Honouliuli, Ewa District, Island of Oahu, Hawaii

WEST BEACH

APPENDIX I

FILE COPY

WEST BEACH

DRAFT SUPPLEMENTAL

ENVIRONMENTAL IMPACT STATEMENT

Honouliuli, Ewa, Oahu, Hawaii

APPENDIX I

TECHNICAL STUDIES

These technical studies have been prepared for the West Beach Supplemental Environmental Impact Statement (EIS) which has been prepared under the Rules & Regulations of the Environmental Quality Commission (Chapter 343, HRS) and NEPA (P.L.91-190). They reflect the current status of condition, forward from the generic EIS prepared in 1979 and accepted in 1980. As such, all comments made by the technical subconsultants are for the current condition of the project site and the proposed project as designed and presented in the EIS.

APPENDIX I - TECHNICAL STUDIES

1. A Report of the Viability of West Beach as a Resort Community and the Estimated Economic Impact; Pannell, Kerr, Forster.

2. Acoustic Evaluation of AICUZ Plan, NAS, Barber's Point, 1984, and Evaluation of HIA Air Craft Noise Impact; Revised Land Use Plans, Proposed West Beach Resort; Darby-Ebisu & Associates, Inc.

3. Air Quality Analysis for West Beach Project Oahu, Hawaii; Root, Barry D.

4. Birds of West Beach; Berger, Andrew J., Ph.D.

5. Botanical Survey of the Proposed West Beach Resort Project; Char, Winona P.

6. Occurrence and Significance of Palaeontological and Archaeological Remains in the West Beach Resorts Development Area, Oahu; Ziegler, Alan C., Ph.D.

7. Traffic Impact Analysis; Community Planning, Inc.

8. West Beach, Oahu: Archaeological Status Report; Barrera, William, Jr.

9. West Beach Project Water Pollution Implications of Project Site Storm Runoff; Dugan, Gordon L. Ph.D.

APPENDIX II - OCEANOGRAPHIC AND MARINA STUDIES:

1. Analysis of Biological Impacts of the Lagoon/Marina Development at West Beach, Oahu, Hawaii; OI Consultants, Inc.

2. Proposed West Beach Marina Hydraulic Model Investigation; U.H. James K.K. Look Laboratory of Oceanographic Engineering, Department of Ocean Engineering; Principal Investigator; Lee, Theodore T.

3. Summary of Technical Input for the West Beach Lagoons and Marina Design Development; Bathen, Karl H.; Dr.

4. Technical Evaluation and Recommendations on Design of Marine Structures; Gerritsen, F.

5. Tsunami and Hurricane Design Criteria and Recorded Wave Data Analysis for West Beach Development Area; Bretschneider, Charles L.

APPENDIX I

SECTION 1

WEST BEACH ESTATES
HONOLULU, HAWAII

A REPORT OF THE VIABILITY OF
WEST BEACH AS A RESORT COMMUNITY
AND THE ESTIMATED ECONOMIC IMPACT

SEPTEMBER 1983

September 1, 1983

Mr. Herbert K. Horita
West Beach Estates
2024 North King Street
Honolulu, Hawaii 96819

Dear Mr. Horita:

In accordance with your request, we have prepared this report as an inclusion to the petition to the Land Use Commission to obtain an urban designation for the lands at West Beach. In conjunction with this assignment, we have prepared a projection of transient resort accommodations on Oahu to the year 2000. Further developed are estimates of employment that could reasonably be generated as the result of the West Beach resort community. Also presented is rationale for the need to develop West Beach with regard to location and timing.

The entire study and conclusions reached are based on our present knowledge and information with respect to the present state and potential growth in market demand, presently available and proposed facilities in the competitive area, and the economics of the hotel industry.

As in all studies of this type, the estimated results are based on the presumption that no significant change will materialize in the competitive position within the hotel industry in the immediate area from that which is set forth in this report.

It is expressly understood that the scope of the study and the report thereon do not include the possible impact of zoning regulations, licensing requirements, or other restrictions concerning the proposed project, except where such matters have been brought to our attention and which are set forth in this report. It is expected that the developers of the project will have prepared their plans within the purview of all such legislative or other restrictions.

This report has been prepared primarily for your use and guidance in determining the potential market size and for assisting you in determining the economic impact of the planned resort complex. As is customary in assignments of this nature, neither our name nor the material submitted may be included in any prospectus, newspaper publicity, or as part of any printed material or used in offerings or representations in connection with the sale of securities or participation interests to the public.

We would be pleased to hear from you if we may be of further assistance in the interpretation and application of our findings and opinions. We express our appreciation to you and your associates for the cooperation extended to us during the course of our assignment.

Yours very truly,

Pannell Kerr Forster

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A REPORT OF THE VIABILITY OF WEST BEACH AS A RESORT COMMUNITY AND THE ESTIMATED ECONOMIC IMPACT

EXECUTIVE SUMMARY

- Estimates reveal that adequate demand by transient visitors could materialize to prove the 4,000 planned resort units viable within the first five years of operations, 1988-1992.

- Tour visitors have been supplanted by the more affluent free independent travelers, who typically require more active recreational amenities such as golf, tennis, boating and fishing. West Beach is well suited to these activities.

- On the basis of our analysis of the visitor market on Oahu and the planned resort development site, it is our opinion that West Beach is well-suited to the development of a resort community for the following reasons:

  - West Beach can provide the long-term job formation needs of Oahu which depend largely on the growth of tourism.
  - The location of West Beach is in Oahu's Ewa area where population growth is accelerating.
  - Public access and enjoyment of the shoreline heightened.
  - Reduction of employee commute time and traffic volume.
  - Enhancement of the cost-benefit ratio.
  - Excellent access to and from Honolulu International Airport.
  - A Superior Water Quality.
  - Inherent Superior Qualities of a Master Planned Development.

- The development in West Beach as a resort community will provide for the creation of a sizeable base of employment. It is estimated that approximately 5,100 direct jobs and 1,000 indirect jobs for a total employment impact of approximately 6,100 jobs when fully operational. In addition, a large number of jobs will be created from the construction of the infrastructure and superstructure elements of the complex.

- On an annual basis, the economic impact to the State of Hawaii from the West Beach resort community is estimated to be $24,354,000 expressed in 1983 dollars. Revenues would accrue from the following sources:

State Unemployment Tax	$ 850,000
Gross Income Tax	8,030,000
State Personal Income Tax	4,779,000
Real Property Tax	10,695,000
	$24,354,000

FUTURE DEMAND FOR TRANSIENT ACCOMMODATIONS

It is a common industry opinion that the visitor growth experienced in Hawaii during the past two decades (1963 - 1982), 12.8 percent annual growth, will not be experienced to the year 2000. Pannell Kerr Forster has projected annual growth of 3.0 percent during this period. The years 1980 and 1981 saw a stabilization of State visitor growth due to inflation, unemployment and rising air fares; 1982 has ushered in the 4 millionth annual visitor to the State with a strong surge in growth; 1983 and beyond are expected to bring continued growth.

Tourism is the State's number one industry generating over $3 billion in visitor expenditures. Tourism accounts for 30 percent of all civilian jobs, personal income and tax revenues in the State. It is generally agreed upon by both private and public economists that tourism is the primary hope for future employment growth.

As the Hawaii tourism industry regains a growth posture additional facilities to accommodate the transient visitors on Oahu will be required if the natural increases in the market are to be assimilated. Due to the constraints of the Waikiki Special Design District, limitations on accommodations growth will continue to be imposed and, therefore, appropriate sites away from Waikiki will afford an alternate resort experience on Oahu.

The "Waikiki 2000" espoused by the city administration is applauded and will, if implemented, upgrade Waikiki for the greater enjoyment of visitors and residents alike. It will not, however, increase the capacity of Waikiki to accommodate additional transient visitors above those allowed by the constraints of the Special Design District. The eventual wholesale enhancement of Waikiki could, however, increase the percentage of future State visitors desiring to spend a portion or all of their vacation on Oahu.

TABLE I

VISITOR PROJECTION - STATE OF HAWAII
1983 - 2000

		Westbound				Eastbound				Summary Total	
	Year	State Visitors	Annual Increase	Annual Trend Growth	Approximated Trend Growth	State Visitors	Annual Increase	Modified Trend Growth	Approximated Trend Growth	State Visitors	Annual Rate of Growth
Actual	1961	248,540				71,267				319,807	
	1962	279,625	12.5			82,520	15.8			362,145	13.2
	1963	332,680	19.0			96,460	16.9			429,140	18.5
	1964	460,290	38.4	22.8		103,635	7.4	15.9		563,925	31.4
	1965	576,218	23.2	26.3		119,701	15.5	22.0		686,919	21.8
	1966	686,886	21.1	25.3		148,570	24.1	24.4		835,456	21.6
	1967	893,103	30.0	20.8	18.5	231,715	56.0	26.0	16.5	1,124,818	34.6
	1968	1,015,844	13.7	18.7	17.5	298,727	28.9	27.3	15.5	1,314,571	16.9
	1969	1,181,029	16.3	16.0	16.5	345,983	15.8	20.8	14.5	1,527,012	16.2
	1970	1,326,135	12.3	14.9	15.5	420,835	21.6	15.4	13.5	1,746,970	14.4
	1971	1,430,325	7.9	15.4	14.5	388,619	(7.7)	14.0	12.5	1,818,944	4.1
	1972	1,782,737	24.6	13.4	13.5	461,640	18.8	12.2	11.5	2,244,377	23.4
	1973	2,067,861	16.0	10.9	12.5	563,091	22.0	8.5	10.5	2,630,952	17.2
	1974	2,184,620	5.6	12.6	11.5	601,869	6.9	11.7	9.5	2,786,489	5.9
	1975	2,207,417	1.0	9.3	10.5	621,688	3.3	7.9	8.0	2,829,105	1.5
	1976	2,551,001	15.6	8.0	9.5	668,550	7.5	2.6	7.5	3,219,551	13.8
	1977	2,763,312	8.3	7.6	8.5	670,355	.3	7.0	6.0	3,433,667	6.6
	1978	3,030,999	9.7	6.8	7.5	639,310	(4.6)	8.0	5.5	3,670,309	6.9
	1979	3,139,455	3.6	3.2	6.5	821,076	28.4	8.1	5.0	3,960,531	7.9
	1980	3,036,933	(3.3)	3.8	6.0	888,372	8.2	8.4	5.0	3,934,504	(.7)
	1981	2,974,791	(2.1)		5.5	959,832	8.0		5.0	3,934,623	.2
	1982	3,278,519			8.2	964,397			0.5	4,242,916	7.8
Projected	1983	3,409,700			4.0	1,002,900			3.9	4,412,600	4.0
	1984	3,580,200			5.0	1,053,000			5.0	4,633,200	5.0
	1985	3,753,100			4.8	1,102,500			4.7	4,855,600	4.8
	1986	3,926,900			4.6	1,152,100			4.5	5,079,000	4.6
	1987	4,099,700			4.4	1,202,800			4.4	5,302,500	4.4
	1988	4,270,700			4.2	1,254,500			4.3	5,525,200	4.2
	1989	4,439,000			3.9	1,307,200			4.2	5,746,200	4.0
	1990	4,605,000			3.7	1,359,500			4.0	5,964,500	3.8
	1991	4,748,300			3.1	1,407,100			3.5	6,155,400	3.2
	1992	4,889,300			3.0	1,450,700			3.1	6,340,000	3.0
	1993	5,027,600			2.8	1,489,900			2.7	6,517,500	2.8
	1994	5,159,900			2.6	1,527,100			2.5	6,687,000	2.6
	1995	5,285,300			2.4	1,562,200			2.3	6,847,500	2.4
	1996	5,397,800			2.1	1,593,500			2.0	6,991,300	2.1
	1997	5,496,500			1.8	1,620,600			1.7	7,117,100	1.8
	1998	5,579,000			1.5	1,644,900			1.5	7,223,900	1.5
	1999	5,649,300			1.3	1,661,300			1.0	7,310,600	1.2
	2000	5,701,800			0.9	1,674,600			0.8	7,376,400	0.9

The addition of apartment/condominium units in the Apartment Precincts of the Waikiki Special Design District will not necessarily mean use by transient visitors. If true beach resorts are allowed to be developed on Oahu away from Waikiki, the more discriminating visitor, which is the trend of the future, will opt for these facilities instead of apartments/condominiums located in the areas away from Kalakaua Avenue and the beach. These facilities will instead be utilized as primary housing by Oahu's residents as the lack of housing becomes more acute.

In order to plan for the future of Oahu's transient visitors the market's needs must be projected. TABLE I illustrates a visitor projection for the State of Hawaii to the year 2000. This projection is in accord with the growth criterion used by the State Tourism Plan, Department of Planning and Economic Development. This is based on growth rates of approximately five percent (5%) between 1982 - 1985, four percent (4%) from 1986 - 1990, two and one-half percent (2.5%) between 1991 and 1995 and one percent (1%) between 1996 - 2000.

In order to compute demand for transient accommodations, demand variables must be analyzed and applied to the projected State visitors. TABLE II illustrates these historic variables from 1970 to 1982 and a projection to the year 2000. In accordance with the trend of a smaller percentage of State visitors staying on Oahu, we have projected this decrease to continue, providing a greater share of total visitors to the Neighbor Islands.

The percentage of Oahu visitors staying in transient accommodations peaked in 1976 at 95 percent and has decreased since that time. It is our judgement that this trend will reverse itself (as is already evident in 1981 and 1982) whereby a greater percentage will stay in hotels and condominiums as alternative types of accommodations become less available (partially as a result of a growing shortage of primary housing for Oahu's residents), as "Waikiki 2000" enhances the desire to stay in existing Waikiki facilities and as other beach resort accommodations become available.

The average length of stay of visitors has also decreased reflecting the shift to a greater percentage of FIT (free independent travelers) visitors and fewer tour/group visitors. This trend is projected to stabilize at 4.75 nights.

TABLE II

HOTEL DEMAND VARIABLES
ISLAND OF OAHU

	Percent To Oahu	Percent Using Hotels	Average Length of Stay	Double Occupancy Factor
1970	N/A	87.2	5.13	N/A
1971	N/A	87.9	5.08	N/A
1972	96.4	91.2	5.10	1.92
1973	94.0	91.4	5.16	1.93
1974	92.3	93.3	4.97	1.92
1975	90.7	93.2	5.02	1.93
1976	89.7	95.1	5.07	1.95
1977	86.9	92.5	4.85	1.97
1978	85.2	91.3	4.84	1.97
1979	82.7	89.9	4.81	1.96
1980	80.1	89.4	4.89	1.94
1981	78.4	90.6	4.86	1.94
1982	80.7	91.2	4.76	1.96
1983	80.5	91.7	4.75	1.95
1984	80.3	92.2	4.75	1.95
1985	80.1	92.7	4.75	1.95
1986	79.9	93.2	4.75	1.95
1987	79.7	93.7	4.75	1.95
1988	79.5	94.0	4.75	1.95
1989	79.3	94.0	4.75	1.95
1990	79.1	94.0	4.75	1.95
1991	78.9	94.0	4.75	1.95
1992	78.7	94.0	4.75	1.95
1993	78.5	94.0	4.75	1.95
1994	78.3	94.0	4.75	1.95
1995	78.1	94.0	4.75	1.95
1996	77.9	94.0	4.75	1.95
1997	77.7	94.0	4.75	1.95
1998	77.5	94.0	4.75	1.95
1999	77.3	94.0	4.75	1.95
2000	77.1	94.0	4.75	1.95

The double occupancy factor (the average number of persons staying in a hotel room) increased from 1.92 in 1972 to 1.96 in 1982. This variable is expected to stabilize at 1.95 persons per occupied room.

TABLE III is presented to illustrate the computational use of these variables in projecting the annual demand for transient accommodations.

TABLE IV shows the existing and anticipated supply of rooms on Oahu. The HVB (Hawaii Visitors Bureau) provides this data three times annually and these numbers are current as of May, 1983. Presented below are the specific future projects:

Project	Planned Units	Date Fully Operational
Halekulani	456	January 1984
*The Hobron (596)	417	July 1984
*The Waikiki Beach Tower (140)	98	July 1984
*The Mandarin Tower (580)	406	January 1985
Aloha Tower Plaza Hotel	500	January 1987

*These properties are condominium developments designed to be used for transient visitor usage. Figures in parentheses are total units available, where the planned units is an estimate of the number to be used for transient use.

TABLE V shows a comparison between the projected demand and supply of rooms to the year 2000. This approach to planning Oahu's tourism industry future directly analyzes all of the necessary visitor market variables. As TABLE V indicates Pannell Kerr Forster projects the need for approximately 5,400 additional transient rooms in 1990, 10,700 by 1995 and 13,500 by 2000.

As previously mentioned the Waikiki Special Design District and the Primary Urban Center Development Plan limit the number of visitor units in Waikiki to a maximum of 30,000 and discourage growth over this number. Secondly, the City Administration's resort policy states that preference in locating new hotels will be in the Primary Urban Center outside Waikiki. It is doubtful that the locational attributes of these areas (Kapiolani, downtown and the airport industrial area) can provide sufficient marketing impetus to the required developers, financial institutions and management companies in order to build such facilities directed toward the pleasure traveler.

TABLE III

PROJECTED ROOM NIGHTS REQUIRED
ISLAND OF OAHU
1983 - 2000

Year	Projected State Visitors	Percent to Oahu	Oahu Visitors	Percent Utilizing Hotels	Visitors Utilizing Hotels	Average Length of Stay	Annual Visitor Nights	Double Occupancy Factor	Annual Hotel Room Nights
1983	4,412,600	80.5	3,552,100	91.7	3,257,300	4.75	15,472,200	1.95	7,934,500
1984	4,633,200	80.3	3,720,500	92.2	3,430,300	4.75	16,293,800	1.95	8,355,800
1985	4,855,600	80.1	3,889,300	92.7	3,605,400	4.75	17,125,700	1.95	8,782,400
1986	5,079,000	79.9	4,058,100	93.2	3,782,200	4.75	17,965,300	1.95	9,213,000
1987	5,302,500	79.7	4,226,100	93.7	3,959,800	4.75	18,809,300	1.95	9,645,800
1988	5,525,200	79.5	4,392,500	94.0	4,129,000	4.75	19,612,700	1.95	10,057,800
1989	5,746,200	79.3	4,556,700	94.0	4,283,300	4.75	20,345,800	1.95	10,433,700
1990	5,964,500	79.1	4,717,900	94.0	4,434,800	4.75	21,065,500	1.95	10,802,800
1991	6,155,400	78.9	4,856,600	94.0	4,562,200	4.75	21,684,800	1.95	11,120,400
1992	6,340,000	78.7	4,989,600	94.0	4,690,200	4.75	22,278,500	1.95	11,424,900
1993	6,517,500	78.5	5,116,200	94.0	4,809,300	4.75	22,844,000	1.95	11,714,900
1994	6,687,000	78.3	5,235,900	94.0	4,921,800	4.75	23,378,400	1.95	11,988,900
1995	6,847,500	78.1	5,347,900	94.0	5,027,000	4.75	23,878,400	1.95	12,245,300
1996	6,991,300	77.9	5,446,200	94.0	5,119,400	4.75	24,317,400	1.95	12,470,500
1997	7,117,100	77.7	5,530,000	94.0	5,198,200	4.75	24,691,400	1.95	12,662,300
1998	7,223,900	77.5	5,598,500	94.0	5,262,600	4.75	24,997,400	1.95	12,819,200
1999	7,310,600	77.3	5,651,100	94.0	5,312,000	4.75	25,232,100	1.95	12,939,500
2000	7,376,400	77.1	5,687,200	94.0	5,346,000	4.75	25,393,400	1.95	13,022,300

Based on these locational exclusions, the remaining areas to be considered are outside the Primary Urban Center. The City and County of Honolulu administration has designated a total of 2,000 additional units to be built in Makaha (300), Laie (200) and Kuilima (1,500)* in the appropriate Development Plans for each area. The following table illustrates that if these units are developed, additional demand will remain to be satisfied. West Beach is well suited to service that demand.

Year	Additional Required Rooms	Development Plan Designations*	Remaining Unsatisfied Demand
1988	2,700	2,000	700
1990	5,400	2,000	3,400
1995	10,700	2,000	8,700
2000	13,500	2,000	11,500

*Kuilima, Laie and Makaha additions allowed by the appropriate Development Plans.

Presented below is a tabulation showing the remaining unsatisfied demand and the potential phasing of resort units at West Beach:

Year	Remaining Unsatisfied Demand	Planned West Beach Phasing
1988	700	800
1989	2,100	800
1990	3,400	800
1991	4,600	800
1992	5,700	800
		4,000

Current planning for West Beach envisions the first resort property being operational in January 1988. If development of all 4,000 resort units allowed under the Development Plan is accomplished within a five-year time frame, the projection provides for adequate demand by transient visitors. It is important to note that adequate demand would still be provided even if the demand projection is overly optimistic by 30 percent. Further, the computations presented assume that Makaha, Kuilima and Laie would absorb required demand before accruing to West Beach. This is a very generous and perhaps unrealistic assumption. If none of the allowable development occurs at Makaha, Kuilima and Laie the projection could be in error by as much as 48 percent and still provide adequate demand to West Beach based on the assumed phasing.

TABLE IV

INVENTORY OF EXISTING AND PLANNED TRANSIENT ACCOMMODATIONS
ISLAND OF OAHU

	Existing, May 1983			Anticipated Additional Units (Scheduled Completion Date)			(Existing and Anticipated Units)		
	Competitive	Noncompetitive	Total	1984	1985	1987	Competitive	Noncompetitive	Total
Waikiki	29,373	733	30,106	714	664		30,751	733	31,484
Ala Moana	1,544	121	1,665				1,544	121	1,665
Honolulu	-	61	61			500	500	61	561
Airport	579	118	697				579	118	697
Leeward Oahu	196	1,118	1,314				196	1,118	1,314
Windward Oahu	487	280	767				487	280	767
Total	32,179	2,431	34,610	714	664	500	34,057	2,431	36,488

THE CHANGING VISITOR PROFILE

Through the primary growth years of Hawaii's tourism, the 1960s and early 1970s, the mass marketed tours were the driving force. Due, however, to changing national and international economies and the deregulation of air transportation, those tour movements have been reduced to a relatively minor marketing force, as seen in the following illustration. Tours have been supplanted by the more affluent and quality free independent travelers (FIT) and incentive movements. In 1982, these two categories accounted for nearly 80 percent of the total market.

Year	Tours	FIT	Incentives
1976	46.2%	53.3%	.4%
1977	42.1	57.5	.4
1978	37.1	59.8	2.6
1979	29.5	66.3	3.7
1980	23.9	72.0	3.7
1981	22.7	73.3	3.5
1982	19.7	75.5	4.4

Source: Hawaii Visitors Bureau

In order to satisfy these more discriminating activity oriented visitors, adequate amenities must be provided in and adjacent to the transient facilities (hotel and condominiums). These should include golf, tennis, boating and fishing.

GENERAL REQUIREMENTS FOR A SUCCESSFUL RESORT

We define a destination area as "a place having characteristics known to a sufficient number of potential visitors to justify it as an entity, independently attracting and motivating travel itself". Within a destination area are resort regions, and it is within one of these regions that a visitor expects to find suitable vacation entertainment to fulfill his desires at a resort complex such as West Beach. Eventually, some resort regions can themselves become destination areas. In the case of Hawaii, Oahu and Waikiki can be referred to as destination areas, while Kaanapali and Kihei-Wailea on Maui, Kona-Keauhou and South Kohala in Hawaii, and Poipu and Wailua on Kauai can be considered

TABLE V

COMPARISON OF ROOM DEMAND WITH EFFECTIVE SUPPLY
ISLAND OF OAHU

Year	75% Occupancy				80% Occupancy			
	Demand	Effective Supply	Cumulative Additional Required	Annual Additional Required	Demand	Effective Supply	Cumulative Additional Required	Annual Additional Required
1983	28,984	32,179	-	-	27,173	32,179	-	-
1984	30,523	32,893	-	-	28,616	32,893	-	-
1985	32,081	33,557	-	-	30,077	33,557	-	-
1986	33,655	34,057	-	-	31,551	34,057	-	-
1987	35,236	34,057	1,179	1,179	33,033	34,057	-	-
1988	36,740	34,057	2,683	1,504	34,445	34,057	338	388
1989	38,114	34,057	4,057	1,373	35,732	34,057	1,675	1,287
1990	39,462	34,057	5,405	1,348	36,996	34,057	2,939	1,264
1991	40,622	34,057	6,565	1,160	38,084	34,057	4,027	1,088
1992	41,735	34,057	7,678	1,113	39,126	34,057	5,069	1,042
1993	42,794	34,057	8,737	1,059	40,120	34,057	6,063	994
1994	43,795	34,057	9,738	1,001	41,058	34,057	7,001	938
1995	44,732	34,057	10,675	937	41,936	34,057	7,879	878
1996	45,554	34,057	11,497	822	42,707	34,057	8,650	771
1997	46,255	34,057	12,198	701	43,364	34,057	9,307	657
1998	46,828	34,057	12,771	573	43,901	34,057	9,844	537
1999	47,268	34,057	13,211	440	44,313	34,057	10,256	412
2000	47,570	34,057	13,513	302	44,597	34,057	10,540	284

as existing or potential resort regions. For the purpose of evaluating West Beach, set forth in the following paragraphs are the generally accepted bases upon which resort complexes are usually accepted.

A resort region is defined as a scenic or recreational environment developed to contain a full range of requisites to the enjoyment of leisure vis-a-vis vacation. The major considerations which support the designation, "resort region", are as follows:

- The project should have a reputation of being a "fun" or pleasure place providing a variety of recreational activities in a setting at least equal to resorts catering to similar markets.
- The location should provide a change of pace in scenic views and/or climate and be easily accessible. The project will have greater advantage if air service and ground transportation are readily available.
- The design of accommodation facilities must be uniquely different, taking on the specific character of and blending well with the local environment and developing the theme of relaxed living.
- The quality and design of exteriors, interiors, furnishings, fixtures and equipment must give the resort an exciting, unusual character of the type which can be sustained through the years.
- Management must be of top caliber, well qualified to direct successfully all phases of development, to supervise food and beverage operations, to plan promotions and to maintain liaison with community, state and national representatives.
- The resort itself when fully developed must almost be self-contained, ranging from facilities required to supporting forces, e.g. labor, to keep functioning.

For a resort complex such as West Beach to be a successful part of a resort region and to fulfill the foregoing requirements, it should embody the following:

- Scenic vistas
- A unique interest generating theme.
- A maximization of inter-relationship between natural and man-made attractions.
- Parks and greenbelt areas.
- Leisurely paced and varied lodging facilities

- Varied restaurants and cocktail lounges.
- Organized and unorganized sporting, recreational and cultural activities such as golf, swimming, tennis, fishing (both surf and deep sea), snorkeling, hiking, nature walks, hunting, surfing, crafts, hobbies, horseback riding, badminton, volleyball, archery and skeet and trap shooting.

The proposed resort development as planned at West Beach embodies these qualities and attributes.

THE ADVANTAGES OF A RESORT COMPLEX AT WEST BEACH

On the basis of our analysis of the visitor market of Oahu and the planned resort development at West Beach, it is our opinion that West Beach is well-suited to the development of a resort complex as envisaged by West Beach Estates for the following reasons:

- West Beach can provide the long-term job formation needs of Oahu which depend largely on the growth of tourism.

The 1970s have witnessed declines in the job-generating prospects of two major private sector industries other than tourism, sugar and pineapple. A number of other industries have attempted to grow and some of these have been successful while some have not. Those that were successful, however, provide little hope for major new job formation. Clearly, the future for new job formation on Oahu lies with tourism. If Oahu's economy is to continue to provide jobs for its present residents and their children, then tourism must play a major role in providing jobs.

Between 1970 and 1980 total employment in Hawaii grew by nearly 34 percent. By comparison pineapple and sugar industry employment was reduced by 24 percent and hotel employment rose 74.0 percent. In 1970 one out of every five jobs in the State were attributed to the tourism industry. By 1980 this ratio has grown to one in three jobs attributed to tourism. Presented on the following page is a tabulation showing the relative employment growth by industries:

Industry	Average Annual Employment 1970	1980	Percent Increase
Total (including governemnt)	250,751	335,538	33.8
Total government	64,494	75,516	17.1
Total (excluding government)	186,257	260,022	39.6
Agriculture	3,309	3,797	14.8
Sugar and pineapple	2,266	1,730	(23.7)
Other	1,043	2,067	98.2
Mining and contract construction	22,741	19,517	(14.2)
Manufacturing	18,597	17,521	(5.8)
Transportation	12,614	18,204	44.3
Communications	5,911	5,605	(5.2)
Utilities	1,874	1,862	(0.6)
Wholesale trade	14,287	16,423	15.0
Retail trade	45,101	71,342	58.2
Finance, Real Estate, Insurance	15,880	26,973	69.9
Services	45,906	78,686	71.4
Hotels	9,292	16,136	73.7
Nonclassified	5,867	92	(98.4)

In 1980 leeward Oahu's unemployment was 7.5% compared to 4.5% for the island of Oahu. July 1983 data for the island of Oahu is available and computes to 6.3%. Data is not available for the current period for leeward Oahu. If, however, the same relationship of Oahu to the leeward area in 1980 were applied to the current period, leeward Oahu would have an unemployment rate of 10.5%.

