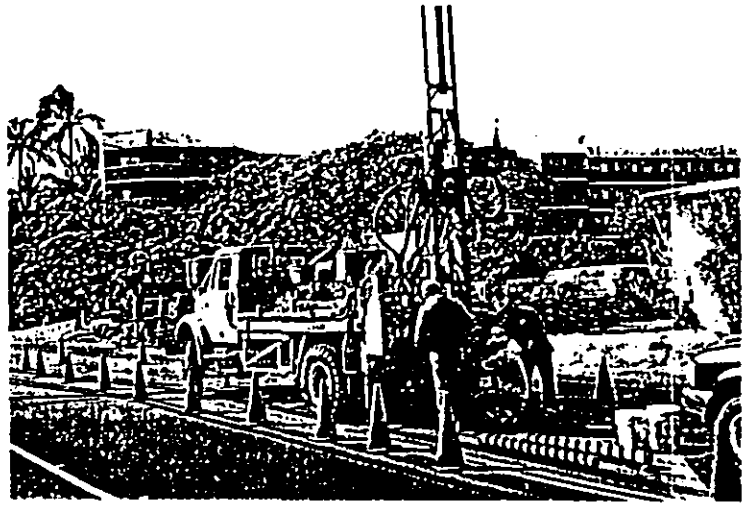

Figure 8 View of Boring Hole # 3 (Just South of Namauu Place) in Progress, View to Southwest

Figure 9 General View of Project Area from North End at Kūlanihāko'i Street, View to South

Figure 10 General View of Central Portion of the Project Area from Waipu'ilani Road, View to South

Figure 11 General View of South Portion of the Project Area from Lipoa Street, View to North