- The location of West Beach is in Oahu's Ewa area where population growth is accelerating.

Government and private studies have recognized the western shift in Oahu's population center and government has planned for this by undertaking highway improvements in the Ewa area, siting major public facilities such as Aloha Stadium Ewa of downtown, planning infrastructure improvements for the area, etc. Yet, employment centers (other than Campbell Industrial Park) continue to be Diamond Head of Pearl Harbor.

The Waianae Coast and Leeward area houses a large population of families that could derive their income from resort employment at West Beach. On the following page is listed the population growth of Leeward area communities:

Urban Area	Resident Population 1970	1980	Percent Increase
Ewa	2,906	2,637	(9.3)
Ewa Beach	7,765	14,369	85.1
Maili	4,397	5,026	14.3
Makaha	4,644	6,582	41.7
Makakilo City	3,499	7,691	119.8
Mililani Town	2,035	21,365	949.9
Nanakuli	6,506	8,185	25.8
Pearl City	27,398	42,575	55.4
Wahiawa	17,598	16,911	(3.9)
Waialua	4,047	4,051	0.1
Waianae	3,302	7,941	140.5
Waipahu	24,150	29,139	20.7
Area Totals	108,247	166,472	53.8
Oahu	630,497	762,534	20.9
State	706,177	872,381	23.5

The planned residential communities of the Campbell Estate lands would also serve to reinforce these employment needs.

- Public access and enjoyment of the shoreline heightened.

At the present time, the coastline of West Beach is a rocky area with little beach area suitable for sun seekers, swimmers or beachcombers. Limited access is via rocky cane field roads. It is our contention that the quality of the shoreline and its access can only be improved by a resort development featuring an increasing number of water related activities. By so doing the local and visitor population can derive far greater benefit from this natural resource.

- Reduction of employee commute time and traffic volume.

In today's mobile society, the automobile has affected the lives of all of us. Traffic on Oahu is an island-wide problem and affects all Oahu residents, more so in the case of residents living in suburban communities who must commute daily to work in Downtown and Waikiki.

A job center in the form of a resort complex at West Beach would serve to reduce traffic congestion by providing employment opportunities close to an available work force. In addition to reducing commute time for employees living in the area, peak traffic to and from Downtown would be reduced in several ways. First, traffic volume inbound (to Downtown) from the leeward communities would be reduced since some of these commuters would be employed by the resort complex and would no longer need to commute into the city. Second, commuters who live east of West Beach in such communities as Waipahu, Pearl City and Aiea may be employed by the resort and would therefore travel in nonpeak directions during rush hours. And third, future residents of West Beach itself who work at the resort will no longer be required to commute daily to Downtown thereby easing peak volume.

It has not been demonstrated that traffic from hotel users would add significantly to congestion. Instead, the likelihood is that such traffic would tend to occur throughout the day in both inbound and outbound directions. In fact, the visitor would be encouraged to avoid travel in peak directions so that the time available for doing other things is maximized. The likely use of some form of mass transit such as charter buses for tour groups, shuttle and group limousine service would also tend to lessen the traffic impact.

- <u>Enhancement of the cost-benefit ratio</u>.

The tourism industry's economic benefits to the State are substantial. However, these benefits are reduced as Hawaii's labor force is absorbed into the visitor industry since labor shortages due to the growing influx of visitors will have to be met by immigrants. These immigrants will require substantial public outlays for housing infrastructure and maintenance, fire and police protection, education of their children and a host of other support requirements. In essence, the cost-benefit ratio for visitors falls sharply as the proportion of immigrants in the labor force needed to serve the additional visitors grows.

Therefore, as additional resort facilities are developed in the less populated areas of Oahu, the cost-benefit ratio accruing from the added visitor expenditures will drop. Public outlays will be required to support the immigrant population required to operate the resorts. If, however, resorts are allowed to be developed in areas where support facilities are already existing or planned, such as at West Beach, the cost-benefit ratio from additional visitor expenditure should not experience any dramatic change inasmuch as public funds would not be required for housing and various other support facilities.

- Excellent Access to and from Honolulu International Airport.

West Beach is within twenty miles driving distance from Honolulu International Airport via a divided four and six lane interstate freeway (H-1). In contrast the resort developments at Makaha and Kahuku are 28 and 34 miles respectively from the airport, partially via single lane highways.

- Existence of an Excellent Climate

A dry, warm climate sought by visitors exists in the West Beach area. The average annual rainfall has been recorded at 20.31 inches and the average coolest and warmest monthly temperatures are 72.1 and 79.7 degrees. West Beach is oriented on Oahu the same as the very successful Kaanapali resort area is on Maui and, therefore, enjoys the same excellent weather without the wind factor.

- A Superior Water Quality.

Environmental studies of the area have shown that not only is the quality and character of the waters off West Beach excellent (calm, clear and clean), but the quantity and variety of sealife is particularly abundant. Additionally, tide pools are found at selected points along the shore, exhibiting the area's indigent sealife.

- Inherent Superior Qualities of a Master Planned Development

The land uses for a planned resort community include hotels, a mixture of housing densities, a community core with commercial activities and recreational amenities. These developments embody the desired characteristic of centralized planning which results in the following:

- Control of land use.
- Restraint in structural placement and design.
- Enhancement of environmental qualities.
- Preservation of scenic and historic sites.
- Avoidance of visual dominance.
- Complimentary circulation of pedestrians and vehicles.
- Coordinated marketing strategy for all segments of the complex.

West Beach as a Planned Resort Community would take advantage of these qualities enhancing the degree of success.

THE PROPOSED WEST BEACH COMMUNITY

The primary objective of the West Beach development is to create a quality community that affords a complimentary environmental and social balance between the tourist visitor and the permanent resident. By amplifying the existing amenities for the site and creating new recreational facilities that serve both resident and tourist, an intermingling occurs that is beneficial to the total community. The quality of that life style is dependent on the environment that is designed for the total project and especially that character and quality that is projected in the development of the first acquisition. Residential and quality hotel facilities and the championship golf course of the first development phase, should set the tone of quality for the entire resort.

The overall development concept is a combination of a resort destination - a defined complex providing a diversity of resort related uses and activities - and a mixed residential community which are the beginnings of a larger mixed use core for the secondary urban center. The project consists of 642.2 acres and 9,200 units. The uses represent the uses shown on the Ewa Development Plan of the City and County of Honolulu.

The general use pattern consists of 1) the resort activities occupying a large portion along the oceanfront, and 2) the residential areas also located along a small portion of the oceanfront areas, as well as on the golf course and in proximity to the marina. The fairways of the golf course help to separate these two major activities as well as provide open space relief throughout the development.

Summarized below are the specific uses, acreages, and units contemplated at West Beach.

Land Use	Acres	Units
Low Density Apartment	108.0	1,500
Medium Density Apartment	78.9	3,700
Resort	86.5	4,000
Commercial	17.8	
Beach Club	2.2	
Hawaiian Cultural Center	21.8	
Marina	36.3	
Lagoons	13.1	
Golf Course	170.5	
Park	51.4	
School	6.9	
Transit Stations	2.7	
Circulation	46.1	
Total	642.2	9,200

In order to plan the development of West Beach, more specific assumptions on facilities have been made. Due to shifts in market preferences, final development may differ from those presented. The Ewa Department Plan allows a total of 4,000 resort units at West Beach that can be used by transient visitors. For purposes of planning and estimating employment we have assumed that 2,000 of these resort units will be hotels and 2,000 will be full service resort condominiums.

THE CREATION OF EMPLOYMENT OPPORTUNITIES

The development of transient accommodations not only satisfies the visitor market requirements, but also creates employment opportunities for the residents of Oahu. As currently planned, the West Beach resort should create approximately 5,100 direct jobs and 1,000 indirect jobs for a total employment impact of approximately 6,100 jobs. Presented on the following page is a tabulation showing the detailed computation of this employment base.

Employment Computation
West Beach Resort

Entity	Basis (Jobs Per Unit)	Employment
*Deluxe Hotel (400 rooms)	1.5/room	600
[1]First Class Hotels (1,600 rooms)	.7 room	1,120
*Resort Condominiums (2,000 units)	.5/unit	1,000
[1]Residential Condominiums (5,200 units)	.05/unit	260
[1]Commercial Retail (185,000 square feet)	.005/sq. ft.	925
[2]Commercial restaurants (35,000 sq. ft./ 7 restaurants)	40/restaurant	280
Elementary school	*	50
Hawaiian Cultural Center	*	125
Luau	*	175
Golf Complex and Club	*	125
Beach Complex and Club	*	150
Yacht Club	*	50
Marina	*	200
Complex Tram System	*	20
West Beach Maintenance/Security	*	30
West Beach Management/Administration	*	20
Total Direct Jobs		5,130
Total Indirect Jobs (.2 x Direct Jobs)[1]		1,026
Total Job Creation		6,156

[1]Based on the Department of General Planning, City and County of Honolulu report "Employment and Population Impacts of Resort Development at Five Oahu Sites", March 1978.

[2]Based on National Restaurant Association annual survey.

*Based on investigations and estimates of Pannell Kerr Forster.

In addition to these jobs relating to the operation of West Beach, a large number of jobs will be created from the construction of the infrastructure, superstructure and amenities.

ECONOMIC IMPACT

In addition to the creation of employment opportunities, the development of the West Beach resort will generate substantial revenues for the State of Hawaii. It has been estimated that a total of $24.5 million would be generated annually in current 1983 dollars assuming that the entire complex is complete and operating at a stabilized level. These revenues would accrue from the following sources:

State Unemployment Tax	$ 850,000
Gross Income Tax	8,030,000
State Personal Income Tax	4,779,000
Real Property Tax	10,695,000
	$24,354,000

Methodologies employed to develop these estimates are set forth in the following paragraphs.

State unemployment taxes were estimated based on one percent of the first $13,800 of salaries and wages of each of the 6,156 new employees. The one percent rate was derived from State of Hawaii Tax Department records as the average currently paid by all tax payers (wage earners).

Gross income taxes were based on 4.0 percent of total estimated revenues generated from all sources at West Beach.

Revenue estimates are as follows:

Deluxe Hotel	$ 29,200,000
First Class Hotel	50,967,000
Resort Condominiums	41,714,000
Commercial Retail	55,038,000
Commercial Restaurants	7,088,000
Hawaiian Cultural Center	250,000
Beach Luau	2,340,000
Golf Complex and Club	2,600,000
Beach Complex and Club	2,600,000
Yacht Club	400,000
Marina Complex	8,550,000
	$200,747,000

State personal income taxes were estimated based on taxable income per employee of $11,587 x an average tax rate of 6.7 percent x the 6,157 employees. State tax office records were the source of estimated data.

Real property taxes were based on currently applied tax rates per thousand dollars of assessed valuation as follows:

Land Valuations

	Assessed Value				Tax Rate		Tax
Residential	$ 520,000,000	÷	1,000	x	$7.05	=	$3,666,000
Nonresidential	538,835,000	÷	1,000	x	$9.00	=	4,849,515
	$1,058,835,000						$8,515,515

Building Valuations

	Assessed Value				Tax Rate		Tax
Residential	$143,623,800	÷	1,000	x	$7.05	=	$1,012,547
Nonresidential	129,650,000	÷	1,000	x	$9,00	=	1,166,850
	$273,273,800						$2,179,397

APPENDIX I SECTION 2

DARBY-EBISU & ASSOCIATES, INC.

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(808) 261-3727

DEA Job #8-1102

May 4, 1984

Environmental Communications, Inc.
1146 Fort Street Mall, Suite 200
Honolulu, Hawaii 96813

Attention: Mr. Fred Rodriguez

Subject: Acoustic Evaluation of AICUZ Plan, NAS, Barbers Point, 1984, And Evaluation of HIA Aircraft Noise Impact; Revised Land Use Plans, Proposed West Beach Resort.

Dear Mr. Rodriguez:

The following report describes our most recent evaluation of potential aircraft noise impacts on the proposed West Beach Resort. As you know, our first evaluation of August 1979 (Reference 1) was done without the benefit of the latest aircraft noise studies relating to Honolulu International Airport (HIA) or Naval Air Station, Barbers Point (NAS, BP). In our August 1979 study (Reference 1), we estimated Year 1979 aircraft noise levels in the proposed West Beach Resort area as between 50 L_{dn} to 55 L_{dn}.

Following distribution of the 1982 Noise Study for NAS, Barbers Point (Reference 2), and completion of the HIA Master Plan and Environs Study, we re-evaluated the potential noise impacts on West Beach via letter report of June 13, 1983 (Reference 3). In our 1983 assessment, no significant changes from our prior assessments were made, and a final conclusion was deferred until an update to Reference 2 was distributed. The most recent update to Reference 2 is incorporated in Reference 4. My current evaluations are based upon the information contained in Reference 4.

A. GENERAL FINDINGS

1. The new NAS, BP AICUZ (Reference 4) has incorporated the following significant changes (relative to the old 1976 AICUZ, NAS, BP) which tend to modify the aircraft noise exposure over the proposed West Beach Resort:

a. All aircraft departing from RWY 29 in the left hand turn pattern are now assumed to fly over the Deep Draft Harbor, whereas the old AICUZ assumed a sharper left hand turn commencing approximately 10,000 FT southeast of the harbor.

b. The number of rotary wing aircraft overflights of West Beach has decreased from 6.1 to an average of 1.0 per day.

c. The number of fixed wing aircraft overflights of West Beach has increased from zero to an average of 7 per day.

d. The number of nighttime (between 10:00 PM to 7:00 AM) aircraft overflights has increased from zero to approximately 0.4 per day.

2. The increase in NAS, BP aircraft noise toward West Beach relative to the 1976 AICUZ contours is evident by the enlargement of the current 65 L_{dn} contour (AICUZ Noise Exposure Zone 2 Contours) approximately 4,000 FT northwest of Kalaeloa Boulevard.

3. Based upon the results of the HIA Master Plan noise study, 1979 noise levels from aircraft arrivals to HIA RWY 08L should have been less than 55 L_{dn}.

4. Under worst case conditions with all HIA RWY 08L arrivals overflying the proposed West Beach Resort (i.e., no curved approaches to HIA RWY 08L), Year 2000 noise exposure from HIA arrivals are predicted to be less than 57 L_{dn}.

5. The prior (see Reference 3) operational assumptions used in developing the 1982 NAS, BP frequency of tradewind vs. Kona operations on RWYS 11/29 have been corrected in the new AICUZ. This correction reduces noise from Kona departures over West Beach. However, the addition of nighttime overflights over West Beach has nullified the noise benefits of the change, and the 1984 AICUZ produces noise contours equal to the 1982 noise study in the West Beach area.

6. There is near zero risk that the 65 L_{dn} aircraft noise contour will enter the proposed West Beach area by the Year 2000, if the operational assumptions of the 1984 AICUZ are maintained.

7. There is a slight risk that the 60 L_{dn} contour may exist over the proposed marina and adjacent park areas of the resort. Reduction of nighttime overflights of West Beach would reduce this risk to near zero.

8. A major concern expressed in our August, 1979 assessment regarding helicopter overflights has been alleviated by the reduction of these helicopter flybys over the proposed resort.

B. HIA AIRCRAFT NOISE PREDICTIONS

1. FIGURE 1 presents calculated 55 L_{dn} contours resulting from noise attributable to aircraft arrivals on HIA RWY 08L for the Years 1979 and 2000. The operational assumptions used for 1979 operations are shown in TABLE 1, with the corresponding Year 2000 operational assumptions also shown in TABLE 1. Since all RWY 08L arrivals are assumed to overfly the proposed West Beach Resort in the Year 2000, a worst case noise increase of approximately 2 L_{dn} units is anticipated from HIA operations. By the Year 2000, HIA aircraft noise over the proposed West Beach Resort is predicted to increase by 2 L_{dn} units over Year 1979 values.

2. Also shown in TABLE 1 are the HIA overflights assumed in the 1984 AICUZ. The 1984 AICUZ used fewer HIA overflights than the Year 2000 assumptions used in this study.

C. NAS, BARBERS POINT AIRCRAFT OVERFLIGHTS

TABLE 2 shows the chronology of changes in the number and type of NAS, BP aircraft overflights over West Beach. The 1976 values were used in our 1979 noise assessment. The July 1982 values were used in our 1983 noise assessment, and the 1984 AICUZ values were used in our current assessment.

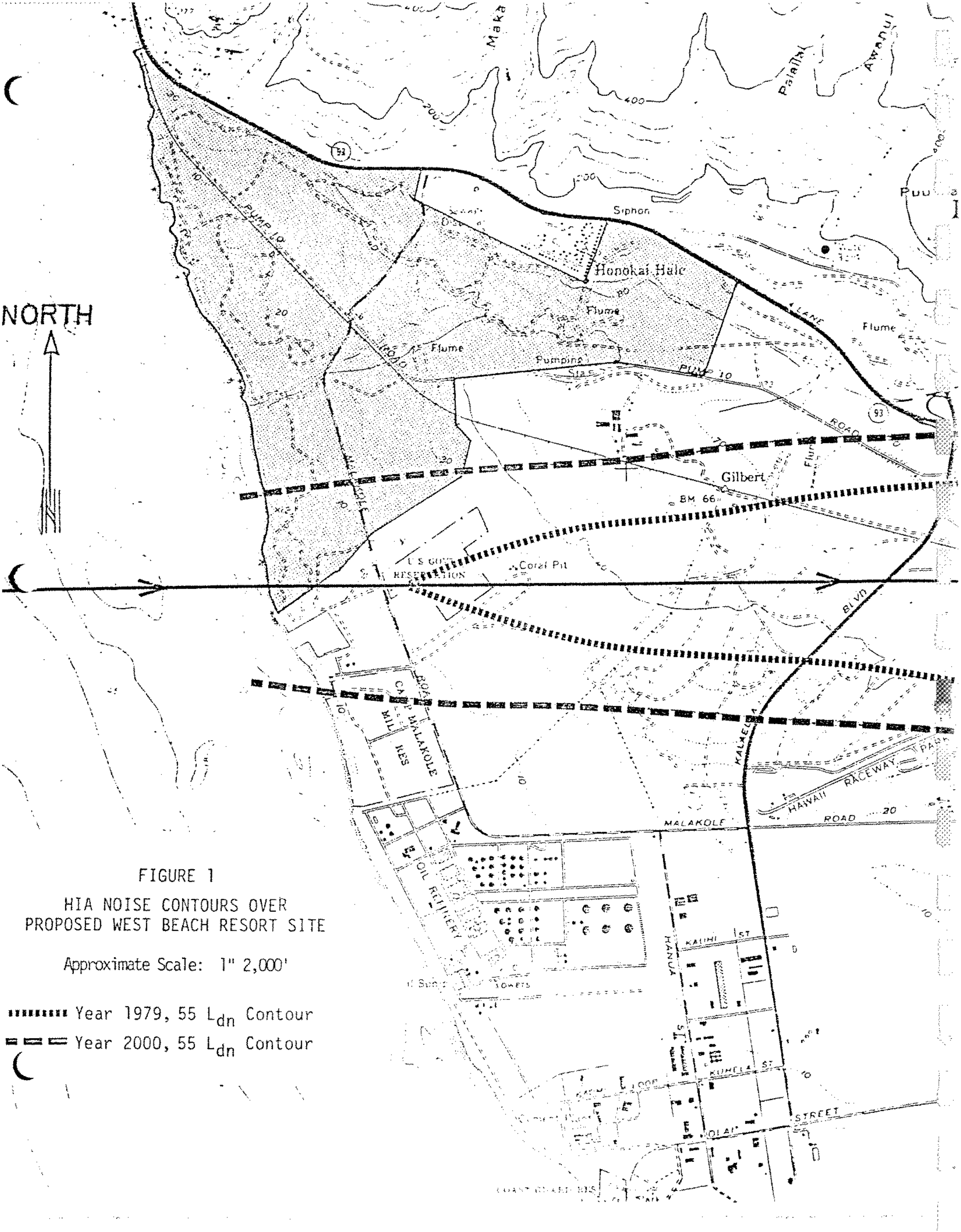


FIGURE 1

HIA NOISE CONTOURS OVER PROPOSED WEST BEACH RESORT SITE

Approximate Scale: 1" 2,000'

Year 1979, 55 L_{dn} Contour

Year 2000, 55 L_{dn} Contour

TABLE 1

HIA ARRIVAL OPERATIONS ON RWY 08L
WHICH OVERFLY WEST BEACH RESORT

Aircraft Type	Year 1979 Average Daily Arrivals Day/Night[1]	Year 2000 Average Daily Arrivals Day/Night[1]	1984 AICUZ (Track #39)
B-747	8.5/1.9	58.7/0	34.40/1.4
DC-10	6.2/0	29.9/0	3.07/0.13
B-707/DC-8	2.8/0	None	None
B-757	None	148.2/0	None
B-737	15.0/0	None	None
DC-9	15.0/0	None	None
F-4	5.4/0	10.8/0	10.0/0
C-141	6.2/0.9	12.3/0	12.3/0
KC-135	0/0	0.9/0	0.9/0
C-130	5.4/0	10.3/0	10.3/0
TOTALS	64.5/2.8	271.1/0	70.97/1.53

[1] Source: HIA Master Plan and Environs Study.

TABLE 2

SUMMARY OF NAS, BARBERS POINT AIRCRAFT OVERFLIGHTS
ASSUMED OVER WEST BEACH RESORT

Aircraft Type	1976 AICUZ (Day/Night)	July 1982 Noise Study (Ref.2) (Day/Night)	1984 AICUZ (Day/Night)
P-3	---	1.064/0	1.769/0.197
C-130	---	0.644/0	1.049/0.117
C-135	---	0.120/0	0.080/0
C-118	---	0.150/0	0.027/0.003
C-141	---	---	0.018/0.002
C-9	---	---	0.022/0.002
A-4	---	0.126/0	0.895/0
F-4	---	---	0.202/0
T-33	---	---	0.089/0
S-3	---	---	0.063/0
H-52/53	3.6/0	0.227/0	0.311/0
H-2/3	0.1/0	5.030/0	0.185/0.021
CH-46/47	0.3/0	3.708/0	0.417/0
H-1/58	2.1/0	---	0.139/0
CIVIL	---	1.141/0	1.370/0
U-11	---	---	0.062/0
O-2	---	---	0.042/0
C-12	---	---	0.014/0
C-7	---	---	0.076/0
Misc.	---	---	0.240/0
TOTALS:	6.1/0	11.57/0	7.070/0.402*

*Since nighttime overflights are multiplied by 10 in the L_{dn} descriptor system, total equivalent overflights are equal to: 7.07 + 10 x 0.402 = 11.09.

TABLE 3 shows the total overflights by NAS, BP aircraft over the West Beach area on a typical tradewind day. These values were obtained from Reference 2, and were assumed to apply during the 1979 time period. TABLE 3 values for NAS, BP were used to construct the composite (HIA plus NAS, BP aircraft) 1979 noise contours over the West Beach area.

D. ADDITIONAL NOISE MEASUREMENTS

1. The 1982 NAS, BP noise study (Reference 2) also included the results of a 5-day noise measurement effort on the proposed West Beach Resort site (Station J), and these results are reproduced in Appendices D and E of the 1984 AICUZ. The measurements were obtained from December 15 to December 19, 1981, and were continuous 24-hour measurements of total (aircraft and non-aircraft) noise at the West Beach site.* Except for questionable data obtained on the 19th, the results are consistent with our August, 1979 conclusions that "aircraft noise at the project site is probably between L_{dn} 50 and L_{dn} 55" (Reference 1).

2. TABLES 4 and 5 summarize the results of the 5-day measurement period at Station J, and includes adjustment factors to convert the results to our estimate of the anually averaged L_{dn} on the project site for the 1979 and 1982 periods. These adjustment factors are necessary to smooth out the measured variations caused by high aircraft activity days (12/15 and 12/16) at NAS, BP. The data obtained on the 19th appeared to be unreliable due to its time of occurrence (2:00 to 4:00 AM), and its extremely high level. An L_{dn} of 92.9 generally does not occur on Oahu, except within a few feet of a major airport runway. For example, at 800 FT from the Reef Runway at HIA, the 1979 noise level was approximately 80 L_{dn}.

*The Station J data on Page D-3 of Reference 4 has incorrect dates shown.

TABLE 3

1979 TRADEWIND DAY OPERATIONAL ASSUMPTIONS
FOR TRACKS #19 AND #14
(NAS, BARBERS POINT)

Aircraft Type	Maximum Operations/Day* Track #19	Track #14
P-3	1.064	4.8345
C-135	0.120	0.1275
C-130	0.644	1.6735
C-118	0.150	---
Civil	1.141	0.9130
A-4	0.126	---
F-4	---	0.5115
H52/H53	0.227	0.454
H2/H3	5.030	0.9270
CH46/CH47	3.708	---

*No nighttime operations on these tracks.

TABLE 4

ANNUAL ENERGY AVERAGE OF L_{dn} DATA FROM STATION J (REFERENCE 2) ADJUSTED FOR 1979 NAS, BP OPERATIONS

Date	Station	(A) Measured 24-HR Ldn	(B) Unusual or Above Average Hourly Noise Level Measured	Probable Cause of High Hourly Noise Level	(C) Contribution of Unusual Events to 24-HR Ldn (1)	(D) 24-HR Ldn Without Unusual Events (2)	(E) Additional Ld Attributable Unusual Events Annually Avera
12/15	J	57.1	67.3	4 ea, F-4 Approaches to RWY 11.	53.5	54.6	-0-
12/16	J	63.5	76.2	2 ea, A-4 to RWY 11.	62.4	57.01	50.39 (4)
12/17	J	56.0	None	N/A	-0-	56.0	-0-
12/18	J	52.4	None	N/A	-0-	52.4	-0-
12/19	J	92.9	96.9 80.4	Unknown early morning events.	92.9 (3)	Not determinable. Data for day unreliable.	

Four-Day Energy Average (Without Unusual Events) $= 10 \text{ Log } [\frac{1}{4} (10^{\frac{54.6}{10}} + 10^{\frac{57.01}{10}} + 10^{\frac{56.0}{10}} + 10^{\frac{52.4}{10}}]$

$= 55.3 \ L_{dn}$

Four-Day Energy Average (Including Annually Averaged Unusual Events) $= 10 \text{ Log } [10^{\frac{55.3}{10}} + 10^{\frac{50.39}{10}}]$

$= 56.5 \ L_{dn}$

NOTES:

(1) $(C) = 10 \text{ Log } [\frac{1}{24} (10^{\frac{(B)}{10}})]$

(2) $(D) = 10 \text{ Log } [10^{\frac{(A)}{10}} - 10^{\frac{(C)}{10}}]$

(3) $(C) = 10 \text{ Log } [\frac{1}{24} (10^{\frac{(B_1 + 10)}{10}} + 10^{\frac{(B_2 + 10)}{10}})]$

(4) Average daily OPS on RWY 11 @ 0.126/DAY on TRACK 19 (see TABLE III, Ref. 2) for A-4 aircraft. Therefore, Annually Averaged A-4 L_{dn} contribution estimated as $62.4 - 10 \text{ Log } [\frac{2}{0.126}] = 50.39 \ L_{dn}$.

TABLE 5

ADJUSTED, ANNUAL ENERGY AVERAGE OF L_{dn} DATA FROM STATION J (REFERENCE 4)
ADJUSTED FOR 1982 NAS, BP OPERATIONS

Date	Station	(A) Measured 24-HR L_{dn}	(B) Unusual or Above Average Hourly Noise Level Measured	Probable Cause of High Hourly Noise Level	(C) Contribution of Unusual Events to 24-HR L_{dn} (1)	(D) 24-HR L_{dn} Without Unusual Events (2)	(E) Additional L_{dn} Attributable to Unusual Events When Annually Averaged
12/15	J	57.1	67.3	4 ea, F-4 Approaches to RWY 11.	53.5	54.6	38.72 (5)
12/16	J	63.5	76.2	2 ea, A-4 to RWY 11.	62.4	57.01	57.44 (4)
12/17	J	56.0	None	N/A	-0-	56.0	-0-
12/18	J	52.4	None	N/A	-0-	52.4	-0-
12/19	J	92.9	96.9 80.4	Unknown early morning events.	92.9 (3)	Not determinable. Data for day unreliable.	

Four-Day Energy Average (Without Unusual Events) $= 10 \text{ Log } [\frac{1}{4} (10^{\frac{54.6}{10}} + 10^{\frac{57.01}{10}} + 10^{\frac{56.0}{10}} + 10^{\frac{52.4}{10}}]$

$= \underline{\underline{55.3 \ L_{dn}}}$

Four-Day Energy Average (Including Annually Averaged Unusual Events) $= 10 \text{ Log } [10^{\frac{55.3}{10}} + 10^{\frac{57.44}{10}} + 10^{\frac{38.72}{10}}]$

$= \underline{\underline{59.5 \ L_{dn}}}$

NOTES:

(1) $(C) = 10 \text{ Log } [\frac{1}{24} (10^{\frac{(B)}{10}})]$

(2) $(D) = 10 \text{ Log } [10^{\frac{(A)}{10}} - 10^{\frac{(C)}{10}}]$

(3) $(C) = 10 \text{ Log } [\frac{1}{24} (10^{\frac{(B_1 + 10)}{10}} + 10^{\frac{(B_2 + 10)}{10}})]$

(4) Average daily OPS on RWY 11 @ 0.895/DAY x $\frac{260 \text{ DAYS}}{365 \text{ DAYS}}$ on TRACK 19 (see TABLE IV-4, Ref. 4) for A-4 aircraft. Therefore, Annually Averaged A-4 L_{dn} contribution estimated as $62.4 - 10 \text{ Log } [\frac{2}{0.638}] = 57.44 \ L_{dn}$.

(5) Average daily OPS on RWY 11 @ 0.187/DAY x $\frac{260 \text{ DAYS}}{365 \text{ DAYS}}$ on TRACK 19 (see TABLE IV-4, Ref. 4) for F-4 aircraft. Therefore, Annually Averaged F-4 L_{dn} contribution estimated as $53.5 - 10 \text{ Log } [\frac{4}{0.133}] = 38.72 \ L_{dn}$.

3. The results of TABLE 4 indicate that a reasonable estimate of the annually averaged L_{dn} at the measurement site for the 1979 period was 56.5 L_{dn}, when non-aircraft and aircraft sources are combined. This estimate is consistent with our August, 1979 estimate of 50 to 55 L_{dn} for aircraft sources only, since we measured the background ambient in 1979 as approximately 45 to 50 dB [$L_{eq}(h)$].

4. From the results of TABLE 5, it can be concluded that a reasonable estimate of the annually averaged L_{dn} at the measurememt site for the 1982 period was approximately 59.5 L_{dn}, when non-aircraft and aircraft sources are combined. This value is 3 dB higher than our August, 1979 estimate of 50 to 55 L_{dn} for aircraft sources. The reason for the increase in noise levels from 1979 to 1982 can be attributed to the increase in average daily overflights of A-4 aircraft as indicated in the 1984 AICUZ (See TABLE 2).

E. ESTIMATED YEAR 1979 and YEAR 2000 TOTAL AIRCRAFT NOISE CONTOURS

1. Using the operational information contained in References 2, 4, and the HIA Year 1979 and Year 2000 noise contours, total aircraft noise contours were developed over the West Beach area. Three contour sets were developed: Year 1979 tradewind day contours; Worst Case Year 2000 composite tradewind/Kona wind contours; and Year 2000 contours with 365-day annual averages. Since rotary wing aircraft are generally noisier on approach than takeoff, since HIA aircraft noise levels are highest during tradewind days, and since the tradewind/Kona runway use allocation for NAS, BP was not available for the 1979 period, it was decided to calculate the total aircraft noise levels in the 1979 period for a typical tradewind day (which should occur approximately 80 percent of the daytime hours, and over 90% of the nighttime hours). From Reference 2, NAS, BP Tracks #19 and #14 were used in conjunction with the HIA ILS approach track as shown in FIGURE 2. RWY 11 operational assumptions used for these tracks are shown in TABLE 3. Military aircraft noise levels were obtained from References 5 and 6. FIGURE 2

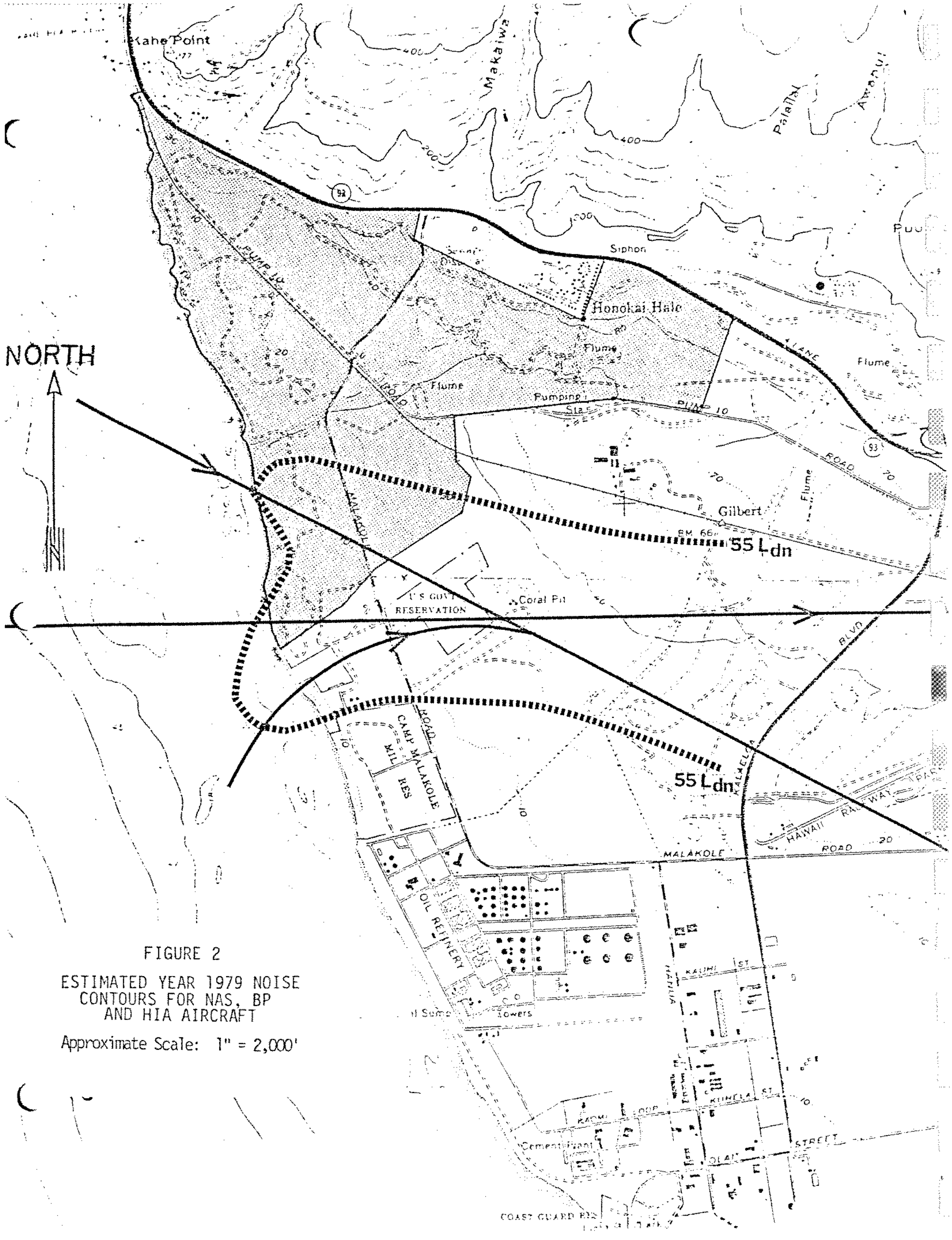


FIGURE 2

ESTIMATED YEAR 1979 NOISE CONTOURS FOR NAS, BP AND HIA AIRCRAFT

Approximate Scale: 1" = 2,000'

depicts the estimated Year 1979 noise contours over the West Beach area. Portions of the south end of the development are within the 1979, 55 L_{dn} contour, and the 60 L_{dn} contour did not exist within the West Beach area in 1979.

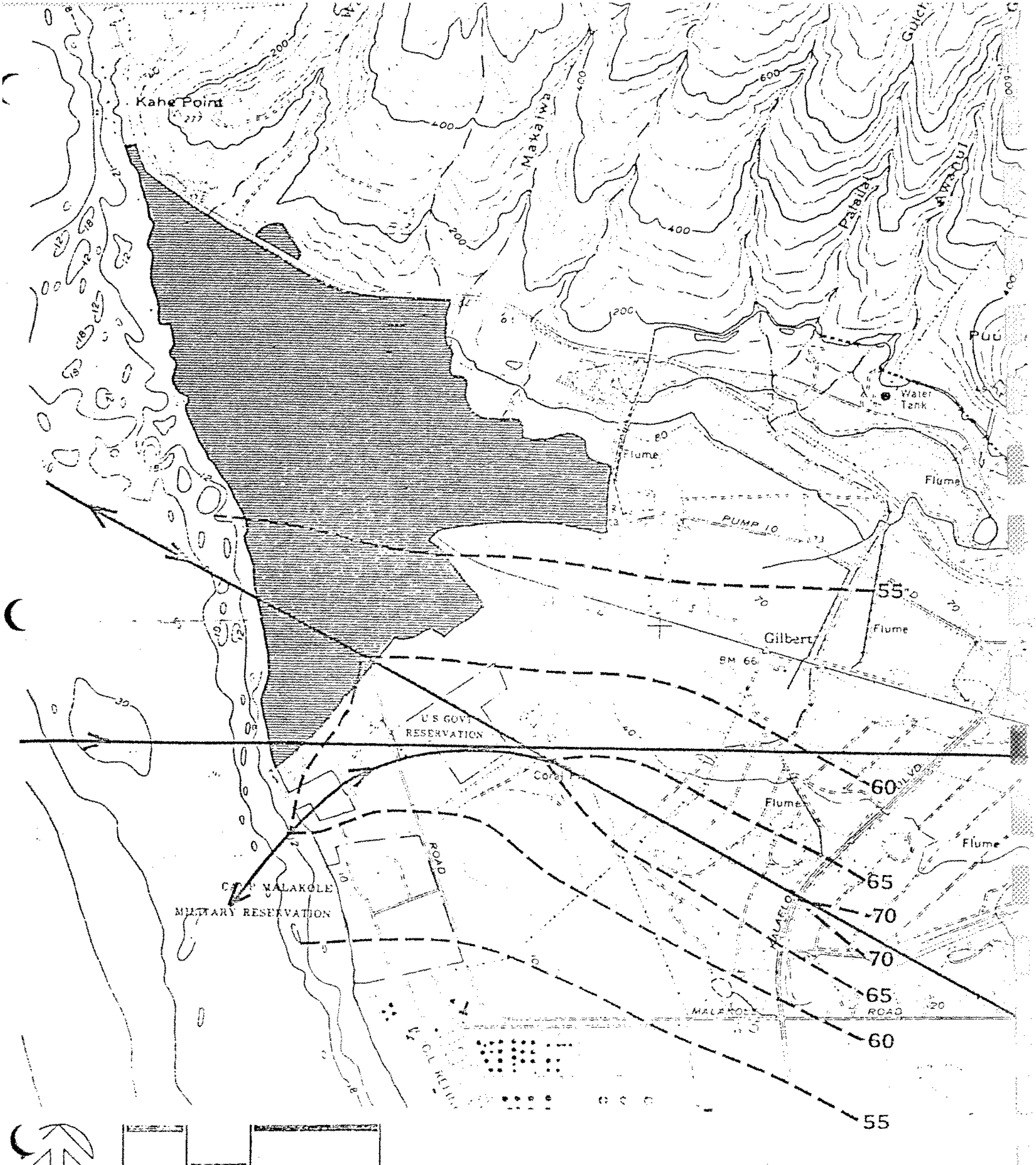
2. A second contour set was developed using the 1984 AICUZ operational assumptions as shown in TABLE IV-4 of Reference 4, and without modification to the TABLE IV-4 values. This contour set is shown as FIGURE 3, and the contours are similar to those depicted in the 1984 AICUZ, with portions of the West Beach Resort within the 60 L_{dn} contour.

3. A third contour set was developed using the 1984 AICUZ operational assumptions corrected for the 365 vs. 260-day annual averaging period, and with southbound itinerant departures from RWY 29 following the 1976 AICUZ tracks. This set is shown as FIGURE 4, and results in a 1.5 L_{dn} reduction in the noise level over West Beach, with the 60 L_{dn} contour shown outside the West Beach area.

F. CONCLUSIONS

1. Based on the preceding evaluations, we believe our prior conclusion of August, 1979 regarding the impact of aircraft noise on future West Beach residents are still valid. By the Year 2000, a margin of 5 to 8 L_{dn} units should exist before federal criteria of 65 L_{dn} is exceeded at residential locations of the proposed development.

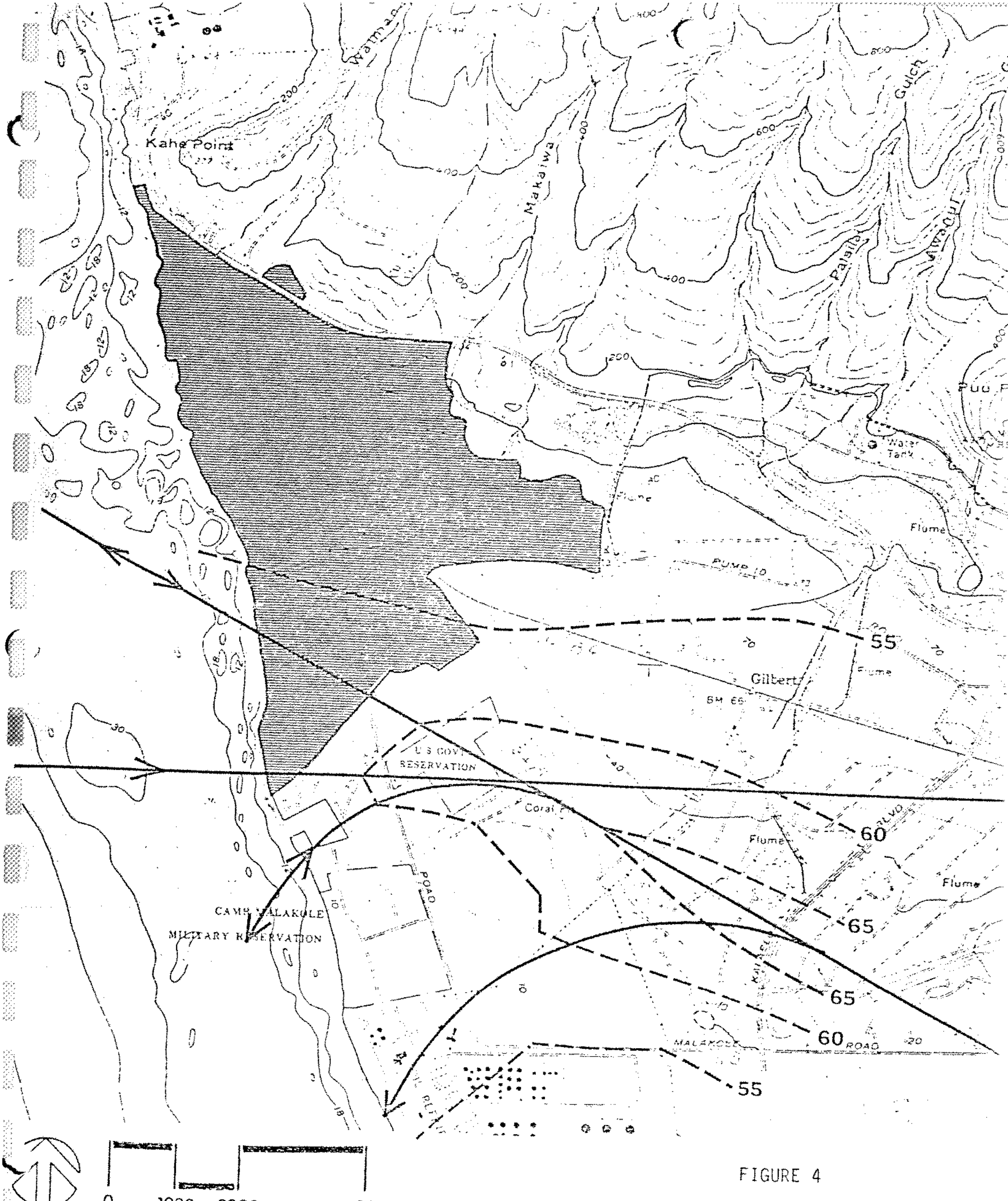
2. A major change in RWY 11/29 operations at NAS, BP has occurred since 1979, and has resulted in an increase of our previous projections of Year 2000 noise levels by 1 L_{dn} unit. However, because the 60 L_{dn} contour does not encroach on residential areas of the proposed development, and because the number of helicopter overflights have been reduced, noise



WEST BEACH RESORT

FIGURE 3

WORST CASE YEAR 2000
COMPOSITE AIRCRAFT
NOISE (L_{dn}) CONTOURS



WEST BEACH RESORT

FIGURE 4

COMPOSITE YEAR 2000 AIRCRAFT NOISE (L_{dn}) CONTOURS USING 365-DAY ANNUAL AVERAGES mitigation measures are not considered necessary for the proposed development.

Sincerely,

Yoichi Ebisu, P.E.

YE:ss

REFERENCES:

1. "Noise Impact Analysis for West Beach Resort Project," August, 1979, Darby-Ebisu & Associates, Inc.

2. "NAS Barbers Point Noise Study," July, 1982, PRC Speas.

3. Letter dated June 13, 1983 to Environmental Communications, Inc. from Darby-Ebisu & Associates, Inc.

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5. "Community Noise Exposure Resulting From Aircraft Operations," November, 1977, J.D. Speakman, R.G. Powell, J.N. Cole, #AMRS-TR-73-110, Aerospace Medical Research Laboratory.

6. "Helicopter Noise Exposure Curves for Use in Environmental Impact Assessment," AD/A-123 467, J.Newman, et al, Federal Aviation Administration, November, 1982.

DRAFT
For Review Only

NOISE IMPACT ANALYSIS
for
WEST BEACH RESORT PROJECT

August, 1979

Prepared by:

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DEA Job #8-11P

August 10, 1979

Mr. Fred Rodriguez
Environmental Communications, Inc.
P. O. Box 536
Honolulu, Hawaii 96809

Subject: West Beach Project Noise Study

Dear Mr. Rodriguez:

In accordance with our agreement dated March 19, 1979, the following letter report is submitted:

I. OBJECTIVES:

To describe the existing and anticipated noise environment in the environs of the subject project, and to evaluate potential noise conflicts which may arise as a result of the project. Recommendations for minimizing potential noise impacts were also to be provided when applicable.

II. SUMMARY OF FINDINGS:

Except for traffic noise along Farrington Highway, the proposed project site is compatible for the multiple uses intended. Aircraft noise resulting from Barbers Point Naval Air Station and Honolulu International Airport does not and is not anticipated to exceed published exterior noise criteria for residential development. However, the possibility of noise complaints from West Beach residents does exist, and should be minimized by mutual cooperation among the developers, future West Beach citizens, and the Navy.

The existing and future traffic noise levels along Farrington Highway are high and far exceed existing and proposed federal noise criteria. Highway noise abatement features should be incorporated within the project due to their potential impact on future West Beach residents.

AUG 14 1979

III. THE EXISTING NOISE ENVIRONMENT:

Daytime noise measurements were performed on March 23, 1979 at Sites No. 1 and No. 2 (as shown in Figure 1) to determine the existing aircraft noise environment at the project site. Additional noise measurements were performed on March 29, 1979 at Sites No. 3 and No. 4, and on June 6, 1979 at Site 4 to determine the existing highway noise environment at the project site, and to determine the the shielding effects afforded by single-story homes in the immediate area.

Based upon a six and one-half hour total measurement period at Sites No. 1 and No. 2, it was apparent that aircraft were the dominant noise sources in the West Beach areas which are distant (in excess of 1600 FT) from Farrington Highway. At Site 1, from 9:00 AM to 12:00 Noon, a total of 58 aircraft were recorded with A-weighted sound levels (L_A) ranging from 55 to 79 dB. Of these 58 aircraft, 16 were helicopters, 23 were commercial air carrier jets, 10 were fixed-wing military aircraft, 5 were general aviation propeller aircraft and 4 were unidentified jet aircraft. At Site 2, from 1:00 PM to 4:30 PM a total of 43 aircraft were recorded with L_A values ranging from 55 to 79 dB. Of these 43 aircraft, 1 was a helicopter, 15 were commercial jets, 17 were fixed-wing military aircraft, 5 were general aviation propeller aircraft, and 5 were unidentified aircraft. FIGURE 2 presents the hourly equivalent sound level (L_{eq}) contribution by the various aircraft types recorded.* From FIGURE 2, it was concluded that aircraft noise sources were major contributors to the hourly equivalent sound levels at Sites 1 and 2 (when all noise sources were combined). Except for potential nuisance type conflicts, the hourly equivalent sound levels measured did not suggest that existing exterior noise criteria for residential or commercial development would be exceeded. Further discussions concerning the aircraft noise environment and the potential for complaints from future West Beach residents are presented in Paragraph IV.

Traffic noise measurements performed at Sites 3 and 4, and vehicle count data provided by the State DOT for Station C-10-C (See FIGURE 1) indicate that highway noise could result in adverse impacts to residential lots within 300 to 400 FT from the near curb edge of Farrington Highway. FIGURE 3 presents 1977 hourly traffic count data along the highway as well as spot counts performed at Sites 3 and 4. FIGURE 4 presents measured and predicted traffic noise (using the L_{eq} descriptor) vs. distance from the near curb edge for various periods of the day. Reference 7 was used in performing highway noise predictions. Based upon the good agreement measured and predicted data at 50FT, and the relatively high equivalent sound levels (71 to 65 dB) from 50 FT to 300 FT.

*A brief description of the acoustic terminology and symbols used are provided in the enclosure to this report.

from the highway under the unshielded and hard ground cover condition, it was concluded that proposed residential lots within 400 FT of the highway should be examined in greater depth for potential noise conflicts and for potential beneficial effects of barriers and natural shielding. These are discussed in further detail in Paragraph V.

IV. PROBABLE IMPACT OF EXISTING AIRCRAFT NOISE ON FUTURE WEST BEACH RESIDENTS:

A general trend has developed toward the increasing use of the Day-Night Sound Level (L_{dn}) in describing environmental noise in general, and particularly near airports. Reference 1, jointly published by the Air Force, Army and Navy in June, 1978 adopts the L_{dn} Metric. Reference 2, proposed as a replacement of HUD Circular 1390.2 (a pioneer document), also utilizes the L_{dn} metric. The U.S. Environmental Protection Agency (EPA), by Reference 3, is working toward the development of a "uniform federal statement and guidance package on the noise element of land use control." Because of EPA's prior support of the L_{dn} metric (Reference 4), it is likely that the L_{dn} metric will be included in this future uniform guidance. A general consensus among federal agencies has developed whereby residential housing is considered acceptable where exterior noise does not exceed L_{dn} 65. EPA's prior recommendations of L_{dn} 55 or less for residential housing has not been adopted by other federal agencies, but is recognized as a desirable long-term goal.

Based upon the aircraft noise measurements obtained on March 23, 1979, the Barbers Point Naval Air Station (NAS) operational data contained in Reference 5, and other aircraft noise data collected with the Honolulu International Airport (HIA) Automatic Noise Monitoring System, it is considered unlikely that aircraft noise currently exceeds L_{dn} 55 in the proposed West Beach project area. Because measured hourly L_{eq}'s at the project site did not exceed 55 dB, because NAS rotary wing activity over the project site is generally confined to daytime operations (see Reference 5), and because HIA related aircraft noise contributions (resulting from Runway 08L approaches) during the nighttime hours of 10:00 PM to 7:00 AM also diminishes greatly (in excess of 10 dB) from the 51 dB (L_{eq}) daytime value measured at the project site, aircraft noise at the project site is probably between L_{dn} 50 and L_{dn} 55, and at least 10 dB below current and proposed federal guidelines for residential housing developments.

From FIGURE 2, between the hours of 10:00 to 11:00 AM, NAS rotary wing aircraft noise was the dominant contributor to the measured hourly L_{eq}. In order to account for the added annoyance factor attributable to rotary wing aircraft noise, 7 dB (Reference 6) should be added to the rotary wing results shown in FIGURE 2. The net effect of this correction would increase the L_{eq} (6.5 HR) from 52.5 dB to 55.0 dB, would increase rotary wing contributions to the total L_{eq} (6.5 HR) from 19% to 54%, and would imply that 17 helicopters (of a total of 101 aircraft measured) contributed over 50% of the total aircraft noise measured on March 23. Because these aircraft currently fly directly over the project site at altitudes below 500 FT, a conflict regarding these overflights may occur following implementation of the project. The existing noise environment would worsen if nighttime overflights of these aircraft began to occur on a regular basis, and the potential for future conflict will increase.

Although potential noise conflicts regarding Barbers Point NAS rotary wing aircraft are possible, the current level of activity over the project site is such that existing HUD and other Federal noise criteria are not exceeded. Therefore, special sound attenuation measures would not be required. However, it is recommended that rotary wing traffic over the project site be confined to a single flight corridor at mandatory altitudes, such as over the Hotel/Condo and commercial areas of the project. Special acoustical design features could then be implemented as necessary to minimize the potential for future conflict.

V. PROBABLE IMPACT OF HIGHWAY NOISE ON FUTURE WEST BEACH RESIDENTS

Existing highway noise levels at 50 FT distance from near curb edge of Farrington Highway are currently between 70 to 72 dB (L_{eq}) during the daytime, and also exceed existing and proposed HUD criteria for residential development. Noise measurements obtained at Honokai Hale on March 29, 1979 indicated that existing residential lots fronting the highway are currently exposed to approximately 70 to 72 dB (L_{eq}). Follow-up measurements at 50 FT distance from the near curb edge performed on 6/6/79 at Site 4 confirmed the March measurements with L_{eq}'s ranging from 71 to 72 dB, and L_{33} values of 70 to 71 dB. At interior lots within 100 to 400 FT of the highway curb, equivalent sound levels of approximately 65 to 56 dB were measured. An excess attenuation of 5 to 8 dB was attributable to the partial noise shielding effects caused by existing homes between the measurement point and the highway traffic. For lots fronting the highway, exterior noise levels of L_{dn} 73 to L_{dn} 74 currently exist (at approximately 21,500 vehicles per day), and are 8 to 9 dB above proposed HUD criteria for residential development.

By 1990, if average daily traffic along Farrington Highway approaches 60,000 vehicles per day*, a 4 to 5 dB increase in highway noise levels above the existing situation can be anticipated. Daily exterior L_{dn} values of 77 to 79 are anticipated for lots within 50 feet of the highway (See Figure 5). Exterior noise levels in excess of L_{dn} 75 are considered unacceptable for residential housing by proposed HUD and existing federal criteria. Noise levels at existing residences fronting the highway (Honokai Hale, for example) will likewise be increased.

*From Ref. 8: 31,154 (Non-Project) plus 14,112 (West Beach Residents) plus 10,980 (Commercial) plus 700 (Marina) plus 794 (Hotel/Condo autos.) plus 1,650 (buses).

Proposed West Beach residential units fronting the highway will require sound attenuation measures such as airconditioning, forced ventilation or noise barrier construction to reduce highway noise to acceptable exterior and interior levels. If multi-story construction is used for residential units fronting the highway, noise barrier construction will not be a practical abatement measure, and the use of air conditioning or forced mechanical ventilation of the units will be required to meet existing and proposed HUD criteria. Without noise abatement measures, interior noise levels of 67 to 69 (L_{dn}) can be expected. Construction of minimum 10 foot height noise barriers and/or earth berms will be required to meet HUD criteria for residential lots fronting the highway if natural ventilation is planned for these homes. In order to minimize the extent of noise barrier construction and to take advantage of excess attenuation afforded by site construction features, it is recommended that acoustical consultants be retained during the project design phase.

Since existing highway noise levels are already above existing HUD and federal criteria for residential housing, and since the proposed project's traffic will increase current noise levels by 3.5 dB (with an additional 1.5 dB increase attributable to non-project traffic increases projected by year 1990), costs associated with noise abatement for existing homes along the highway should not be borne solely by the West Beach developer. Noise barrier construction along existing Honokai Hale homes fronting the highway is recommended, with federal aid suggested as a funding source for a major portion of costs associated with the noise abatement treatment.

VI. PROBABLE IMPACT OF INTERNAL STREET SYSTEM NOISE ON FUTURE WEST BEACH RESIDENTS.

Internal street system noise generated by residential and commercial vehicular movement (26,586 trips) and by buses anticipated to service the hotel/condominium units (1,650 trips) may exceed L_{dn} 65 at 50 foot setback from the curb edge. Bus noise, in particular, is anticipated to be a dominant noise source along the two streets between Farrington Highway and the hotel/condominium units although bus noise is not anticipated to occur between the nighttime hours of 10:00 PM to 7:00 AM. Suggested mitigation measures include use of 50 to 100 foot setback of residential units from the main thoroughfares, control of vehicle speed below 35 miles per hour, minimization of heavy vehicle and bus traffic between the hours of 10:00 PM to 7:00 AM, and lot specific treatments such as noise barriers and building treatment. Internal street system noise is unlikely to exceed L_{dn} 75, and hence, the interior residential lots can be developed to HUD and other federal noise criteria.

VII. POTENTIAL IMPACT OF BLAST NOISE/VIBRATION DURING MARINA CONSTRUCTION.

Because existing residential or industrial structures are located beyond 1000 foot distance from the site of the proposed marina, the risks of structural damage resulting from possible blasting operations can be minimized by the blasting contractor in accordance with the procedures delineated in Reference 9. These procedures are summarized as follows:

1. Maximum charge weight (in equivalent pounds of TNT) per delay should not exceed $(D \div 50)^2$ pounds, where D is the distance in feet between the charge and the existing structure.

2. If the maximum charge weight or distance restrictions are not conducive to efficient blasting operations, utilize vibration measurement instruments during blasting operations, and do not exceed a safe blasting limit of 2.0 inches/second peak particle velocity in the ground adjacent to the structure of interest.

3. Since human complaints resulting from ground vibrations and air blast noise may occur at levels considerably below those necessary to cause structural damage, additional mitigation measures such as limiting peak particle velocity at inhabited structures to 0.4 inches/second, advising the surrounding residents about the blasting operations and precautionary steps taken, and use of milli-second delay charges are recommended.

It is assumed that construction of the proposed Barbers Point Deep Draft Harbor will occur prior to construction of the West Beach Marina and Hotel/Condominium units, and that construction of the West Beach Hotel/Condominium units will occur following the construction of the marina. Therefore, West Beach building occupants should not be a dominantly restrictive factor during the construction and blasting phases of the harbor or marina.

Sincerely,

Yoichi Ebisu, P.E.

YE:ss
Encls.

REFERENCES

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2. Proposed HUD Regulations for Determining Acceptability of Housing Projects in Terms of Noise Exposure; 43 FR 60396, December 27, 1978.

3. "Land Use: EPA Launches Effort to Consolidate Federal Land Use Guidance," Noise Regulation Reporter, No. 104, May 8, 1978, pp. A-14.

4. Guidelines for Preparing Environmental Impact Statements on Noise, Report of Working Group 69 (CHABA), National Research Council, National Academy of Sciences, 1977.

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6. AICUZ Preparation Policy, Federal Register, Vol. 42, No. 2, January 4, 1977.

7. FHWA Technical Advisory T 50405.5, Hand-Held Calculator Listings for the FHWA Highway Noise Prediction Model; U.S. DOT, FHWA, September 5, 1978 and October 17, 1978 (Change 1).

8. Traffic Impact Statement for West Beach Resort Project, Henry Tuck Au, Consulting Engineer, August 1, 1979.

9. Blasting Vibrations and Their Effects on Structures; PB-231-971; Denver Mining Research Center; 1971.

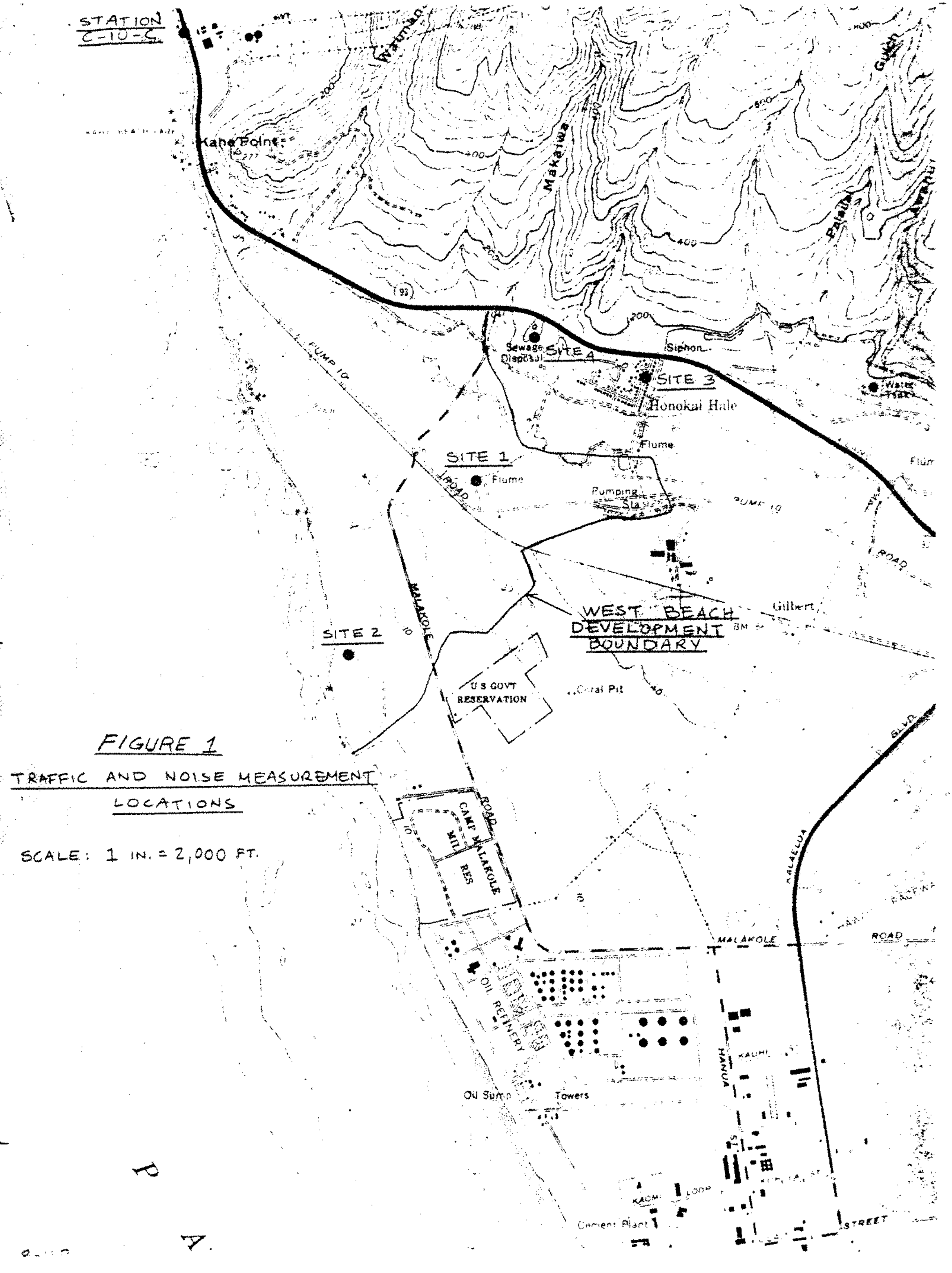


FIGURE 1

TRAFFIC AND NOISE MEASUREMENT LOCATIONS

SCALE: 1 IN. = 2,000 FT.

FIGURE 2

AIRCRAFT NOISE MEASURED AT SITES 1 AND 2

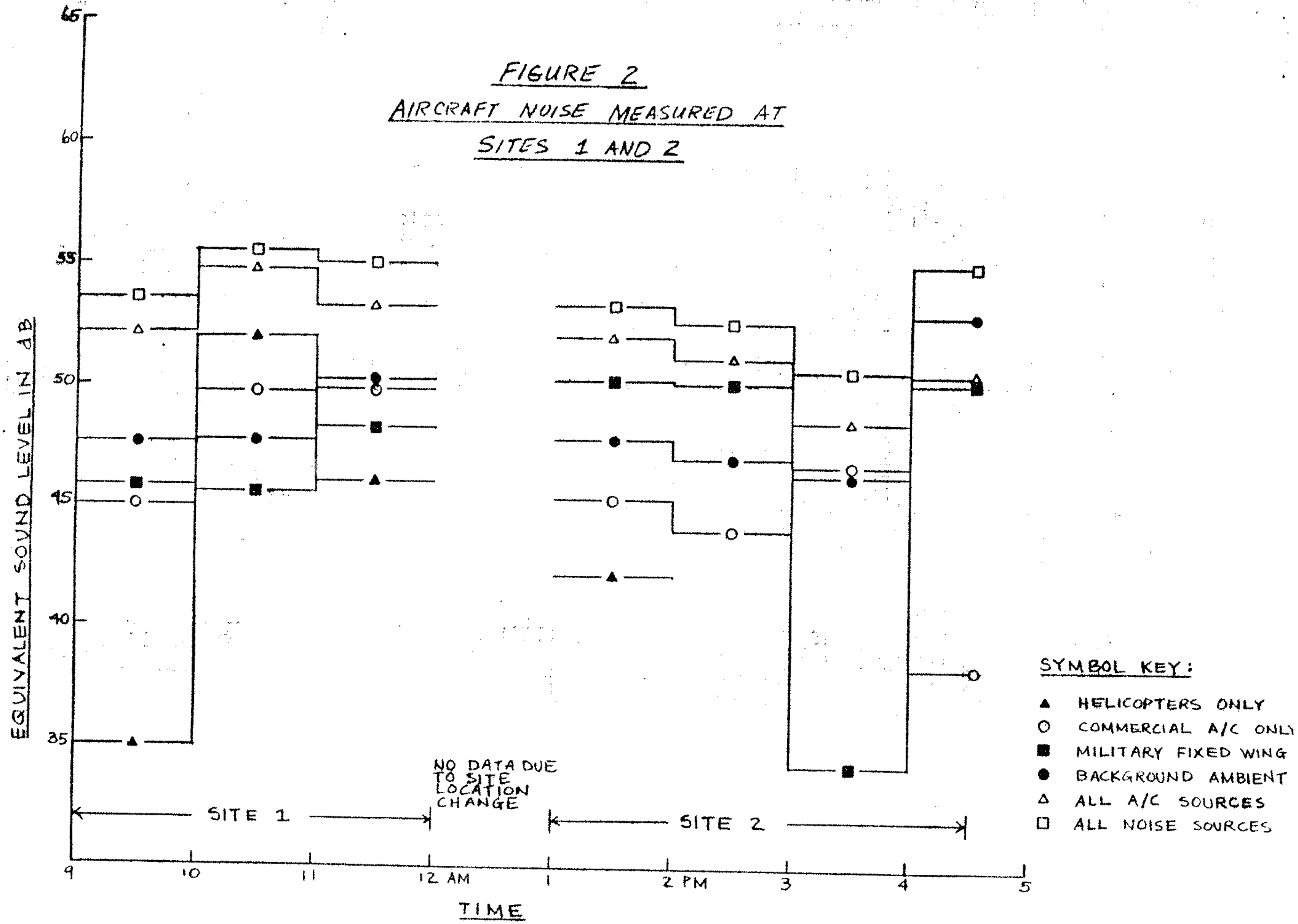
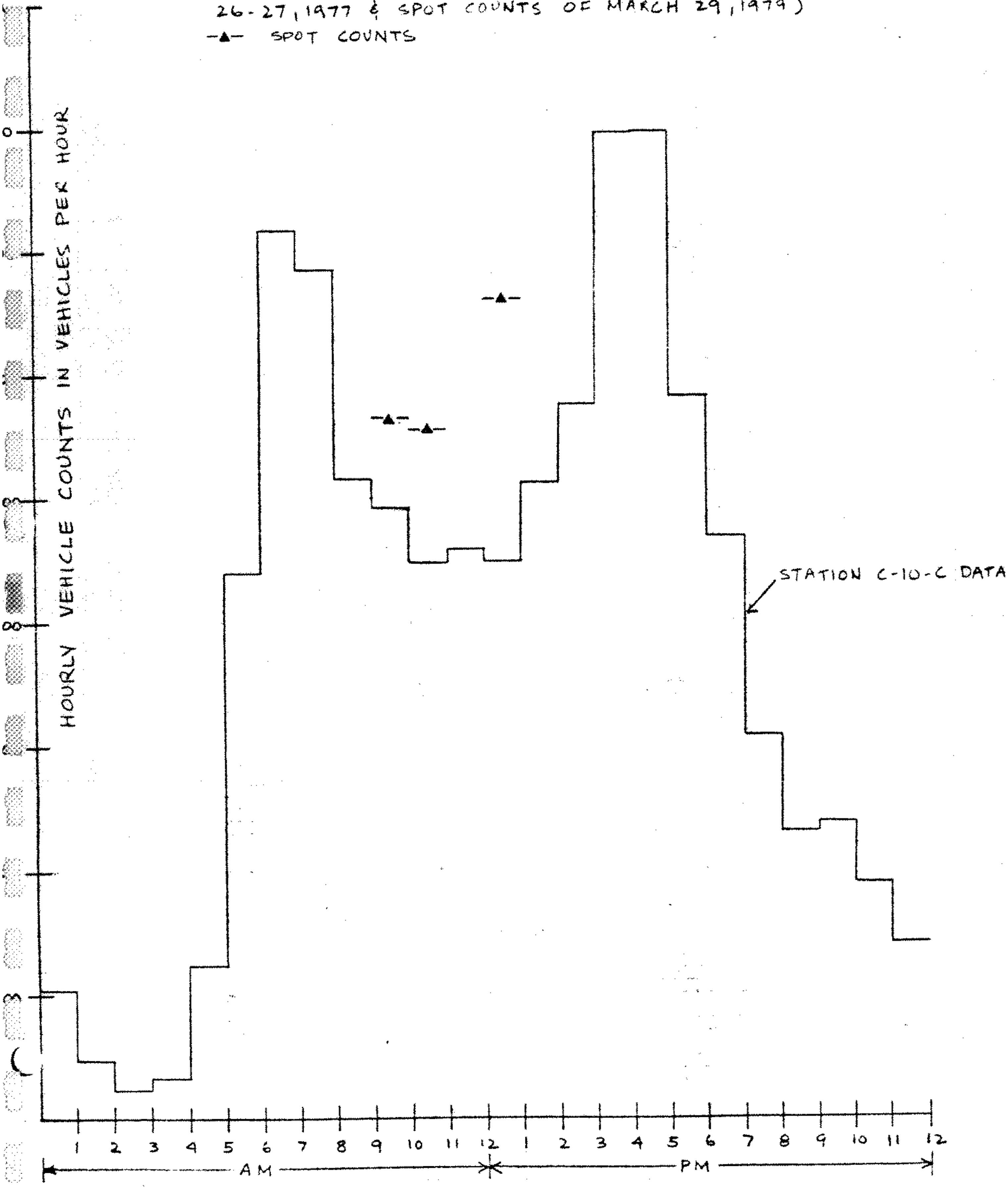


FIGURE 3

ESTIMATED TOTAL HOURLY TRAFFIC VARIATION ALONG FARRINGTON HWY. FRONTING WEST BEACH DEVELOPMENT

(SOURCES: STATION C-10-C METER COUNTS OF JAN. 26-27, 1977 & SPOT COUNTS OF MARCH 29, 1979)

—▲— SPOT COUNTS



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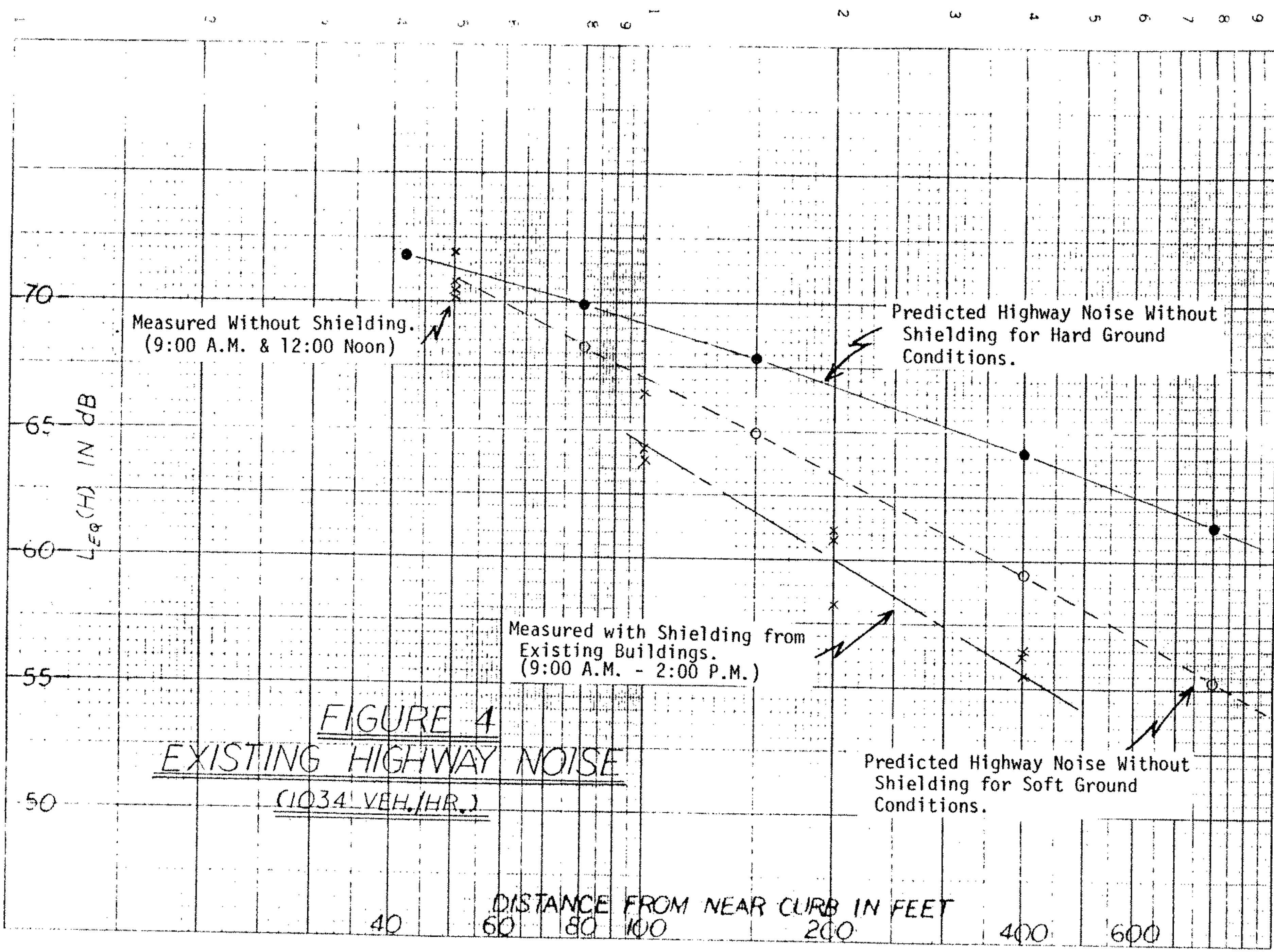

FIGURE 4
EXISTING HIGHWAY NOISE
(1034 VEH./HR.)

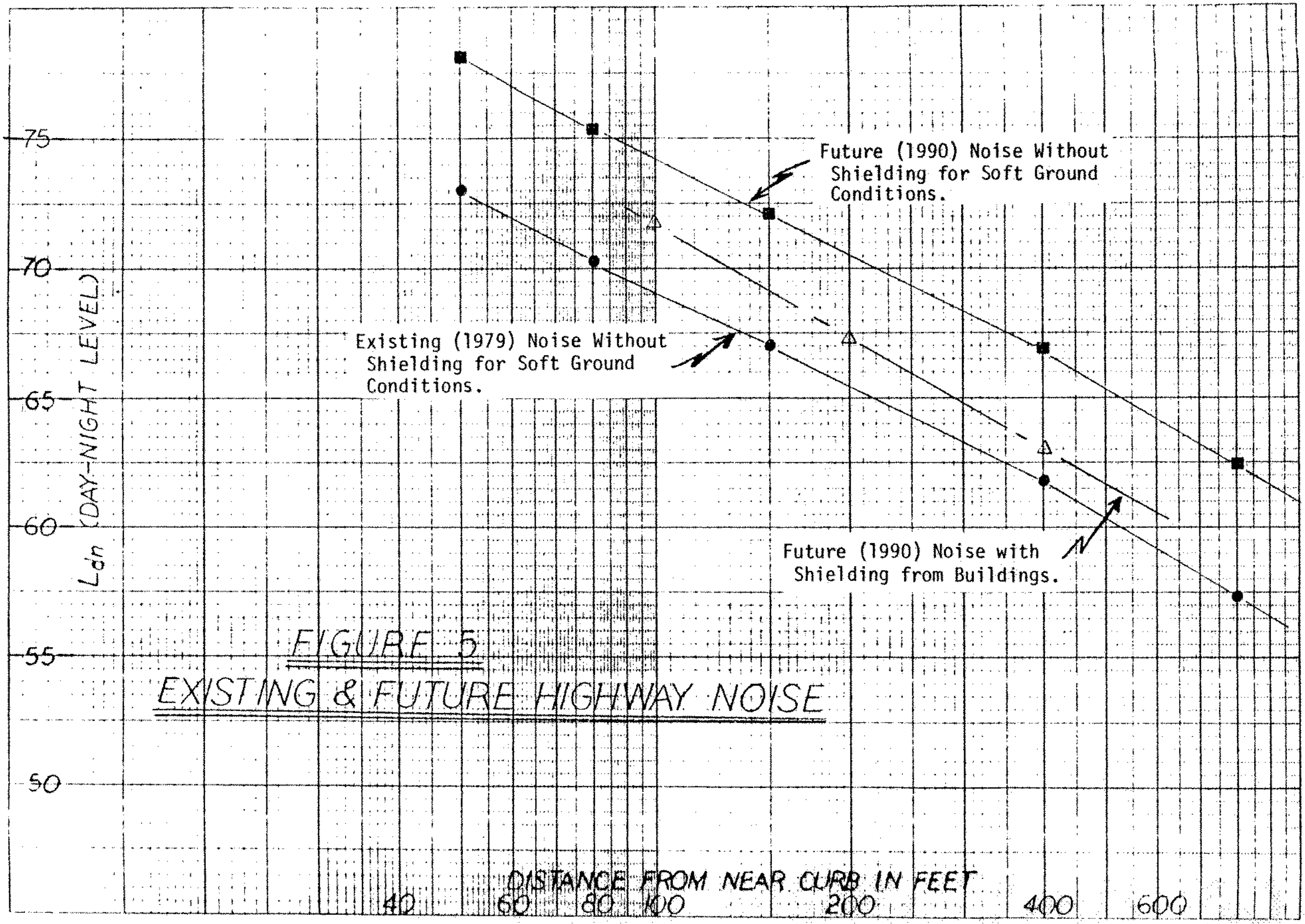

FIGURE 5

EXISTING & FUTURE HIGHWAY NOISE

BNA

TEXT

EXCERPTS FROM EPA'S ACOUSTIC TERMINOLOGY GUIDE

Descriptor Symbol Usage

The recommended symbols for the commonly used acoustic descriptors based on A-weighting are contained in Table 1. As most acoustic criteria and standards used by EPA are derived from the A-weighted sound level, almost all descriptor symbol usage guidance is contained in Table I.

Since acoustic nomenclature includes weighting networks other than "A" and measurements other than pressure, an expansion of Table I was developed (Table II). The group adopted the ANSI descriptor-symbol scheme which is structured into three stages. The first stage indicates that the descriptor is a level (i.e., based upon the logarithm of a ratio), the second stage indicates the type of quantity (power, pressure, or sound exposure), and the third stage indicates the weighting network (A, B, C, D, E.....). If no weighting network is specified, "A" weighting is understood. Exceptions are the A-weighted sound level and the A-weighted peak sound level which require that the "A" be specified. For convenience in those situations in which an A-weighted descriptor is being compared to that of another weighting, the alternative column in Table II permits the inclusion of the "A". For example, a report on blast noise might wish to contrast the $L_C$dn with the LAdn.

Although not included in the tables, it is also recommended that "L_{PN}" and "L_{EPN}" be used as symbols for perceived noise levels and effective perceived noise level, respectively.

It is recommended that in their initial use within a report, such terms be written in full, rather than abbreviated. An example of preferred usage is as follows:

> The A-weighted sound level (LA) was measured before and after the installation of acoustical treatment. The measured LA values were 85 and 75 dB respectively.

Descriptor Nomenclature

With regard to energy averaging over time, the term "average" should be discouraged in favor of the term "equivalent". Hence, L_{eq}, is designated the "equivalent sound level". For L_d, L_n, and L_{dn}, "equivalent" need not be stated since the concept of day, night, or day-night averaging is by definition understood. Therefore, the designations are "day sound level", "night sound level", and "day-night sound level", respectively.

The peak sound level is the logarithmic ratio of peak sound pressure to a reference pressure and not the maximum root mean square pressure. While the latter is the maximum sound pressure level, it is often incorrectly labelled peak. In that sound level meters have "peak" settings, this distinction is most important.

"Background ambient" should be used in lieu of "background", "ambient", "residual", or "indigenous" to describe the level characteristic of the general background noise due to the contribution of many unidentifiable noise sources near and far.

With regard to units, it is recommended that the unit decibel (abbreviated dB) be used without modification. Hence, dBA, PNdB, and EPNdB are not to be used. Examples of this preferred usage are: the Perceived Noise Level (L_{PN} was found to be 75 dB. L_{PN} = 75 dB.) This decision was based upon the recommendation of the National Bureau of Standards, and the policies of ANSI and the Acoustical Society of America, all of which disallow any modification of bel except for prefixes indicating its multiples or submultiples (e.g., deci).

Noise Impact

In discussing noise impact, it is recommended that "Level Weighted Population" (LWP) replace "Equivalent Noise Impact" (ENI). The term "Relative Change of Impact" (RCI) shall be used for comparing the relative differences in LWP between two alternatives.

Further, when appropriate, "Noise Impact Index" (NII) and "Population Weighted Loss of Hearing" (PHL) shall be used consistent with CHABA Working Group 69 Report Guidelines for Preparing Environmental Impact Statements (1977).

TABLE I: A-Weighted Recommended Descriptor List

	Term	Symbol
1.	A-Weighted Sound Level	L_A
2.	A-Weighted Sound Power Level	L_{WA}
3.	Maximum A-Weighted Sound Level	L_{max}
4.	Peak A-Weighted Sound Level	L_{Apk}
5.	Level Exceeded x% of the time	L_x
6.	Equivalent Sound Level	L_{eq}
7.	Equivalent Sound Level over Time (T) (1)	$L_{eq(T)}$
8.	Day Sound Level	L_d
9.	Night Sound Level	L_n
10.	Day-Night Sound Level	L_{dn}
11.	Yearly Day-Night Sound Level	$L_{dn(y)}$
12.	Sound Exposure Level	L_{SE}

(1) Unless otherwise specified, time is in hours (e.g. the hourly equivalent level is L_{eq} (1)). Time may be specified in non-quantitative terms (e.g., could be specified a $L_{eq(WASH)}$ to mean the washing cycle noise for a washing machine.)

TABLE II: Recommended Descriptor List

TERM	A-WEIGHTING	ALTERNATIVE(1) A-WEIGHTING	OTHER WEIGHTING (2)	UNWEIGHTED
1. Sound (Pressure) (3) Level	L_A	L_{pA}	L_B, L_{pB}	L_p
2. Sound Power Level	L_{WA}		L_{WB}	L_W
3. Max. Sound Level	L_{max}	L_{Amax}	L_{Bmax}	L_{pmax}
4. Peak Sound (Pressure) Level	L_{Apk}		L_{Bpk}	L_{pk}
5. Level Exceeded x% of the time	L_x	L_{Ax}	L_{Bx}	L_{px}
6. Equivalent Sound Level	L_{eq}	L_{Aeq}	L_{Beq}	L_{peq}
7. Equivalent Sound Level Over Time(T) (4)	$L_{eq(T)}$	$L_{Aeq(T)}$	$L_{Beq(T)}$	$L_{peq(T)}$
8. Day Sound Level	L_d	L_{Ad}	L_{Bd}	L_{pd}
9. Night Sound Level	L_n	L_{An}	L_{Bn}	L_{pn}
10. Day-Night Sound Level	L_{dn}	L_{Adn}	L_{Bdn}	L_{pdn}
11. Yearly Day-Night Sound Level	$L_{dn(y)}$	$L_{Adn(Y)}$	$L_{Bdn(Y)}$	$L_{pdn(Y)}$
12. Sound Exposure Level	L_S	L_{SA}	L_{SB}	L_{Sp}
13. Energy Average value over (non-time domain) set of observations	$L_{eq(e)}$	$L_{Aeq(e)}$	$L_{Beq(e)}$	$L_{peq(e)}$
14. Level exceeded x% of the total set of (non-time domain) observations	$L_{x(e)}$	$L_{Ax(e)}$	$L_{Bx(e)}$	$L_{px(e)}$
15. Average L_x value	L_x	L_{Ax}	L_{Bx}	L_{px}

(1) "Alternative" symbols may be used to assure clarity or consistency.

(2) Only B-weighting shown. Applies also to C,D,E,..... weighting.

(3) The term "pressure" is used only for the unweighted level.

(4) Unless otherwise specified, time is in hours (e.g., the hourly equivalent level is $L_{eq(1)}$). Time may be specified in non-quantitative terms (e.g., could be specified as $L_{eq(WASH)}$ to mean the washing cycle noise for a washing machine)).

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APPENDIX I SECTION 3

AIR QUALITY ANALYSIS
FOR
WEST BEACH PROJECT
OAHU, HAWAII

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August 31, 1984

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FIGURES

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1. INTRODUCTION AND PROJECT DESCRIPTION

The proposed West Beach Project involves constructing a totally planned community including 4,000 resort units, 5,200 residential units, commercial buildings, public facilities, and recreational amenities including an 18 hole golf course, four lagoons and a marina, on a 642 acre parcel of land located in southwestern Oahu (Figure 1). The Master Plan (Figure 2) shows proposed land use allocation and roadway configuration. The site is nearly level with only a gentle increase in elevation from the southern ocean boundary to Farrington Highway along the northern border of the project. The area has previously been used for sugar cane cultivation.

This report contains a discussion of relevant Federal and State of Hawaii Air Quality Standards, a description of present air quality in the project area, a modeling study of potential worst case carbon monoxide concentrations likely to result from different projected traffic scenarios, and a discussion of potential short and long term measures that might be employed to mitigate any adverse air quality impacts that could result from construction of the project as proposed.

2. AIR QUALITY STANDARDS

Because the proposed project does not entail construction of any new major fixed sources of air pollutants, the primary consideration regarding its environmental acceptance from an air quality standpoint will be estimated impact on ambient air quality levels in the project area.

Federal and State of Hawaii Ambient Air Quality Standards (AQS) have been set for six classes of pollutants as shown in Table 1. An AQS is a pollutant concentration not to be exceeded over a specified sampling period.

For particulate matter and sulfur dioxide the Federal Standards are subdivided into Primary and Secondary AQS. Primary Standards are set a levels deemed necessary to protect public health (with an adequate margin of safety), while Secondary Standards are designed to prevent welfare impacts such as reduced visility, diminished human comfort levels, soiling, or injury to vegetation or animals.

State of Hawaii AQS were for the most part promulgated in the early 1970's and were set at lower levels than the federal limits in order to recognize the low level of pollutant concentrations that appeared to prevail here at that time. In May of 1984 public hearings were held by the State Department of Health (DOH) to consider revisions to State air pollution control regulations including changes to the particulate and sulfur dioxide AQS that would make them identical to present Federal limits. It is expected that a decision regarding this matter will be forthcoming shortly.

3. PRESENT AIR QUALITY

The primary pollutant generated by present usage of the project site is fugitive dust raised by the wind blowing over bare soil areas within former cane fields or occasional vehicles traveling over unpaved cane haul roads. Vehicular traffic is too infrequent to generate significant levels of carbon monoxide, nitrogen dioxide, or lead.

Outside sources that can affect air quality in the project area include periodic cane fires, traffic on Farrington Highway or other nearby roadways, stack emissions from the Hawaiian Electric Power Plant Complex at Kahe, and fugitive and stack emissions from oil refineries and other industrial activities located in Campbell Industrial Park.

Natural air pollutant producers that might affect present air quality at the project site include sea spray, aeroallergens from plants, or volcanic emissions from the Island of Hawaii. Concentrations of pollutants from these sources at West Beach should not differ markedly from values that might be expected at other beachside locations on Oahu and natural air pollutants are thus discussed no further in this report.

There are no long-term air quality measurements available for any sampling site within the project boundaries. Present air pollutant levels must therefore be estimated based on data from nearby monitoring stations, short-term on-site measurements, and air pollutant dispersion modeling. This description can most logically be presented by considering each pollutant class separately.

PARTICULATES

Particulates are any kind of non-gaseous airborne material that can be trapped and weighed using collectors designed for that purpose.

The State of Hawaii particulate monitoring station nearest to the proposed West Beach project has been operating in the Campbell Industrial Park since 1971. Reported results from this station are listed in Table 2. The sampling station was originally located at the Barbers Point lighthouse, but analysis of the particulates collected there indicated a high percentage of sea salt particles. The hi-vol sampler was thus moved inland to a site on the grounds of the Chevron oil refinery in March, 1972. In August, 1979, the sampler was relocated to a rooftop at the Chevron site.

From the data shown in Table 2 it appears that Federal AQS for particulates are generally being met at the sampling site in Campbell Industrial Park (one exceedence of the Federal 24 hour AQS per year is permitted), but the more stringent State of Hawaii AQS is being exceeded at the rate of about twice per year. These occurrences are most likely the result of agricultural activities or natural salt deposits from sea spray combining with local industrial emissions.

A detailed chemical analysis of particulates collected on high volume air filters in conjunction with air quality monitoring for a proposed Conoco-Dillingham Refinery at Campbell Industrial Park in 1972 (1) are presented in Table 3. Total concentrations measured are listed in Table 4. Since the elements listed in Table 3 account for less than 10 percent of the total particulates collected, it can be concluded that most of the material captured was probably carbon-based residues from combustion of organic materials or sodium chloride sea spray particles. Even the relatively high levels of iron (Fe) are likely to be windblown dust, since Hawaiian soils are rich in iron oxides.

It is entirely possible that the twice per year violation of the State of Hawaii 24 hour AQS for particulates at the Campbell Industrial Park monitoring station could be associated with sugar cane field burning. A detailed analysis of particulate concentrations produced by three sugar cane fires in the Barbers Point area was carried out in 1971 (2). Results are depicted in Figures 3-5. As noted, each of these fires lasted just over an hour, and the isoline of particulate concentration shown in each figure is essentially a one hour average which includes all other background contributions for that time period.

If an existing ambient particulate concentration of 60 micrograms per cubic meter were to be present as the 24 hour average in the area into which the cane smoke was carried, then it would require an additional input from the cane fire of about 1000 micrograms per cubic meter for a one hour period to cause the allowable 24 hour AQS of 100 micrograms per cubic meter to be exceeded. The area covered by the 1000 microgram per cubic meter isoline on Figures 3-5 amounts to an average distance downwind from the fire of about one-half mile. Since there are sugar cane fields near the proposed project site, an occasional exceedance of the 24-hour AQS can probably be expected for locations within a one-half mile downwind distance from these fields.

When the Federal AQS of 150 micrograms for the same time period is considered, however, an average ambient background level of nearly 100 micrograms per cubic meters would be required before the blowing smoke from a cane fire could produce an average concentration in excess of the Federal limit. If the proposed change of State AQS to levels matching Federal AQS is adopted, then it is highly unlikely that any ambient air quality standards will be reached because of sugar cane fires. It is also important to note that the potential impact of sugar cane burning is greatly mitigated by the fact that any given field is burned only about once every two years and that on any given day no more acreage is burned than is needed to supply milling operations for that day.

There is also a significant amount of fugitive dust generated by cane harvesting and trucks running over unpaved cane haul roads. Estimated concentrations of particulates generated by these activities are impossible to calculate because of the highly variable nature of the actions and soil states involved.

Table 5 is the latest published summary of air pollutant emission sources in the State of Hawaii (1980). State-wide the most prolific producer of particulates or total suspended particulates (TSP) is the mineral products industry, followed closely by fuel combustion in the agricultural industry and agricultural field burning. Emissions from steam electric power plants and the refinery industry are much lower.

Emission rates of particulates from siginificant stationary sources in the Campbell Industrial Park are summarized in Table 6. A recent comprehensive diffusion modeling study (3) based on these emission rates yielded 24 hour concentrations of particulates under worst case meteorological conditions of about 80 micrograms per cubic meter in the Campbell Industrial Park, and less than 40 micrograms per cubic meter in the West Beach project area. These values are well within either State or Federal limits.

Aside from the above sources, the only other significant potential fixed source contributor of particulates to the West Beach site is the Kahe Power Plant. A comprehensive mathematical and wind tunnel dispersion modeling study for Kahe carried out by Stearns-Roger, Inc. in 1977 (4) yielded a maximum particulate concentration in the West Beach area of 8.2 micrograms per cubic meter.

The 1983 modeling study carried out for Campbell Industrial Park (3) does not address particulates from Kahe, but it does show emission rates of sulfur dioxide for each of the six units there. By analogy from the emissions data listed in Table 5, particulate emissions from steam electric plants are only about 5.9 percent of sulfur dioxide emissions and therefore the total particulate emission rate from Kahe is estimated to be a little over 24 grams per second. Using the stack plume rise parameters presented in the study and a technique for estimating maximum concentrations developed by Bowman (5), it is possible to determine that highest particulate concentrations in the West Beach area from the stacks at Kahe would occur under stability category C (slightly unstable) with a prevailing windspeed of 8.4 meters per second.

These conditions yield a maximum expected one hour concentration of particulates of 13 micrograms per cubic meter at a distance of 2400 meters downwind from Kahe (near the center of the West Beach site). Using a 24 hour estimation factor developed in the Stearns-Roger study, this one hour maximum concentration would indicate a 24 hour average of about 2.3 milligrams per cubic meter, or a level that is essentially insignificant.

At this point it is important to note that the geometry of the West Beach/Kahe/Cambpell Industrial Park area is such that it is almost impossible for pollutant emissions from both Kahe and Campbell Industrial Park to reach West Beach at the same time. A south southeast wind is required to transport Campbell Industrial Park emissions to West Beach while a north northwest wind is required to transport Kahe emissions to West Beach. These two wind directions are exactly opposite and it is therefore highly unlikely that the wind would blow from both directions into West Beach simultaneously.

Wind direction frequencies of occurrence in the West Beach area are summarized in Table 7. Using long term wind data from Barbers Point it appears that the wind blows from Cambpell Industrial Park toward West Beach less than 2 percent of the time. This data shows a wind direction frequency of less than 1 percent from the Kahe direction, but a shorter term wind record from Kahe with calm winds allocated proportionally to each direction indicates that this percentage could be on the order of 3 percent. In any case, it must be stressed that pollutant transport from either Campbell Industrial Park or Kahe Power Plant into the West Beach area is a very low percentage occurrence.

SULFUR DIOXIDE

Sulfur dioxide is a gas produced mainly by combustion of sulfur-containing fuels. It is regulated as an air pollutant because of its potential to act as an irritant creating or contributing to a variety of human respiratory ailments. Sulfur dioxide in conjunction with particulates of respiratory size is potentially more hazardous than sulfur dioxide acting alone. The Federal AQS listed in Table 1 have been set based on this consideration.

From the latest state-wide emissions inventory (Table 5), the most significant industrial sources of sulfur dioxide in Hawaii are steam electric power plants, with refineries a very distant second. Smaller, but perhaps locally significant emissions are also produced by fuel combustion in the agricultural and mineral products industries.

Readings from the long term DOH monitoring station at Barbers Point (Table 2) indicate that sulfur dioxide readings there have been running well within allowable Federal and State AQS. This sampling site is not particularly well located to receive any contribution from nearby elevated industrial sources, however, and the single high reading recorded in 1983 may indicate a rare case of plume downwash from a source that does not usually contribute to the levels of sulfur dioxide measured at this site. The reading could also be partly attributable to ongoing volcanic eruptions on the island of Hawaii during 1983. In any case, even that one high reading was well within Federal AQS.

The 1983 modeling study described above (3) shows estimated sulfur dioxide concentrations from the Campbell Industrial Park complex for 3 hour, 24 hour, and annual averaging times. Emissions data for the modeling are summarized in Table 6. Concentration patterns are shown in Figures 6-8. Table 8 compares the maximum sulfur dioxide concentrations shown for the West Beach area to allowable State and Federal AQS. Modeled concentrations are within Federal AQS but well in excess of present State of Hawaii AQS.

Published results of previous modeling studies of sulfur dioxide from the Kahe Power Plant complex are based on a different stack configuration and fuel sulfur content than is now in use. Hawaiian Electric is presently collecting data from an extensive monitoring network in the vicinity of Kahe but a published summary has not been made available for public use.

Using the maximum concentration estimation technique developed by Bowman (6) and the stack parameters provided in the 1983 Campbell modeling study (3), yields an estimated one hour maximum sulfur dioxide concentration of 612 micrograms per cubic meter near the center of West Beach from Kahe stacks as presently operating. Applying to that the 3-hour, 24-hour, and annual correction factors suggested by Stearns-Roger (4):

3-hour= 0.803
24-hour= 0.184
annual= 0.018

yields the sulfur dioxide concentration estimates shown in Table 6. As shown these values are well within Federal AQS, but under worst case dispersion conditions, the present stringent State of Hawaii AQS could be exceeded by emissions from Kahe. Again it is important to note, however, that concentrations from Kahe and Campbell Industrial Park are not likely to be additive.

CARBON MONOXIDE

Carbon monoxide is an odorless, colorless, tasteless gas that can cause adverse human health effects by limiting the capability of human red blood cells to absorb and distribute oxygen to other body organs. Very high concentrations in confined spaces have produced carbon monoxide poisoning fatalities. The Federal AQS shown in Table 1 are designed to prevent lower level symptoms such as headaches or dizziness. The State of Hawaii AQS are substantially more stringent than Federal AQS in the case of carbon monoxide.

The nearest State of Hawaii DOH long term monitoring station for carbon monoxide is at the Department of Health building in urban Honolulu and results obtained there are not deemed to be representative of values that presently exist in the more rural West Beach area.

In previous environmental impact study work conducted for this project a one-hour spot measurement of carbon monoxide concentration was collected at a site near the geometric center of the project. This reading, collected on Friday, May 11, 1979, between 0800 and 0900 was 1.4 milligrams per cubic meter. That value represents a level likely to occur under adverse meteorological conditions since a visible air pollution pall could be observed over urban Honolulu during the sampling period.

From the state-wide summary of air pollutant emission sources (Table 5), motor vehicles are shown to account for 78.5 percent of all carbon monoxide emissions. The one hour measurement in 1979 was most likely the result of motor vehicle emissions, primarily from Farrington Highway, but possibly from as far away as the H-1 freeway. The second greatest source of carbon monoxide in Hawaii is agricultural field burning, but there was no buring in progress when the 1979 measurement was collected. The third greatest source is aircraft. There was a single aircraft landing at Barbers Point during the 1979 measurement, but the nearest runway at Barbers Point NAS is about 2.5 miles from the southeastern boundary of the proposed project area and the generally low level of flight activity there coupled with the relatively high altitude of aircraft at this distance from the runway make it unlikely that Barbers Point aircraft contribute any measurable levels of carbon monoxide to the West Beach area.

Since motor vehicles are likely to be the most significant contributors to carbon monoxide levels in the West Beach area, a peak hour monitoring program of traffic related carbon monoxide levels was conducted there during May, 1979. Results are presented in Table 9. The sampling site was located about 3 meters from the edge of Farrington Highway near the present entrance to the project. Carbon Monoxide values were determined using an Ecolyzer carbon monoxide monitor with results recorded on a Linear recorder. The peak one hour value measured was 3.1 milligrams per cubic meter on Friday, May 11, between 0615 and 0715. On this same day the DOH monitoring station in urban Honolulu recorded a peak one hour reading of 3.5 milligrams per cubic meter.

The sampling data collected in 1979 along Farrington Highway confirmed the intuitive conclusion that weekday morning traffic would generate higher carbon monoxide levels than traffic at other times. Meteorological conditions encountered during sampling were not necessarily the worst that could occur at this location. Unfavorable stable conditions would persist much longer into the morning rush period during the winter months than was the case in May, and values twice those recorded could have occurred if the prevailing windspeeds had been just half those encountered. On the other hand, vehicular carbon monoxide emission rates have decreased considerably since 1979 and in 1984 measured concentrations of carbon monoxide under the same meteorological conditions would likely be about 1 milligram per cubic meter lower than those measured in 1979.

To check this supposition and to evaluate potential maximum carbon monoxide concentrations that could occur in the future under worst case meteorological conditions a detailed carbon monoxide study has been carried out with results reported in the impact assessment portion of this report.

Carbon monoxide results from inefficient fuel combustion. Since most industrial sources are designed and maintained to utilize fuels very efficiently, they produce very little carbon monoxide. Thus the major industrial sources of particulates and sulfur dioxide in the West Beach area are not likely to contribute any significant amounts of carbon monoxide to the atmosphere.

Sugar cane fires, on the other hand, represent a form of uncontrolled combustion with the potential to produce substantial emissions of carbon monoxide. In general a cane fire produces 3.5 times more carbon monoxide than it does particulates. Using this relationship, Figures 3-5 can be converted to show that the isoline depicting 3000 micrograms per cubic meter of particlates also shows about 10 milligrams per cubic meter of carbon monoxide, which is the one hour State of Hawaii AQS. Figures 3-5 thus indicate that carbon monoxide concentrations in excess of the allowable State of Hawaii one hour limit can occur in some cases. The distance downwind within which the standard would be exceeded depends on existing basckground concentrations as well as individual characteristics of the fire and prevailing meterological conditions. Using the data from the three fires studied in Figures 3-5 and prevailing background values in the West Beach area of 1 to 3 milligrams per cubic meter of carbon monoxide, it appears that sugar cane fires have the capability to exceed State AQS to a downwind distance of about one mile.

It is possible, in fact, that the peak carbon monoxide concentration of 11 milligrams per cubic meter recorded during the 1972 Conoco Dillingham refinery study (Table 4) was the result of a cane fire. The late April sampling date is well within the cane burning season.

Aside from intermittent impacts from cane burning, however, prevailing levels of carbon monoxide in the proposed project area appear to be very low.

NITROGEN OXIDES

Nitrogen oxides resulting from high temperature combustion processes, are chiefly measured in the atmosphere as nitrogen dioxide, and are regulated only on an annual basis. At very high concentrations nitrogen dioxide has the potential to produce or enhance human respiratory ailments, but the pollutant has been regulated at significantly lower levels primarily because of its potential to react with other pollutants to produce more damaging secondary pollutants such as ozone.

In Hawaii the major sources of nitrogen dioxide are motor vehicles and steam electric power plants. Monitoring data from the DOH sampling station at Barbers Point indicates that values there were running well within allowable Federal and State AQS for those years prior to 1976 when sampling was discontinued.

By analogy to the modeling procedures used to estimate maximum values of particulates and sulfur dioxide in the West Beach area from the Kahe Power Plant complex, it can be seen from Table 5 that nitrogen dioxide emissions from power plants are about 34.6 percent of sulfur dioxide emissions. This means that the maximum one hour value of nitrogen dioxide in the West Beach area from the stacks at Kahe would be about 223 micrograms per cubic meter, with a maximum 24 hour level of about 41 micrograms per cubic meter and an annual average of no more than 4 micrograms per cubic meter. These modeling values not only compare well with measured levels at Barbers Point, but indicate that nitrogen dioxide levels in the West Beach area are well within allowable AQS.

OZONE

Ozone is a secondary pollutant formed as a result of photocatalytic reactions among primary air pollutants and normal constituents of the atmosphere. Primary precursors are hydrocarbons and nitrogen oxides. Sunlight is the photocatalyst. Ozone is a strong respiratory irritant and is representative of a large class of photochemical oxidants that can produce or aggravate a wide range of human respiratory ailments as well as severely damage vegetation and synthetic materials.

No ozone readings are available from the immediate vicinity of the proposed project, but ozone levels have been routinely measured by the Department of Health at sampling locations in downtown Honolulu and, more recently, at Sand Island, about 17 miles east of West Beach (Table 10).

Since ozone formation is related to mixing of pollutants over a wide area it is reasonable to conclude that measurements of ozone at Sand Island are representative of values that could occur at West Beach. From Table 10 it thus appears that ozone levels in the project area exceed allowable State of Hawaii AQS about twice per year, although highest levels recorded are well within the less stringent Federal AQS.

LEAD

Lead is a poisonous heavy metal that can become airborne as a particulate constituent of motor vehicle exhausts. The concentration of lead in vehicle exhausts is proportional to the amount of lead additive in the gasoline used for fuel.

To date no standard methodology has been implemented to assess airborne lead emissions and resulting concentrations. The only lead measurements available for a location near the proposed project are four samples collected in 1972 as part of the environmental assessment for the proposed Conoco-Dillingham Refinery at Campbell Industrial Park (Table 3). The maximum value of .55 micrograms per cubic meter was well within the allowable quarterly standard of 1.5 micrograms per cubic meter.

Airborne lead levels closer to Farrington Highway could be higher, however. A 10 year monitoring program of lead levels in the vicinity of urban highways conducted by the DOH (Table 11) shows at least one quarterly value above the allowable standard during the early years of the study (1971), but by 1980 measured lead levels appear to have declined to levels well within allowable limits.

Because of federal regulations the number of vehicles using leaded fuel has been steadily decreasing since 1972, and the Federal EPA is currently pushing for a change to the law that would totally eliminate leaded gasoline in the near future.

ODORS

Hawaii Meat Company maintains a feedlot operation at Campbell Industrial Park. Animal wastes from such operations can generate unpleasant odors.

In the processing of oil at refineries odorous compounds such as hydrogen sulfide and mercaptans can be produced.

While on-site efforts are usually effective in controlling these stockyard and refinery odors it is conceivable that some odors could travel as far as the proposed West Beach site at detectable levels. It is not very likely that this will occur, however, because the wind blows from Campbell Industrial Park towards West Beach only about 2 percent of the time, and when this particular wind direction occurs the atmosphere is generally unstable. Unstable atmospheric conditions favor rapid dispersion and dilution of airborne odors and it is therefore not likely that significant odor concentrations will persist after covering the 2 mile distance from Campbell Industrial Park to West Beach.

4. DIRECT AIR QUALITY IMPACT OF PROJECT CONSTRUCTION

Over the ten year construction phase of this project it is inevitable that a certain amount of fugitive dust will be generated by activities within the project area. Based on field measurements of such emissions from apartment and shopping center construction, an emission rate of 1.2 tons of dust per acre of construction, per month of activity has been estimated (6). This figure assumes medium-level activity, a moderate soil silt content, and a semi-arid climate. While those assumptions may fit the proposed project fairly well, it is nearly impossible to predict what fugitive dust emissions will be on a day to day basis.

Since the project area is fairly level, not much grading should be needed. On the other hand, a substantial amount of excavation or earthmoving might be required to construct such features as a golf course, lagoons, and a marina. It is assumed that most excavated materials can be used as fill at other locations within the project area and that transport of loose dirt beyond project boundaries will be minimized.

There will also be vehicular emissions from construction equipment being used on the job site. These emissions should be minor compared to pollutant levels produced by normal traffic on nearby roadways.

5. INDIRECT AIR QUALITY IMPACT OF INCREASED TRAFFIC

Once construction is completed the proposed project will not in itself constitute a significant direct source of air pollutants. The only emission sources within the project are likely to be the inevitable tiki torches in the resort area and fugitive cooking aromas.

By providing a significant residential and resort destination, however, the project must be considered to be a significant indirect air pollution source in that automobiles and other vehicles will be attracted to the location, generating a substantial number of trips that would not occur if the present use of the site were to remain unchanged.

Motor vehicles, especially those with gasoline-powered engines, are prodigious emitters of carbon monoxide. Significant increases in traffic volume can result in significant increases in carbon monoxide concentration, especially if such traffic volume increases cause congested conditions to develop when such conditions were not previously present.

Federal and State carbon monoxide AQS have been set for time periods of just one and eight hours because it is short term exposures to high concentrations that are most important from a human health standpoint. These time periods also correspond to peak periods of traffic volume.

Existing Federal air pollution control regulations call for decreasing vehicular carbon monoxide emission rates in future years. By 1995, carbon monoxide emissions from vehicles then operating are mandated to be just a little more than half the amounts now emitted.

In order to estimate present carbon monoxide levels in the project area and to evaluate the potential impact of different project-related traffic scenarios a detailed carbon monoxide diffusion modeling study has been carried out.

CARBON MONOXIDE DIFFUSION MODELING

Four critical receptor sites were selected for analysis: site 1 on the east side of the main roadway leading into the project; site 2 on the makai side of Farrington Highway just downstream in the Honolulu-bound direction from the primary interchange leading into the project; site 3 on the west side of the interior project road leading to the secondary interchange with Farrington Highway; and site 4 on the makai side of Farrington Highway downstream from both intersections in the Honolulu-bound direction. The location of these receptor sites is indicated on Figure 2.

Expected worst case concentrations of carbon monoxide at each of these locations were computed for morning peak hour conditions under four possible traffic scenarios. Case 1 is the no-build alternative; Case 2 is the build alternative with the addition of another surface arterial leading to H-1 via a route other than Farrington Highway; Case 3 is the build alternative with an additional traffic lane added to Farrington Highway from the secondary project interchange to H-1; and Case 4 is the build alternative with no change to the present Farrington Highway configuration other than intersection construction.

The traffic study for the project (7) uses 1982 as the year of project commencement and provides 1992 projections of traffic volume at the primary and secondary interchange with surface arterial (Figure 9) and without (Figure 10). Twenty year projections for the year 2002 were not provided, but volumes have been estimated using the same 7 percent per year increase for the next ten years.

Vehicle mix was assumed to be: 81% gasoline-powered light duty vehicles (automobiles); 14% gasoline-powered light duty trucks (pickups) and vans; 2% gasoline-powered heavy duty vehicles; 1% light duty diesel vehicles; and 2% heavy duty diesel vehicles. This vehicle mix is important in estimating vehicular air pollutant emission rates. Gasoline-powered vehicles are heavy emitters of carbon monoxide. Diesel-powered vehicles, on the other hand, emit very little carbon monoxide, but they have substantial nitrogen dioxide emission rates and produce unplesant odors and irritants such as sulfuric acid, aldehydes, phenols, and oxygenates.

By the year 2002 it has been estimated that the percentage of diesels in the vehicle fleet could increase to as much as 15%. Since the cost differential between gasoline and diesel fuel has been decreasing in recent years while gasoline-powered cars have at the same time been gaining in the fuel economy ratings, the disadvantages of higher initial cost, limited fuel availability, more frequent oil changes, and other inconveniences associated with diesel-powered vehicle ownership would seem to mitigate against any significant increase in the percentage of diesel-powered vehicles on the roadways in future years. It is therefore assumed that the vehicular mix in the West Beach area will remain essentially unchanged between now and 2002.

Vehicular carbon monoxide emission rates for the years studied were determined using EPA's computerized Mobile Source Emissions Model, MOBILE 2 (8). An ambient temperature of 68 degrees F was assumed with 20% of all vehicles operating in the cold start mode.

Intersections and traffic flow within the project are designed in such a way that no traffic controls will be required to move traffic into and out of the project from Farrington Highway. The primary interchange will have a modified cloverleaf design while the secondary interchange will allow project entry only from the extreme right hand Honolulu-bound traffic lane of Farrington Highway and project exit only in the Honolulu-bound direction (no left turns).

Vehicle speeds were varied according to traffic conditions. For vehicles entering the project from Farrington Highway in unrestricted flow during morning rush hour, speeds of 25 mph were assumed. For vehicles exiting the project onto Farrington Highway in the Honolulu-bound direction, speeds of only 5 mph were used. For vehicles exiting the project onto Farrington Highway in the offpeak direction, speeds of 15 mph were used. Vehicles on Farrington Highway were assumed to be traveling at 35 mph when hourly volume per lane was less than 500, 25 mph when volume was between 500 and 1000, and only 15 mph when volume was greater than 1000 per lane. It is realized that these speed restrictions are somewhat arbitrary and perhaps a little slower than those that might actually occur, but they provide a good indication of the effects of incresed traffic congestion on resulting carbon monoxide levels.

The EPA computer model HIWAY-2 (9) was used to calculate carbon monoxide concentrations at the selected receptor sites under each of the traffic scenarios. Stability category D was used for determining diffusion coefficients. This stability category is the most stable, and therefore least favorable, atmospheric condition that would be expected in a suburban area such as this.

To simulate worst case wind conditions a uniform windspeed of one meter per second was used with the worst case wind direction for site 1 from the north. For sites 2, 3, and 4, worst case wind direction was from the northeast, which is the prevailing direction in the West Beach area.

At each receptor site concentrations were computed at a height of 1.5 meters to simulate levels that would exist within the normal human breathing zone. Background concentrations of carbon monoxide from sources not directly considered in the analysis were assumed to be zero.

Results of the peak hour carbon monoxide analysis are presented in Table 12. At sites 1, 2, and 3 projected concentrations of carbon monoxide are expected to be within allowable State of Hawaii one hour carbon monoxide standards with or without the proposed project, but the traffic scenario which employs an alternative surface arterial is likely to produce lower concentrations of carbon monoxide. At site four, this difference becomes more significant in that Case 4 (with no changes to Farrington Highway) is predicted to lead to carbon monoxide levels in excess of the State one hour AQS.

Eight hour traffic volumes were not provided in the traffic analysis for the project, but it is herein estimated that the average hourly volume during eight hours will be about 80 percent of the peak hour volume. Eight hour carbon monoxide values are determined based on this average hourly traffic and the additional application of a 'meteorological persistence factor' of 0.6 recommended in EPA guidelines to account for the fact that meteorological dispersion conditions are likely to be more variable (and hence more favorable) over an eight hour period than they are for a one hour period.

Multiplying the projected peak hour carbon monoxide concentrations shown in Table 12 by a combined factor of about 0.48 will yield values that are about one half those shown in Table 12. The State of Hawaii eight hour AQS for carbon monoxide is also half the one hour standard, or 5 milligrams per cubic meter. Thus the conclusions reached above with regard to the one hour State of Hawaii carbon monoxide AQS will hold with respect to the eight hour standard as well.

All carbon monoxide concentrations calculated in the above analysis are well within the less stringent Federal one and eight hour AQS whether the project is constructed or not and no matter which traffic scenario is ultimately selected.

6. INDIRECT AIR QUALITY IMPACT OF INCREASED ENERGY USE

Energy requirements of an urban project have been estimated to be 800 million BTU per acre (10). This 642 acre project is therefore estimated to require an annual energy input of 513.6 billion BTU. One barrel of fuel oil has a potential energy production of 5.8 million BTU. This project is therefore likely to generate a requirement for consumption of an additional 88,600 barrels of fuel oil if its energy demands are met strictly by burning fuel oil.

The major impact of burning fuel oil to supply the future energy needs of West Beach will, rather ironically, be increased levels of sulfur dioxide in the West Beach area since the increased demand for energy is likely to be met by increased fuel comsumption at Kahe Power Plant.

If, however, the increased demand is met by an Ocean Thermal Energy Plant planned for a location off Kahe, or by windmills, or by geothermal energy delivered by pipeline from the Island of Hawaii, the effect on air quality of this increased energy demand could either be insignificant, or significant, but at a location far from West Beach.

7. MITIGATIVE MEASURES

SHORT TERM

As indicated by the foregoing anlaysis, the only direct adverse air quality impact that this proposed project is expected to create is the emission of fugitive dust during the 10-year construction period. Since some of the earliest structures are likely to be inhabited before construction of the entire project has been completed, a certain amount of effort will have to be directed toward preventing the creation of excessive amounts of fugitive dust. State of Hawaii DOH administrative rules stipulate the control measures that are to be employed to reduce this type of emissions. Primary control consists of frequent wetting-down of loose soil areas. An effective watering program can reduce particulate emissions from construction sites by as much as 50 percent. Other control measures include good housekeeping on the job site and possibly, erection of dust-catching barriers if nearby local residents are being subjected to excessive particulate concentrations.

LONG TERM

Once completed, this project, in itself is not expected to significantly affect air quality in the surrounding region. To the contrary, if any long term mitigative measures are required, they will be needed to reduce the exposure of future West Beach residents to air pollutant intrusions from sources outside the project boundaries. To a certain extent such impacts can be mitigated by the planting of landscaping vegetation that is likely to grow to be both tall and dense. Heavy plantings of trees and shrubs along the project boundaries can be effective in removing some pollutants such as particulates and carbon monoxide from the air. Landscaping along the edge of Farrington Highway and in the vicinity of proposed intersections can be especially effective in this respect.

Indirectly, it might be possible to mitigate potential air pollution impacts from the electrical power generating units of Kahe by designing dwellings within the project to be as energy efficient as possible. This could help to delay the date when it will be necessary to add units 7 and 8 to the complex. In fact, the use of solar and other 'clean' local energy sources within the project should be maximized since new demand for refined oil and manufactured gas from the Campbell Industrial Park could then be somewhat reduced as well.

Long range development plans for the Ewa area indicate that sugar cane will be gradually giving way to more urban and suburban development. As this happens, fugitive dust from unpaved cane haul roads and air pollutant emissions from cane fires will disappear. In the meanwhile, the State DOH has open burning control regulations which ban burning on days when meteorological conditions are deemed to be unfavorable for pollutant dispersion.

Any additions or significant changes to industrial emission sources in the West Beach area will have to conform to stringent Federal New Source Performance Standards and comply with requirements set forth in the State of Hawaii Prevention of Significant Deterioration program. One feature of this program requires the use of 'offsets'. If a new source of pollutants applies for a permit to construct in an area where it could cause a significant deterioration of existing air quality beyond a fixed incremental level, the permit may not be granted until existing sources are removed or shut down to an extent that matches or 'offsets' the requested emission increase.

In fact, in the final analysis, future residents of West Beach can only rely on governmental implementation and enforcement of existing air pollution laws to be assured protection from excessive levels of air pollution. To this end, it might prove beneficial if a new air pollutant monitoring station were to be established within the West Beach project area so that potential problems could be detected early and appropriate control actions initiated as quickly as possible. Relocation of the existing Barbers Point monitoring station to West Beach would serve the same purpose at very little additional cost.

8. SUMMARY

The proposed West Beach Project involves construction of a residential/resort community on a 642 acre parcel of land located between Barbers Point and Kahe Point in southwestern Oahu.

Federal and State of Hawaii Ambient Air Quality Standards (AQS) have been set for six classes of pollutants: particulates, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone and lead. For most pollutants the State of Hawaii AQS are considerably more stringent than Federal levels. Public hearings have been held on a proposal by the State Department of Health to revise State of Hawaii AQS for particulates and sulfur dioxide to match Federal levels, but a decision on the matter has not yet been announced.

Having previously been used for sugarcane growing, the project site is currently unused and emissions of air pollutants are therefore minimal. Significant outside air pollution sources that could affect air quality in the project area include periodic cane fires, traffic on Farrington Highway, stack emissions from the Kahe Power Plant, and fugitive and stack emissions from oil refineries and other industrial activities located in the Campbell Industrial Park.

Cane fires represent the only emission source likely to cause the current State of Hawaii AQS for particulates to be violated, but Federal AQS are not likely to be exceeded by this source.

Although measured levels of sufur dioxide at the Barbers Point long term monitoring station are very low, recent modeling studies indicate that sulfur dioxide concentrations in the vicinity of West Beach from both the Kahe Power Plant and sources within the Campbell Industrial Park could be in excess of allowable State of Hawaii AQS under unfavoable meteorological dispersion conditions. The same studies show that Federal limits are likely to met, however, and it is important to note that the geometry of the West Beach/Kahe/Campbell Industrial Park is such that it would be nearly impossible for air pollutant emissions from Kahe and Campbell Indusrial Park to affect West Beach at the same time. Further, surface winds from Kahe blow towards West Beach only about 3% of the time and those from Campbell Industrial Park blow toward West Beach only about 2% of the time.

Motor vehicles are the major source of carbon monoxide in the area. A monitoring program of traffic generated carbon monoxide conducted in 1979 indicated that levels of this pollutant along Farrington Highway were running about 1 to 3 milligrams per cubic meter. Federal laws have mandated substantial annual reductions in vehicular carbon monoxide emissions through 1995. A carbon monoxide modeling study carried out in conjunction with this report produced current worst case predictions of 1 to 3 milligrams per cubic meter in the same area as the previous monitoring study. These levels are well within the State of Hawaii AQS of 10 milligrams per cubic meter for a one hour period. At present sugar cane fires represent the only emission source capable of causing the AQS for carbon monoxide to be violated in the West Beach area.

Nitrogen dioxide levels in the project area appear to be much lower than allowable AQS. Ozone measurements show that levels in the leeward Oahu area have been exceeding the State of Hawaii limit for this pollutant at the rate of about twice per year for the last few years. Lead levels in the project area are estimated to be low and Federal regulations gradually curtailling the use of leaded gasoline seem to be having an effect in lowering measured lead levels throughout Oahu.

The major direct air quality impact of project development will be in the form of fugitive dust generated during the estimated 10 year construction period that will be required for project completion. Once the project is completed, however, it will no longer be a direct source of air pollutant emissions.

By serving as an attraction for increased vehicular traffic the project will constitute a potentially significant indirect source of increased carbon monoxide levels in the area. A detailed carbon monoxide modeling study of four locations near the primary and secondary project intersections with Farrington Highway evaluates the quantitative impact of each of four possible traffic scenarios: (1) no build; (2) build, with an additional surface arterial connecting the project to the H-1 Freeway via a route other than Farrington Highway; (3) build, with an extra surface lane added to Farrington Highway in the Honolulu-bound direction from the project to H-1; and (4) build, with no changes to Farrington Highway through 2002.

Carbon monoxide levels computed in the modeling study were all well below allowable Federal AQS, but model results did indicate that the build scenario with no changes to Farrington Highway could lead to a potential exceedence of State of Hawaii AQS at some point shortly before 2002. The other build alernatives appear to be acceptable strictly from a carbon monoxide standpoint, but the build alternative with an additional surface arterial to relieve potential Farrington Highway traffic congestion clearly presented the smallest carbon monoxide impact of any of the build alternatives.

The project could also have an indirect impact on air quality in the form of increased energy demand. A project of this size will require a substantial increase in fuel oil consumption at electric power plants if the demand is met solely by burning more fuel oil. Ironically, one probable impact of increased energy demands at West Beach will be increased levels of sulfur dioxide in the air over West Beach since the increased demand would most likely be met by the nearby Kahe Power Plant. Hawaiian Electric Company has several alternatives, such as offshore Ocean Thermal Energy Conversion, that could preclude this impact, however. The overall energy use of the project could also be decreased by planning for extensive use of solar and other 'clean' local energy sources within the project.

Another mitigative measure that might be employed to protect future inhabitants of West Beach from intrusions of pollutants from outside sources is heavy palnting of landscaping plants that will grow to be both tall and dense. It is also suggested that an air pollution monitoring station be established at West Beach so that potential problems can be detected early and appropriate control actions initiated as soon as possible.

In the final anlysis, future residents of West Beach will have to rely on governmental implementation and enforcement of existing air pollution control laws to be assured an acceptable level of air quality in their community.

REFERENCES

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7. Community Planninng, Inc., West Beach Resort Traffic Impact Analysis, December, 1983, revised July, 1983.

8. U.S. EPA, Users Guide to MOBILE 2: Mobile Source Emissions Model, February, 1981.

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10. California Dept of Transportation, Energy and Transportation Systems, December, 1978.

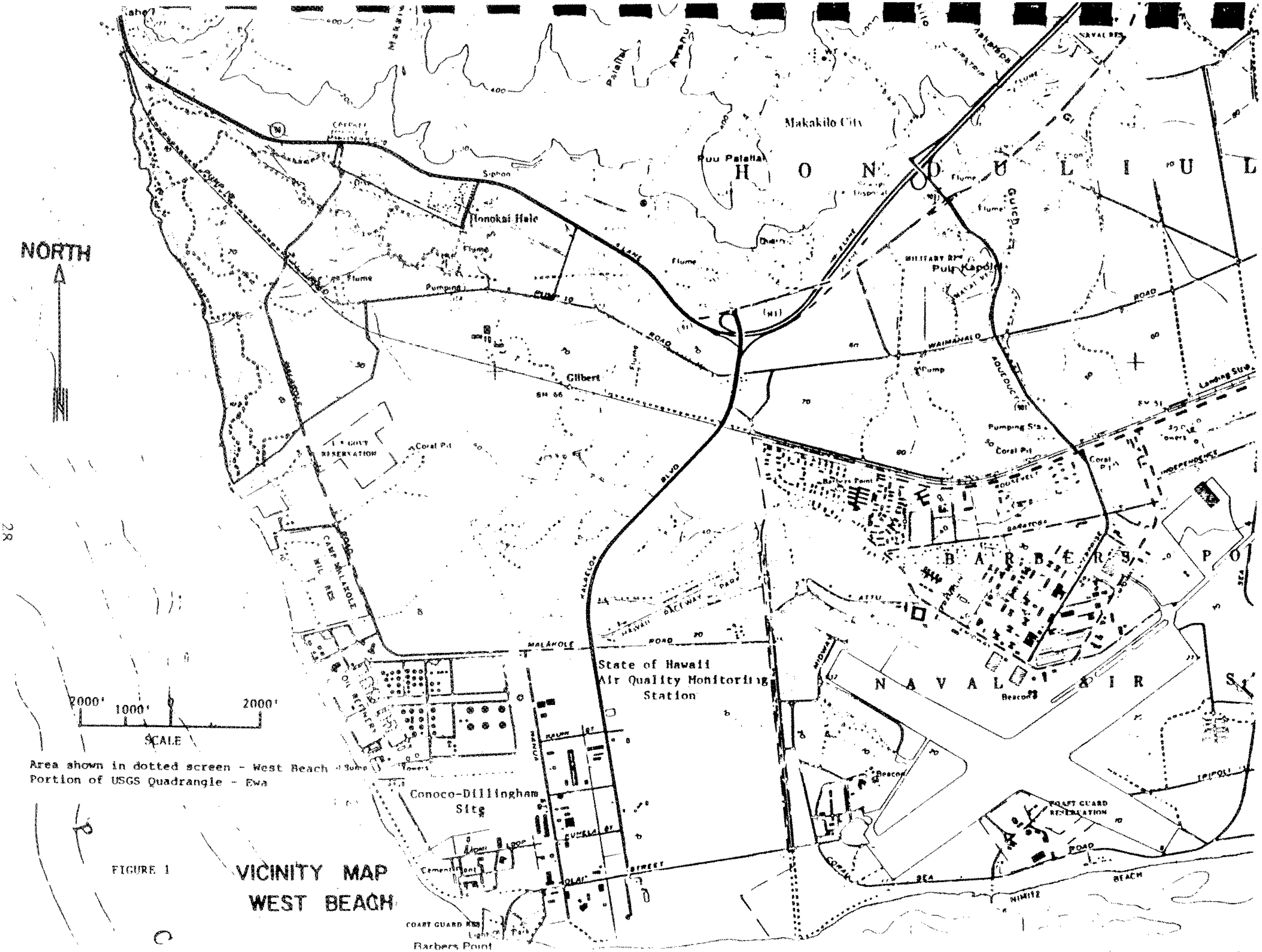
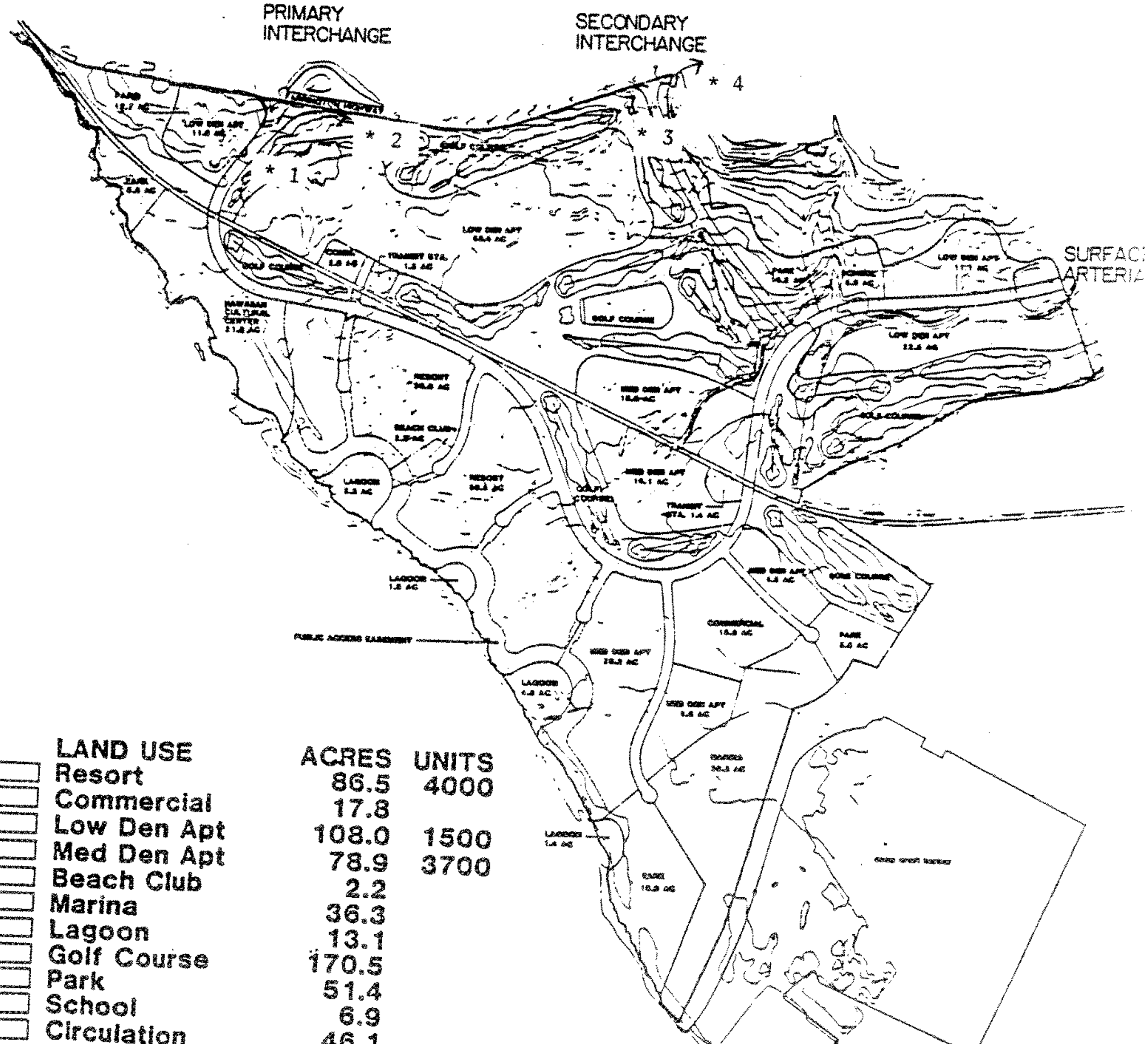


FIGURE 1

VICINITY MAP
WEST BEACH



LAND USE	ACRES	UNITS
Resort	86.5	4000
Commercial	17.8	
Low Den Apt	108.0	1500
Med Den Apt	78.9	3700
Beach Club	2.2	
Marina	36.3	
Lagoon	13.1	
Golf Course	170.5	
Park	51.4	
School	6.9	
Circulation	46.1	
Transit Station	2.7	
Hawn Cult Center	21.8	
TOTAL	642.2	9200

* LOCATION OF CARBON MONOXIDE RECEPTOR SITES

0 400 800 1600

WEST BEACH RESORT

FIGURE 2

MASTER PLAN

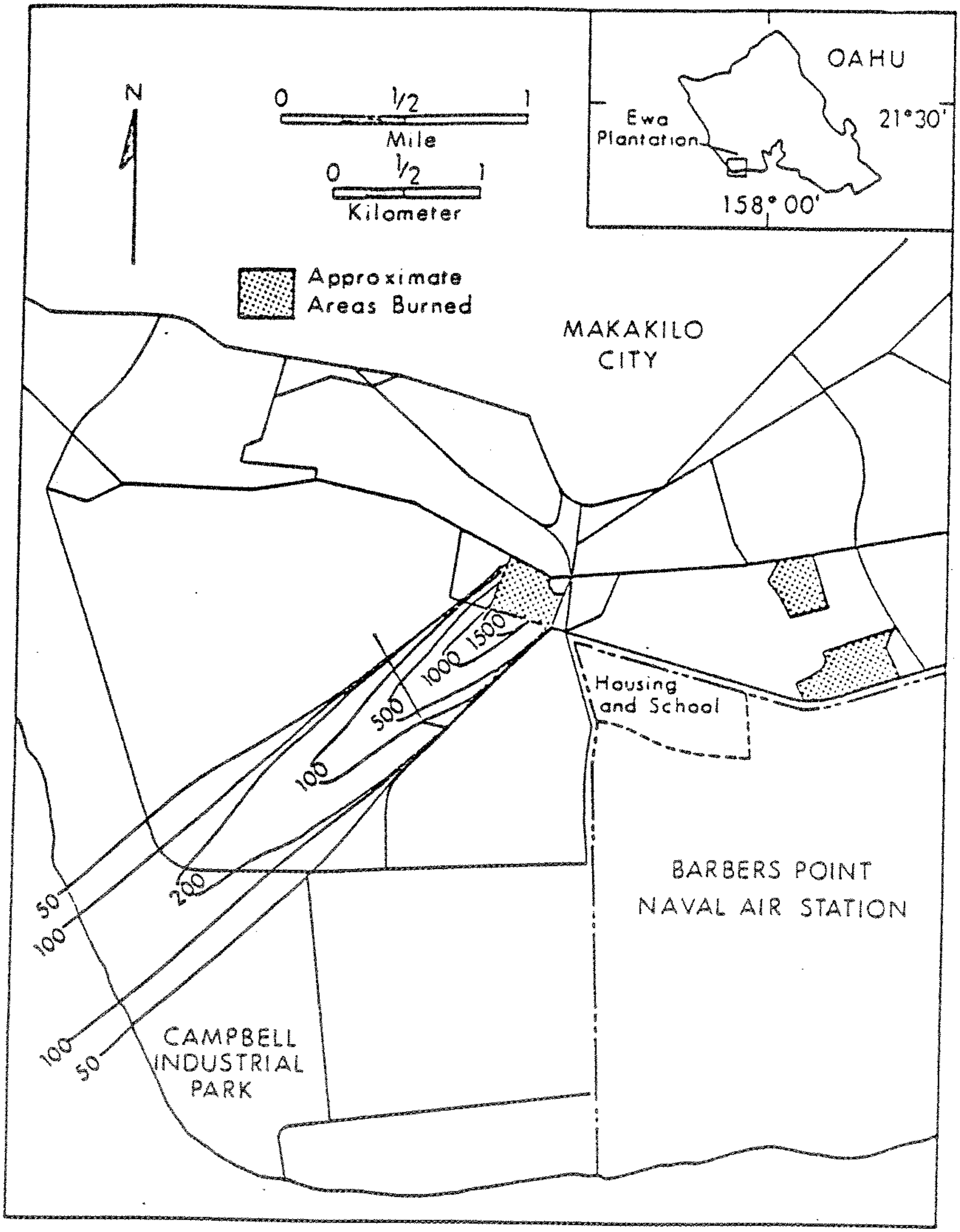


FIGURE 21

The Time-Weighted Average Isoline Pattern of Particulate Concentration (ug/m3), March 8, 1971 (0705 - 0813 HST)

SOURCE: Reference 2

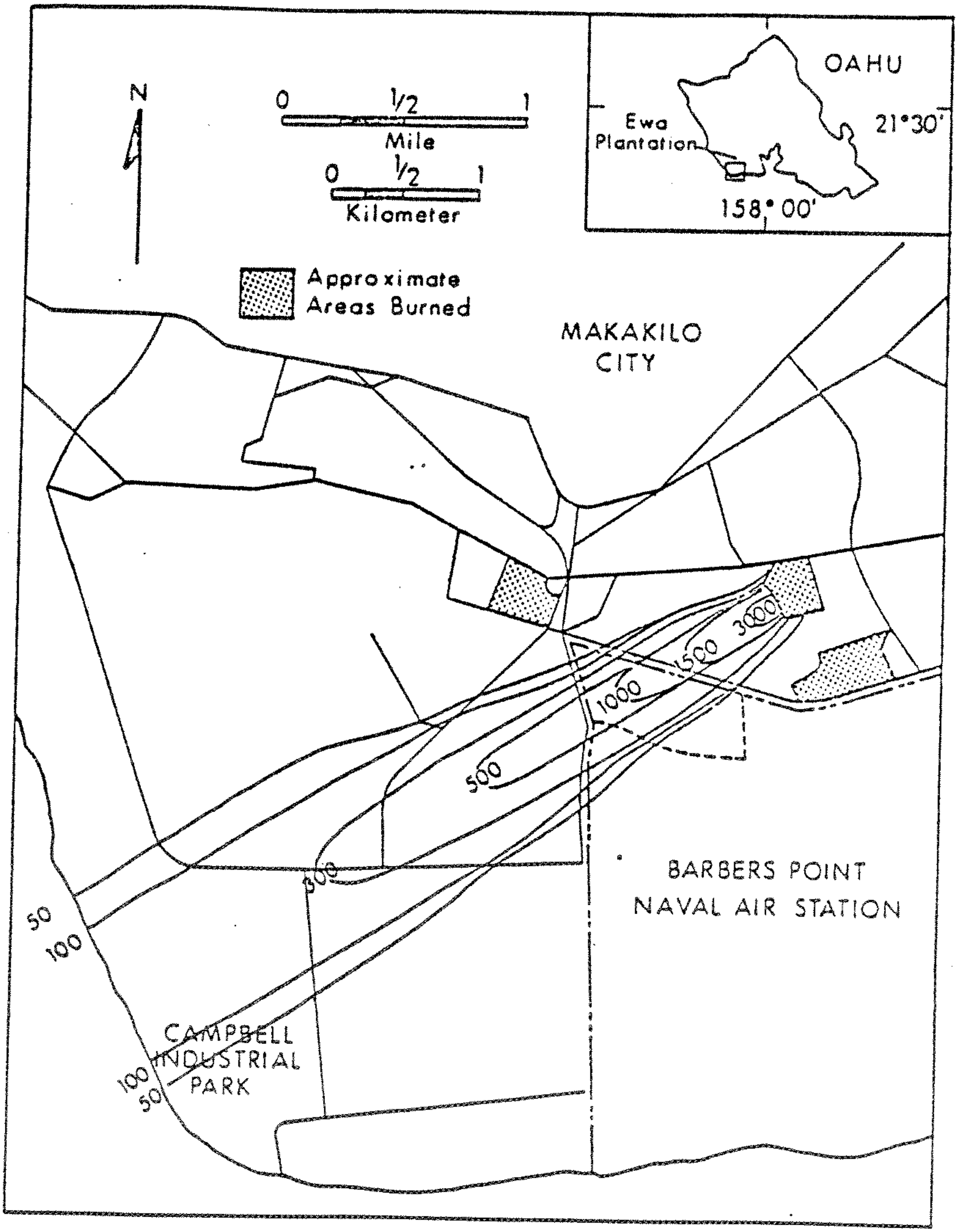


FIGURE ~~4~~ 22

The Time-Weighted Average Isoline Pattern of Particulate Concentration (ug/m3), March 10, 1971 (0700 - 0811 HST)

SOURCE: Reference 2

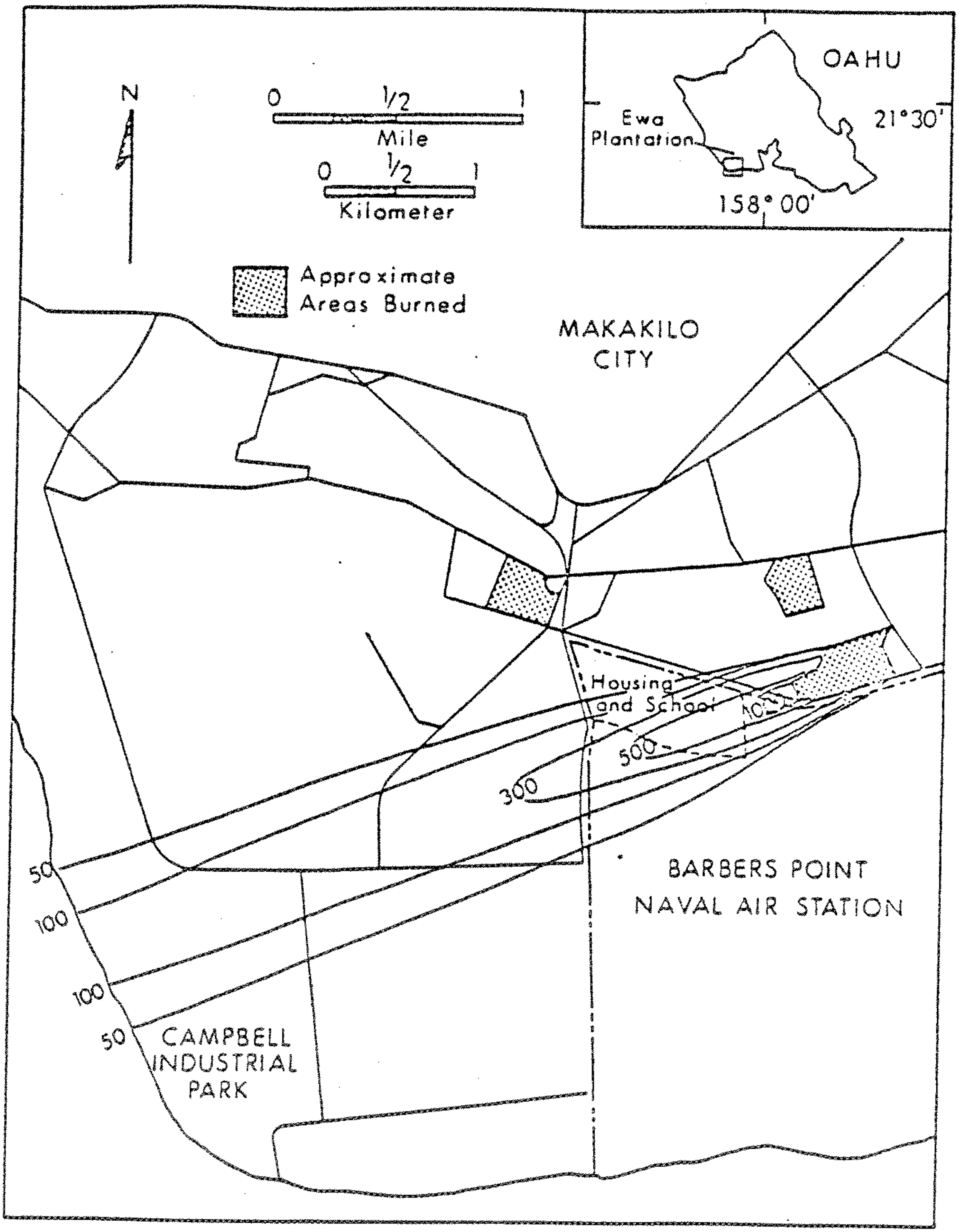
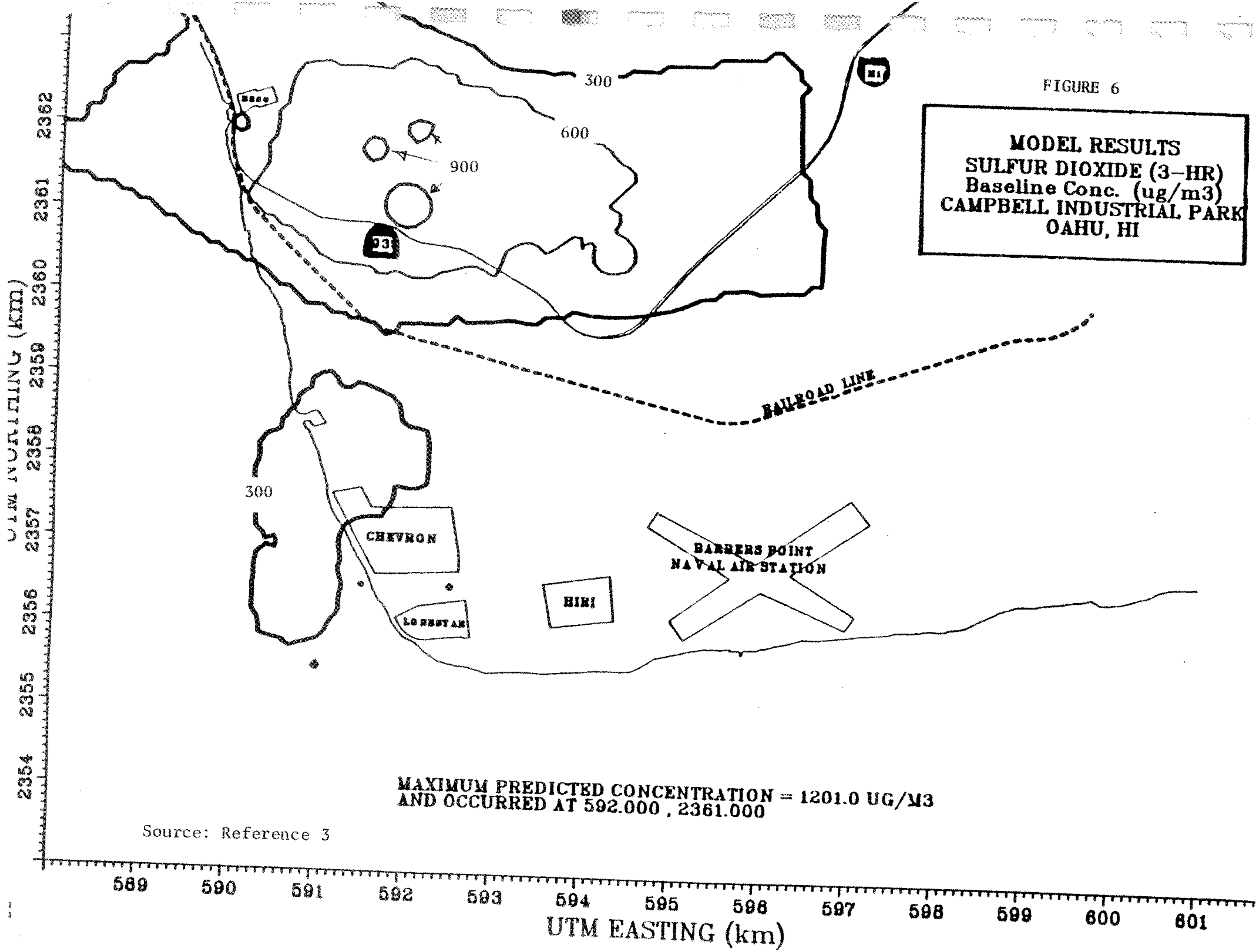


FIGURE 5 23

The Time-Weighted Average Isoline Pattern of Particulate Concentration (ug/m^3), March 12, 1971 (0640 - 0745 HST)

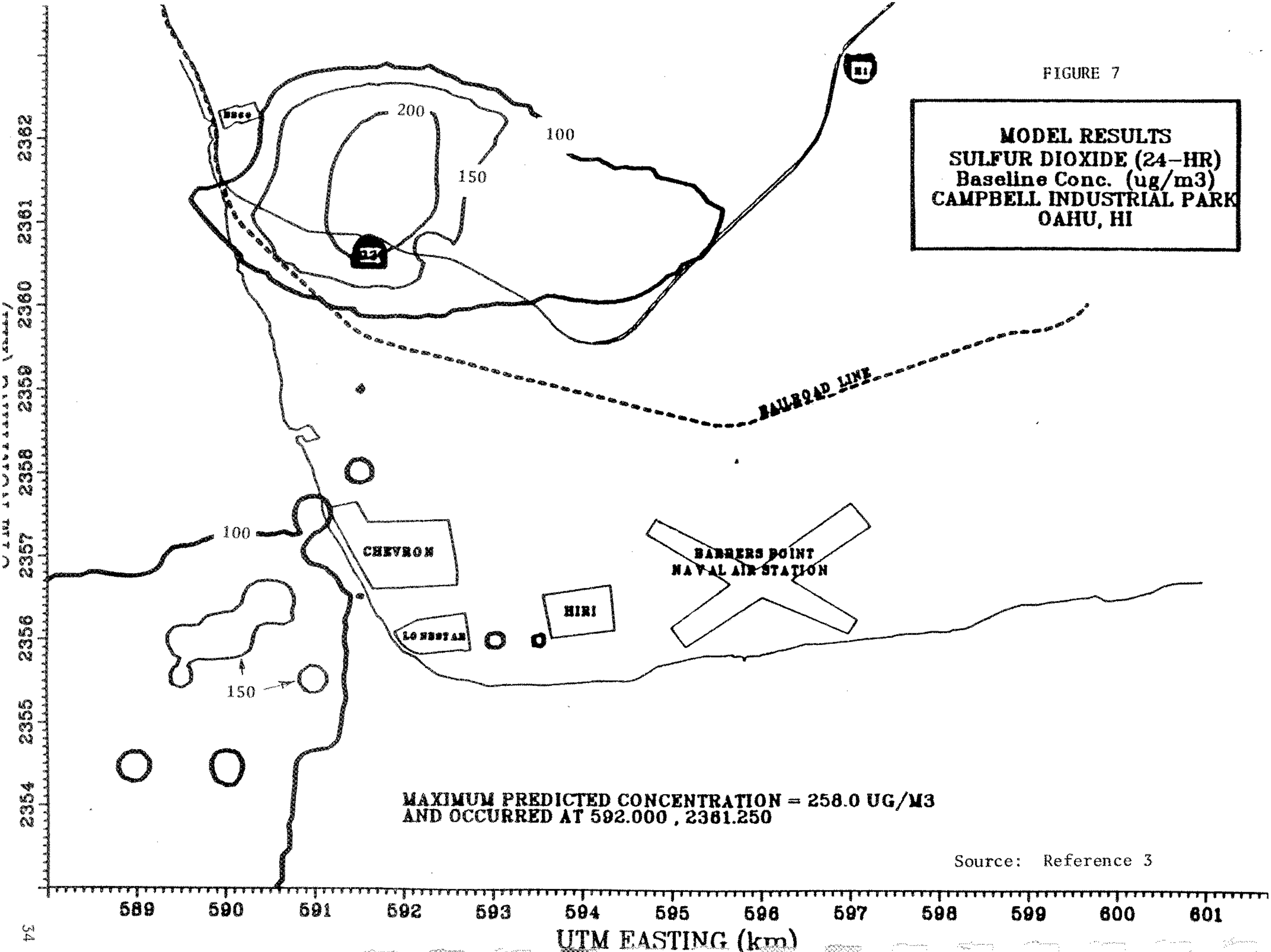
SOURCE: Reference 2

FIGURE 6



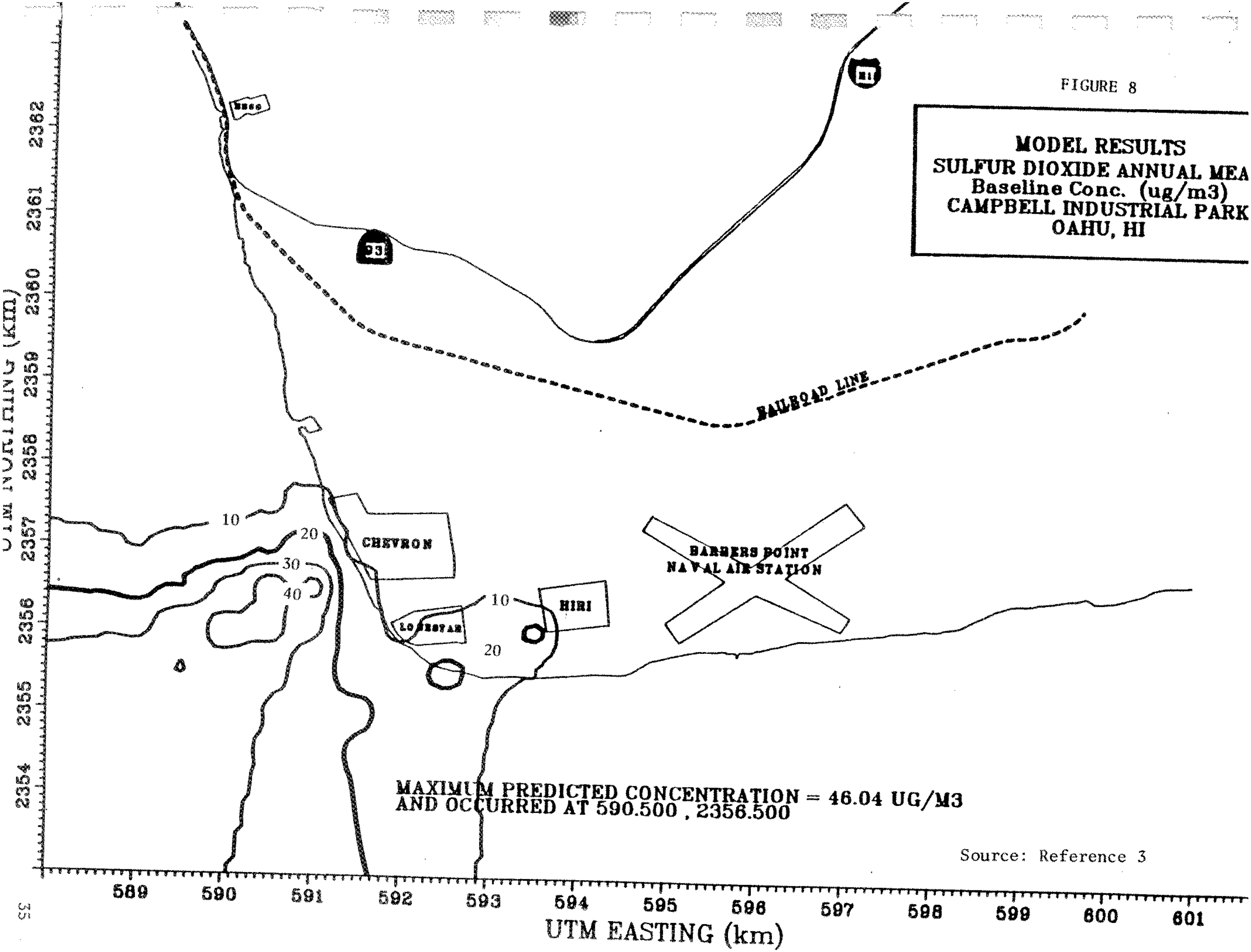
Source: Reference 3

FIGURE 7



Source: Reference 3

FIGURE 8



Source: Reference 3

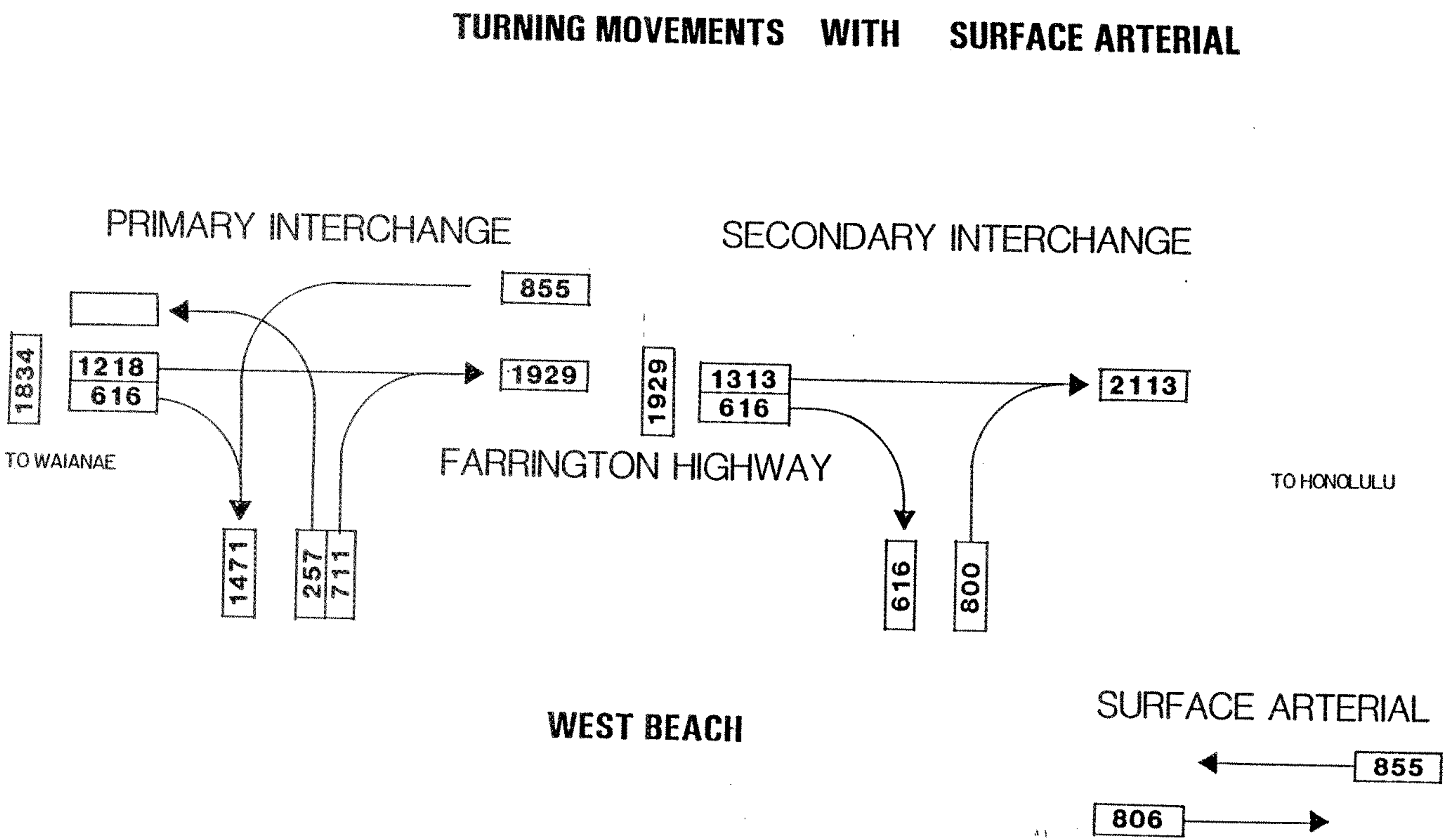

TURNING MOVEMENTS WITH SURFACE ARTERIAL
PRIMARY INTERCHANGE
SECONDARY INTERCHANGE
855
1834
1218
616
1929
TO WAIANAE
1471
257
711
1929
1313
616
2113
FARRINGTON HIGHWAY
616
800
TO HONOLULU
WEST BEACH
SURFACE ARTERIAL
855
806

FIGURE 9

TURNING MOVEMENTS WITHOUT SURFACE ARTERIAL

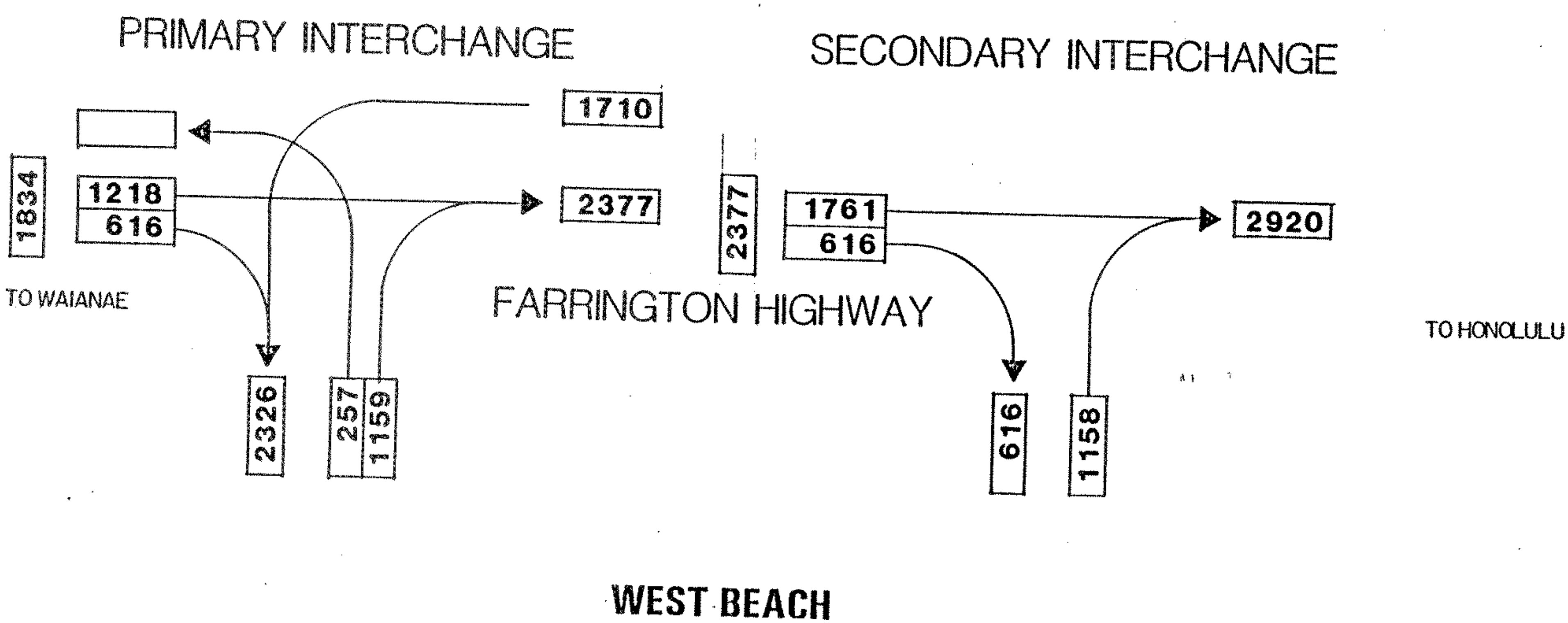


FIGURE 10

TABLE 1

SUMMARY OF HAWAII AND NATIONAL AMBIENT AIR QUALITY STANDARDS
(Micrograms per Cubic Meter)

<table>
<tr><th></th><th></th><th colspan="3">AMBIENT AIR QUALITY STANDARDS</th></tr>
<tr><th></th><th></th><th colspan="2">NATIONAL</th><th>HAWAII</th></tr>
<tr><th>POLLUTANT</th><th>SAMPLING PERIOD</th><th>Primary</th><th>Secondary</th><th></th></tr>
<tr><td>Particulates</td><td>Annual Geometric Mean</td><td>75</td><td>60</td><td>--</td></tr>
<tr><td></td><td>Annual Arithmetic Mean</td><td>--</td><td>--</td><td>55</td></tr>
<tr><td></td><td>Maximum 24-Hour Average</td><td>260</td><td>150</td><td>100</td></tr>
<tr><td>Sulfur Dioxide</td><td>Annual Arithmetic Mean</td><td>80</td><td>--</td><td>20</td></tr>
<tr><td></td><td>Maximum 24-Hour Average</td><td>365</td><td>--</td><td>80</td></tr>
<tr><td></td><td>Maximum 3-Hour Average</td><td colspan="2">1300</td><td>400</td></tr>
<tr><td>Nitrogen Dioxide</td><td>Annual Arithmetic Mean</td><td colspan="2">100</td><td>70</td></tr>
<tr><td>Ozone</td><td>Maximum 1-Hour Average</td><td colspan="2">240</td><td>100</td></tr>
<tr><td>Carbon Monoxide</td><td>Maximum 8-Hour Average</td><td colspan="2">10</td><td>5</td></tr>
<tr><td></td><td>Maximum 1-Hour Average</td><td colspan="2">40</td><td>10</td></tr>
<tr><td>Lead</td><td>Calendar Quarter</td><td colspan="2">1.5</td><td>1.5</td></tr>
</table>

Notes: 1. Carbon Monoxide Standards are in milligrams per cubic meter.
2. National Standards based on 40 CFR Part 50; Hawaii Standards based on Title 11, Administrative Rules, Chapter 59.

TABLE 2

SUMMARY OF MEASUREMENTS FROM BARBERS POINT
(micrograms per cubic meter)

	SUSPENDED PARTICULATES			SULFUR DIOXIDE			NITROGEN DIOXIDE		
YEAR	RANGE	MEAN	>AQS	RANGE	MEAN	>AQS	RANGE	MEAN	>AQS
1971	18-471	125	54	<5-16	<5	0	<20-49	29	0
1972	24-155	55	4	<5- 7	<5	0	<20-49	21	0
1973	14-129	50	1	<5- 5	<5	0	<20-33	<20	0
1974	23-132	47	1	<5-10	<5	0	<20-40	25	0
1975	13-137	52	1	<5-11	<5	0	<5-25	11	0
1976	12-101	40	1	<5- 7	<5	0	<5-29	14	0
1977	25-134	54	1	<5-18	<5	0			
1978	22-127	48	1	<5-40	<5	0			
1979	23-223	76	10	<5-27	<5	0			
1980	29-158	53	2	<5-10	<5	0			
1981	26-188	51	2	<5-40	<5	0			
1982	15- 63	41	0	<5-12	<5	0			
1983	28-193	54	2	<5-95	<5	1			

AMBIENT AIR QUALITY STANDARDS

	SUSPENDED PARTICULATES	SULFUR DIOXIDE	NITROGEN DIOXIDE
24 HOUR	Fed 150 State 100	Fed 365 State 80	NONE
ANNUAL	Fed 60 State 55	Fed 80 State 20	Fed 100 State 70

NOTE: >AQS means number or readings greater than State of Hawaii AQS

Source: State of Hawaii Department of Health

TABLE 3

ANALYSIS OF PARTICULATE MATTER ON HIGH VOLUME AIR FILTERS AT CONOCO-DILLINGHAM REFINERY SITE

Date	Fe ($\mu g/m^3$)	Cu ($\mu g/m^3$)	Cr ($\mu g/m^3$)	Ni ($\mu g/m^3$)	Be ($\mu g/m^3$)	As ($\mu g/m^3$)	V ($\mu g/m^3$)	Hg ($\mu g/m^3$)	B ($\mu g/m^3$)	Pb ($\mu g/m^3$)	Se ($\mu g/m^3$)
2/09/72	0.480	0.020	<0.001	0.016	0.002	<0.16	0.016	0.0030	N.D. [a]	0.278	N.D.
2/11/72	0.822	0.034	<0.001	0.018	0.006	<0.16	0.018	0.0001	N.D.	0.396	N.D.
4/24/72	1.420	0.047	<0.001	0.029	<0.001	<0.02	<0.001	0.0001	<0.001	0.552	0.001
4/28/72	0.757	0.046	<0.001	0.026	<0.001	<0.02	<0.001	0.0001	<0.001	0.167	0.001

[a] N.D. = Not Determined.

SOURCE: Reference 1, 1972.

TABLE 4

RESULTS OF AIR POLLUTANT MONITORING AT CONOCO-DILLINGHAM REFINERY SITE

Pollutant	Averaging Time	Hawaii Air Quality Standard	Barbers Point Concentration			
			2/09/72	2/11/72	4/24/72	4/28/72
Sulfur Oxides as SO_2	24 hours	80 μg/m^3	<6 μg/m^3	<6 μg/m^3	<6 μg/m^3	<5 μg/m^3
Nitrogen Oxides as NO_2	24 hours	150 μg/m^3	13 μg/m^3	18 μg/m^3	10 μg/m^3	9 μg/m^3
Carbon Monoxide	1 hour	10 mg/m^3	N. D. [a]	N. D.	11 mg/m^3 [b]	2 mg/m^3 [b]
Particulate Matter	24 hours	100 μg/m^3	31 μg/m^3	45 μg/m^3	25 μg/m^3	36 μg/m^3

[a] N. D. = Not Determined.
[b] Highest carbon monoxide concentration measured during each 24-hour sampling period.

SOURCE: Reference 1, 1972.

TABLE 5

CY 1980 EMISSION INVENTORY

State of Hawaii

Percent of Total Emissions Statewide

Source Category	TSP	SO_x	NO_x	CO	HC
Steam Electric Power Plants	9.2	75.8	29.6	0.4	0.6
Gas Utilities	0.1	0.0	0.4	0.0	0.0
Fuel Combustion in Agricultural Industry	24.8	3.5	3.9	0.0	0.1
Refinery Industry	2.0	12.4	4.1	0.1	5.4
Petroleum Storage	0.0	0.0	0.0	0.0	3.7
Metallurgical Industries	0.1	0.2	0.1	0.0	0.0
Mineral Products Industry	29.8	3.4	1.3	0.0	0.1
Municipal Incineration	0.1	0.3	3.8	0.0	0.4
Motor Vehicles	7.4	2.5	45.5	78.5	66.7
Construction, Farm, and Industrial Vehicles	1.0	0.5	6.4	1.5	1.2
Aircraft	1.4	0.3	3.8	2.2	3.9
Vessels	0.3	1.1	1.1	0.1	0.4
Agricultural Field Burning	23.8	0.0	0.0	17.2	17.5
TOTAL IN PERCENT	100.0	100.0	100.0	100.0	100.0
TOTAL IN TONS PER YEAR	27,497	57,074	53,297	427,708	48,097

Source: STATE OF HAWAII DEPT OF HEALTH

TABLE 6

PARTICULATE AND SULFUR DIOXIDE EMISSION RATES FOR SIGNIFICANT INDUSTRIAL SOURCES IN THE WEST BEACH AREA

SOURCE	EMISSION RATE (g/sec)	
	PARTICULATES	SULFUR DIOXIDE
Hawaiian Electric Kahe Units 1 - 6	Not Available	411.3
Chevron Refinery	11.08	187.49
Hawaiian Indipendent Refinery (HIRI)	2.68	51.66
Hawaiian Western Steel	8.0	0.5
Lonestar Hawaiian Cement	2.0	0.02
ENERCO	0.15	0.12
Barbers Point NAS (boilers)	0	0.18

Source: Reference 3, 1983

TABLE 7

MEAN WIND DIRECTION FREQUENCIES OF OCCURRENCE
FOR LOCATIONS NEAR THE WEST BEACH AREA (Percent)

DIRECTION	(DEGREES)	BARBERS POINT (1949-1972)	KAHE POWER PLANT (1973-1976)
N	0	3.1	3.5
NNE	22.5	13.3	4.4
NE	45.0	34.4	10.4
ENE	67.5	23.1	19.8
E	90.0	7.0	14.9
ESE	112.5	2.5	6.0
SE	135.0	3.0	4.7
SSE	157.5	1.9	2.8
S	180.0	2.3	2.6
SSW	202.5	1.5	3.3
SW	225.0	1.5	4.9
WSW	247.5	1.1	5.8
W	270.0	1.5	5.6
WNW	292.5	0.8	4.5
NW	315.0	0.5	3.5
NNW	337.5	0.4	3.2
CALM	-	1.9	*

*Calm winds allocated proportionally to each directional percentage.

SOURCE: Reference 4

TABLE 8

MAXIMUM SULFUR DIOXIDE CONCENTRATIONS:
MODELING RESULTS FOR WEST BEACH AREA

TIME PERIOD	FROM CAMPBELL INDUSTRIAL PARK highest	second highest	FROM KAHE UNITS 1-6 maximum	FEDERAL AQS	STATE AQS
3 Hour	1355	1201	492	1300	400
24 Hour	313	258	113	365	80
Annual	46	-	11	80	20

Notes: See reference 3 for modeling technique used in the Campbell Industrial Park study. Comparison to Federal AQS is based on second highest modeled concentration. In the Campbell Industrial Park modeling study, highest concentrations occurred in elevated terrain just across Farrington Highway from West Beach (see Figures 6 - 8). Maximum concentrations from Kahe were calculated for the center of the West Beach project site. See text for modeling technique used. All values are in micrograms per cubic meter.

TABLE 9

RESULTS OF CARBON MONOXIDE MONITORING
FARRINGTON HIGHWAY AT ENTRANCE TO WEST BEACH

May, 1979

PART I. WEEKDAY MORNINGS

DATE	DAY	HOUR	TRAFFIC COUNT To Honolulu	TRAFFIC COUNT To Waianae	WIND[a] DIRECTION/SPEED (KTS)	STABILITY	CARBON MONOXIDE (mg/m^3)
5/4	Fri	0600-0615					
		0615-0630	334	124	04/06	E	2.9
		0630-0645					2.3
		0645-0700	292	178	03/09	C	2.3
		0700-0715					2.4
		0715-0730	263	175			2.2
		0730-0745			03/10	C	2.1

PEAK ONE-HOUR AVERAGE: 2.5

DATE	DAY	HOUR	TRAFFIC COUNT To Honolulu	TRAFFIC COUNT To Waianae	WIND[a] DIRECTION/SPEED (KTS)	STABILITY	CARBON MONOXIDE (mg/m^3)
		0500-0515			05/03	E	2.3
		0515-0530	189	18			2.0
		0530-0545					2.0
		0545-0600	348	57	04/02	E	2.9
		0600-0615					2.3
		0615-0630	395	121			2.9
		0630-0645					2.8
		0645-0700	285	155	CALM	B	2.3
		0700-0715					2.2
		0715-0730	259	163			2.9
		0730-0745			06/02	B	

PEAK ONE-HOUR AVERAGE: 2.7

DATE	DAY	HOUR	TRAFFIC COUNT To Honolulu	TRAFFIC COUNT To Waianae	WIND[a] DIRECTION/SPEED (KTS)	STABILITY	CARBON MONOXIDE (mg/m^3)
5/11	Fri	0500-0515	152	10	05/03	E	
		0515-0530	185	23			2.3
		0530-0545	255	35			2.3
		0545-0600	310	51	05/04	E	2.8
		0600-0615	384	53			2.8
		0615-0630	432	127			3.5
		0630-0645	329	174			2.9
		0645-0700	310	155	05/04	B	3.2
		0700-0715	279	128			2.9
		0715-0730					
		0730-0745			03/04	B	

PEAK ONE-HOUR AVERAGE: 3.1

TABLE 9
Continued

PART II. WEEKDAY AFTERNOONS

DATE	DAY	HOUR	TRAFFIC COUNT To Honolulu	TRAFFIC COUNT To Waianae	WIND[a] DIRECTION/SPEED(KTS)	STABILITY	CARBON MONOXIDE (mg/m^3)
5/2	Wed	1615-1630					1.7
		1630-1645	140	330			1.8
		1645-1700			07/08	B	2.1
		1700-1715	135	295			2.4
ONE-HOUR AVERAGE: 2.0							
5/7	Mon	1545-1600	192	438	07/08	B	
		1600-1615					2.2
		1615-1630	138	339			2.1
		1630-1645	143	335			2.2
		1645-1700			06/08	B	2.1
		1700-1715	130	259			2.0
PEAK ONE-HOUR AVERAGE: 2.2							
5/9	Wed	1445-1500			12/08	B	
		1500-1515	232	177			2.1
		1515-1530	237	201			1.5
		1530-1545	266	310			1.7
		1545-1600	170	406	12/10	B	1.7
		1600-1615	144	369			1.5
		1615-1630	138	359			1.5
		1630-1645					1.4
		1645-1700	116	319	12/10	B	1.7
PEAK ONE-HOUR AVERAGE: 1.8							

PART III. SATURDAYS

DATE	DAY	HOUR	TRAFFIC COUNT To Honolulu	TRAFFIC COUNT To Waianae	WIND[a] DIRECTION/SPEED(KTS)	STABILITY	CARBON MONOXIDE (mg/m^3)
5/5		0945-1000			04/11	B	
		1000-1015	181	162			
		1015-1030					1.8
		1030-1045	163	179			2.2
		1045-1100			06/11	B	1.8
		1100-1115	171	204			1.7
		1115-1130					2.2
		1130-1145	154	183	04/11	B	2.1
5/12		1315-1330	162	210			
		1330-1345					2.1
		1345-1400	137	232	07/11	B	2.1
		1400-1415	176	212			2.1
		1415-1430	147	198			1.9
		1430-1445	170	206			1.8
		1445-1500	162	194	05/10	B	1.4

TABLE 9
Continued

DATE	DAY	HOUR	TRAFFIC COUNT To Honolulu	To Waianae	WIND[a] DIRECTION/SPEED(KTS)	STABILITY	CARBON MONOXIDE (mg/m^3)
5/12	Sat	1500-1515	156	220			1.5
		1515-1530	197	196			1.9
		1530-1545	187	207			1.8
		1545-1600	221	217	08/07	B	1.6
		1600-1615	223	228			1.9
		1615-1630					1.9
		1630-1645	223	204			
		1645-1700			10/06	B	

PEAK ONE-HOUR AVERAGE: 2.1

[a] From Barbers Point Naval Air Station

TABLE 10

LONG TERM OZONE MONITORING IN URBAN HONOLULU
ONE HOUR SAMPLES (MICROGRAMS PER CUBIC METER)

YEAR	No. of Samples	Range of Values	Average	No. of times State of Hawaii AQS exceeded
1974	59	6-122	40	2
1975	234	6- 65	25	0
1976	322	2-127	40	1
1977	300	4- 61	25	0
1978	284	10- 84	33	0
1979	338	10- 80	39	0
1980	295	10- 84	48	0
1981	314	10-104	37	1
1982	335	0-151	32	2
1983	349	0-123	47	2

Air Quality Standards: Federal = 240
Hawaii = 100

Notes: Sampler moved from DOH building at Punchbowl and Beretania Streets in Honolulu, to Sand Island, December 11, 1980.

Source: State of Hawaii Department of Health

TABLE 11

Lead Monitoring Data, Honolulu, 1970-81

YEAR	AVERAGE CONCENTRATION (micrograms/cubic meter) 1st QUARTER	2nd QUARTER	3rd QUARTER	4th QUARTER	ANNUAL MEAN
1970	0.78	0.81	0.65	0.92	0.79
1971	1.65	0.63	0.65	1.05	1.00
1972	—	0.75	0.65	0.48	—
1973	0.52	0.52	0.72	0.55	0.58
1974	0.84	0.61	0.70	0.92	0.77
1975	0.65	0.81	0.59	1.05	0.78
1976	0.91	0.65	0.99	1.00	0.89
1977	0.89	0.59	0.48	0.80	0.71
1978	—	—	—	0.72	0.72
1979	0.39	0.25	0.26	0.42	0.33
1980	0.41	0.23	0.21	0.20	0.26
1981	0.25	—	—	—	0.25

Source: State of Hawaii
Department of Health

TABLE 12

RESULTS OF PEAK HOUR CARBON MONOXIDE ANALYSIS
(milligrams per cubic meter)

	1982	1992	2002
SITE 1			
Case 1	0.9	0.8	1.7
Case 2		5.3	5.6
Case 3		5.3	5.6
Case 4		7.8	7.8
SITE 2			
Case 1	2.7	2.3	5.1
Case 2		3.5	6.5
Case 3		4.8	8.8
Case 4		5.1	9.6
SITE 3			
Case 1	1.5	1.2	2.8
Case 2		5.4	6.3
Case 3		5.5	7.7
Case 4		8.2	9.7
SITE 4			
Case 1	2.8	2.3	5.1
Case 2		3.7	7.5
Case 3		6.6	10.0
Case 4		6.7	10.9

STATE OF HAWAII AQS: 10
FEDERAL AQS: 40

NOTES: See Figure 2 for location of receptor sites.
Case 1 = no build
Case 2 = build, with surface arterial over route other than Farrington Highway
Case 3 = build, with additional traffic lane on Farrington Highway
Case 4 = build, no change to Farrington Highway

APPENDIX I SECTION 4

May 12, 1984

Mr. F. J. Rodriguez, President
Environmental Communications, Inc.
P.O. Box 536
Honolulu, HI 96809

Dear Mr. Rodriguez:

Following is a summary of my studies of the birds of West Beach, Oahu.

I studied (12 field days) all habitats in the West Beach area during the fall of 1973 (October 27 to November 18, 1973); I repeated my study during April and May 1979; and on October 3, 1979, I visited the area with Ms. Jenny Peterson in order to identify sinkholes in the limestone formation there.

During this field work, I identified 14 species of exotic or introduced birds. None of these is an endangered species, and several have proven to be serious pests on agricultural crops in the Hawaiian Islands. Moreover, most of these species adapt well to both urban and rural areas. The proposed construction at the West Beach site will have no adverse effects on any of these introduced birds.

I found only two species of migratory shorebirds: the Golden Plover (Pluvialis dominica fulva) and the Wandering Tattler (Heteroscelus incanum). Neither are endangered species and both are common winter residents in the islands. The plover is an abundant winter resident, being found on the lawn around the State capitol building, as well as in mountain pastures. The tattler frequents beaches and tidal pools. The proposed construction will have no adverse effects on either of these migratory birds.

The Pueo or Hawaiian Owl (Asio flammeus sandwichensis) is now classified as an "endangered" species by the State Division of Forestry and Wildlife (although not by the Federal Fish & Wildlife Service). It is possible that it forages over the West Beach area although I did not see any during my field studies in 1973 or 1979. The owl prefers grassland areas and not sugarcane fields or kiawe thickets at low elevations. Therefore, it is my opinion that the proposed construction will not impact adversely on the Pueo.

There are no suitable ponds, marshes, or other wetland areas in the West Beach area to accomodate any of the endemic Hawaiian waterbirds. Hence, they are not found in this region. Similarly, there is no habitat for the endangered Hawaiian forest birds.

Sincerely,

A. J. Berger

Andrew J. Berger
1349 Kainui Drive
Kailua, HI 96734

BIRDS OF WEST BEACH

Region Follow-up Report
April-May 1979

Ewa, Oahu

Revised August 27, 1979

Report by:
Andrew J. Berger

TABLE OF CONTENTS

This report updates the information given in my November 1973 study of the birds found in the West Beach Region of Oahu. I am familiar with the dominant exotic plants found in dry habitats in Hawaii and discussed them in relationship to the birds in the 1973 report. At this time, however, the plants are being studied by a botanical consultant. I found only the same bird species given in my November 1973 report. A discussion of these follows. The sequences of bird families follows Van Tyne and Berger (1976).

Birds of the West Beach Area. Two general groups of birds are found in the West Beach area: migratory shorebirds and introduced or exotic species. It is possible that the Hawaiian Owl or Pueo (*Asio flammeus sandwichensis*) occurs in the dry leeward regions but I did not see any during my study, either in 1973 or 1979. The scant native vegatation in the dry leeward areas of Oahu was destroyed so long ago that there are no records of any other endemic landbirds that may have occupied such habitat, that is, prior to 1786 (Berger 1972; Charles H. Lamoureux, personal communication). There are no suitable ponds or marshes in the West Beach area to accommodate the endemic Hawaiian water birds.

I made an intensive study (12 field days) of all habitats in the West Beach area during the fall of 1973. The nesting season had ended for most species and they were quiet and inconspicuous. Under such conditions it is not possible to estimate accurately the numbers of birds per square mile or other unit of measurement; numbers given would be sheer guesses. During April and May of 1979, I stopped the field work after four days because I found no species that I had not identified during 1973. All but two of these species (Golden Plover and Wandering Tattler) are exotic birds that have been introduced to the Hawaiian Islands. The West Beach area contains several diverse habitats (e.g., shoreline, kiawe thickets, sugarcane fields) so that an estimate of abundance (other than rare, uncommon, common, and abundant) of most species would be misleading because few of the species are of any concern in relationship to the Endangered Species Act of 1973 (16 U.S.C. $1531 *et seq*, 1974) and some of these species have, in the past, caused considerable damamge to agricultural crops in Hawaii, and, therefore, often are serious nuisance birds. I do plan to do further field work at the West Beach site as soon as information on sink holes is provided by the Archaeology consultant.

On all field trips, transects were walked slowly in all major habitats (e.g., shoreline, kiawe thickets, cane roads); I recorded in a field notebook the species seen or heard as well as their particular activity at the time (e.g., feeding, singing, perching quietly, flying, etc.). This made it possible to estimate relative abundance of each bird species. Map 1 shows the transects I studied.

The migratory shorebirds. These are birds that spend the breeding season in Alaska (and/or Siberia) and then migrate to Hawaii for the nonbreeding season. I observed only two such species in the West Beach area, both in very small numbers.

Family Charadriidae, Plovers, Turnstones, Surfbirds

1. Pacific Golden Plover (Pluvialis dominica fulva). This is a very common winter resident in the Hawaiian Islands, being found from sea level to approximately 10,000 feet elevation on Maui and Hawaii. It inhabits pastures, golf courses, city lanes, cutover sugarcane fields, and other disturbed or weedy areas. The cutover cane fields at West Beach were very dry on most visits during the period of my 1973 study, and I never saw more than six Golden Plover on any one day. During 1979, cane of different ages was growing in the several fields, and thus did not provide suitable habitat for the plovers, and I saw none. Moreover, the bulk of the wintering plovers leave Hawaii for the breeding grounds before May 2.

Family Scolopacidae, Woodcock, Sandpipers, Curlews

2. Wandering Tattler (Heteroscelus incanum). This shorebird breeds in Alaska and northwestern British Columbia, flying south to Hawaii and other Pacific islands for the nonbreeding season. I saw only one or two birds during each of my visits to the ocean shore, the birds being found in both sandy and rocky beach areas in 1973 and 1979.

Introduced birds. More than 160 different species of exotic birds have been introduced to the Hawaiian Islands since about 1800 (Berger, 1972). The dry leeward regions of the islands provide excellant habitat for a number of these foreign birds, and at least 14 species are found in the West Beach area.

Family Ardeidae, Herons and Egrets

1. Cattle Egret (Bubulcus ibis). This species was imported to Hawaii from Florida to aid "in the battle to control house flies, horn flies, and other flies that damage hides and cause lower weight gains in cattle" (Breese, 1959). A number of Cattle Egrets were released on Oahu in 1959 and 22 additional birds were released July 1961. Thistle (1962) reported that the population of Egrets on Oahu exceeded 150 birds by July 1962; the population has continued to increase since that time. In addition to their propensity for feeding near cattle, Cattle Egrets often feed in alfalfa fields and in plowed cane fields (the latter especially in the Pearl Harbor area). I saw three Cattle Egrets in flight over the cane fields on November 2 (8:45 p.m.) and two birds on November 11 (4:30 p.m.), 1973.

Family Columbidae, Pigeons and Doves

2. Spotted or Chinese Dove (Streptopelia chinensis). This Asian dove was introduced to the Hawaiian Islands at an early date; the exact date is unknown, but the birds are said to have been very common on Oahu by 1879. The species is now common on all the islands and is classified as a game bird. This dove is also called the Lace-necked Dove because of the conspicuous band of

the neck. Although this species occurs where rainfall exceeds 100 inches per year, the highest densities are found in drier areas where the introduced kiawe (mesquite) is one of the dominant plants. Schwartz and Schwartz (1949), for example, found densities as great as 200 birds per square mile in dry areas on Molokai. I would estimate densities between 50 and 100 birds per square mile in the West Beach area. The largest concentration of birds occurs in the kiawe thickets and the weedy borders and roads around them. The diet, as determined by examining crop contents of 91 birds, was found by the Schwartzes to consist of 77 percent weed seeds and about 23 percent fruits; animal matter was "almost negligible." Tapeworm parasitism was found to be heavy, however, indicating that the small amount of animal matter eaten by the doves was important in contracting the parasities.

3. Barred Dove (Geopelia striata). This species also is called the Zebra Dove in its native habitat in the Orient and Australia. This species is said to have been introduced to Hawaii sometime after 1922 (Bryan, 1958). It is now common to abundant on all of the main islands in the chain. The Barred Dove also prefers the drier areas where weed seeds are abundant. Schwartz and Schwartz (1949) reported densities as great as 400 to 800 birds per square mile in some areas on Oahu (e.g., from Barbers Point to Makaha) and Molokai in 1947. The Barred Dove is probably the most abundant species in the area, so that populations could well exceed 400 birds for square mile at this time. The Barred Dove also is classified as a game bird in Hawaii. One study of the food habits of the Barred Dove in Hawaii revealed that the diet consists of 97 percent seeds and other plant matter; the 3 percent animal matter include several species of beetles, weevils, and wireworm larvae. The Schwartzes emphasized that even though the Spotted Dove and the Barred Dove are both predominantly seed eaters, they do not compete for food because "only one plant occurred as more than 2 percent by volume in the diet of both birds. This one, uhaloa, occurs in great abundance throughout most dove range and is more than ample to supply the needs of both species of doves," as well as those of several species of other game birds (e.g., quail, pheasant) in Hawaii.

Family Sturnidae, Starlings and Mynas

4. Common Myna (Acridotheres t. tristis). The Common Myna which is native to Ceylon, India, Nepal, and adjacent regions. was introduced from India in 1865 by Dr. William Hillebrand to combat the plague of army worms that was ravaging the pasture lands of the islands. It has spread and multiplied to an amazing extent; reported to the abundant in Honolulu in 1879, it is now extremely common throughout the Territory" (Caum, 1933). The Myna is still common to abundant in lowland areas of the inhabited islands, being most common in residential and urban areas as well as in the vicinity of human habitation in rural areas. Mynas occur as birds of passage in the cane fields, and they undoubtedly nest in palm trees and other sites around the Campbell homestead along the beach; I saw a few birds along the edges of kiawe thickets and a

flock of 23 birds in a plowed cane field (November 11, 1973). On April 28 and during May 1979, the birds were conspicuous in the vegetation along the shore, especially.

Family Zosteropidae, White-eyes

5. Japanese White-eye (*Zosterops j. japonicus*). Long a favorite cage bird in the Orient, Caum (1933) wrote that the Japanese White-eye was first imported from Japan to Oahu by the Territorial Board of Agricultural and Forestry in 1929. Later importations were made by the Hui Manu and private individuals. The White-eye rivals the House Sparrow and the European Starling as a successful exotic species, and the White-eye is now undoubtedly the most common bird species in Hawaii (Berger, 1972). It is found from sea level to tree line (on Maui and Hawaii) and it is found in the driest and the wettest areas in the Hawaiian Islands. The White-eye is ubiquitous in the West Beach area, feeding in the cane fields and feeding and nesting in the kiawe thickets and other vegetation. The breeding season on Oahu extends from February to August. I did not hear any singing during October and November, but the birds were conspicuous by their callnotes; I found several old nests in kiawe trees. Singing birds were conspicuous during April and May 1979.

Family Ploceidae, Weaverbirds and Their Allies

This is a large family of birds, predominantly Old World in distribution; the best known example in Hawaii is the House Sparrow (*Passer domesticus*). However, since 1965 more than 15 different species of this family have been intentionally or accidentially released on Oahu (*Elepaio*, 26, 1966:79; 33, 1973:81-82). Some of these species obviously have become established as breeding birds and are spreading in distribution (Berger, 1972).

6. Orange-cheeked Waxbill (*Estrilda melpoda*). This weaverbird was first reported in the wild in Hawaii (on the slopes of Diamond Head) on January 2, 1966, during the annual Christmas count of the Hawaii Audubon Society (*Elepaio*, 26, March 1966, pp. 77-81). The species has been reported annually in the same area by the Audubon Society (*Elepaio*, 33, February 1973, pp. 77-86). The species apparently has not been reported outside of the Diamond Head-Kapiolani Park region previously. I saw one Orange-cheeked Waxbill at the edge of a cane field (perched on cane) along Malakole Road on November 2, 1973. There may have been more birds, but the waxbills have a habit when disturbed of dropping suddenly downward into the depths of the cane and out of sight, thus making positive identification very difficult or impossible.

7. Red-eared Waxbill (*Estrilda troglodytes*). This species (also called the Black-rumped and Common Waxbill) has the same history as the Orange-cheeked Waxbill: first reported at Diamond Head on January 2, 1966, and seen annually there since that time. I have not found any published records of the distribution of this species in other parts of Oahu. On November 7, 1973, I watched

a flock of between 20 and 25 birds feeding on grass seeds in a gully at the edge of a cane field. This suggests that a breeding population is established in the West Beach area. I saw small flocks on all other visits to the cane fields. As seed eaters, both species of waxbills constitute a threat to any grain crops that might be comtemplated on Oahu.

8. Strawberry Finch (Amandava amandava). Caum (1933) wrote that "it is not known with certainty just when these birds came to Hawaii, but it was probably sometime between 1900 and 1910. Many were imported as cage birds during this period and it is supposed that the present population is derived from individuals escaped from captivity." One of the puzzling features about the Strawberry Finch is that it appeared not to extend its range over a long period of time. Ord (1967), for example, wrote that the Strawberry Finch "can usually be found near grassy open areas around sugar-cane fields ... in the lowlands about Pearl Harbor." I know of no reports of the species having been seen in any other part of Oahu. However, on November 4, 1973, I saw two birds at the edge of a cane field along Malakole road; I also saw two birds in the same area on November 18.

9. Ricebird or Spotted Munia (Lochura punctulata). This Asian species was released in Hawaii by Dr. William Hillebrand about 1865 (Caum, 1933). Caum wrote that the Ricebird "feeds on the seeds of weeds and grasses and does considerable damage to green rice." Rice is no longer grown in Hawaii, but the Ricebird has recently become a serious pest by eating the seeds of sorghum, as already mentioned. The Ricebird is another abundant species on all of the inhabited islands, and it is tolerant of both very dry and very wet habitats. It is an abundant species in the West Beach area, and the birds spend much time eating the seeds of grasses and other plants along the edges of and within the cane fields. The birds also inhabit the kiawe thickets and adjacent disturbed areas.

10. Black-headed Mannikin (Lonchura malacca atricapilla). This is another Asian species that has long been a popular cage bird. The species apparently was first reported breeding in the wild by Udvardy (1960), who observed 10 adults and 15 juveniles birds near West Loch, Pearl Harbor, on April 26, 1959. Ord (1967) reported that the species was abundant "in open grassy areas around Middle and West Lochs of Pearl Harbor." Donaghho (1967) reported that he observed this species along the road to Palehua at the southern end of the Waianae Mountains in 1967. I saw three small flocks of Black-headed Mannikins on November 4, 1973, along the edge of a cane field. This species has a notable habit of flushing rapidily, flying upward, and then dropping downward quickly into the cane, where it is impossible to see the birds. I saw at least 12 birds in full adult breeding plumage on November 18. Many birds in immature plumage (all brown feathers) were seen during earlier visits to the area, and, on November 11, I watched that presumably was a family group consisting of one adult, two immature birds showing incoming black feathers on the

breast and belly, and two birds in the brown juvenile plumage. I saw both adult and juvenile birds in 1979.

11. House Sparrow (Passer domesticus). The House Sparrow (also erroneously called the English Sparrow) was first imported to Oahu in 1871 when nine birds were brought from New Zealand (where the species had previously been introduced from England). Caum (1933) wrote that "whether or not there were further importations is not known, but the species was reported to be numerous in Honolulu in 1879." The House Sparrow in North America (first introduced to Brooklyn, New York, in 1852) became a serious pest, and tens of thousands of dollars were spent in attempting to control the population. The House Sparrow apparently never became a serious pest in Hawaii; it is omnivorous in diet, eating weed seeds as well as insects and their larvae. House Sparrows are found around the houses as well as in the kiawe thickets, both inland and along the shore.

Family Fringillidae, Sparrows, Cardinals, and Buntings

12. Red-crested Cardinal (Paroaria coronata). This species traditionally has been called the Brazilian Cardinal in Hawaii, but the native range includes Uruguay, Paraguay, Brazil, and parts of Bolivia and Argentina. This species was released in Hawaii on several occasions between 1928 and 1931 (Caum, 1933). The Red-crested Cardinal is a common species in urban and residential areas as well as in the introduced vegetation in the leeward areas of Oahu. One of the interesting features of the West Beach area is that both species of cardinals occupy the same habitats and appear to be present in about equal numbers.

There was very little irrigation water on November 18, and several species collected to bathe and drink in the small trickle of water in a ditch along Malakole Road. For about a half hour at midday, I watched the following species using the water: Red-crested Cardinal, Ricebirds, Black-headed Mannikin, and Red-cheeked Waxbill. The two Strawberry Finches were in the cane nearby, but they did not go to the water when I was watching.

During my 1979 field work, the Red-crested Cardinal were even more conspicuous because of the territorial songs given by the males. Juvenile birds, with brown heads, were seen in several areas, as well.

13. Cardinal (Cardinalis cardinalis). This species has been given a number of vernacular names: e.g., Virginia Cardinal, Kentucky Cardinal. Its native range is the eastern part of mainland United States east of the plains and northward into Ontario. The Cardinal was released several times in Hawaii between 1929 and 1931 (Caum, 1933). The species is fairly common in some lowland areas, and is a characteristic bird of the leeward parts of Oahu, finding the dry introduced vegetation (kiawe, koa haole, etc.) suitable habitat for its annual cycle. The birds visit the edges of cane fields but spend most of their time in the kiawe areas and the vegetated areas along the shore.

14. House Finch (Carpodacus mexicanus frontalis). Also known as the Papayabird in Hawaii, the House Finch was introduced from California "prior to 1870, probably from San Francisco" (Caum, 1933). The House Finch is now an abundant species in both urban and rural areas on all of the islands, and probably is the second most common land bird species in Hawaii now. Although House Finches eat overripe papaya and other soft fruits at times, the species is predominantly a seed eater. House Finches and Ricebirds caused a great deal of damage to the experimental sorghum crops planted on Kauai and Hawaii during 1971-1972. "A report by the Senate Committee on Ecology, Environmental and Recreation says rice birds and linnets caused a 30 to 50 percent loss in the sorghum fields at Kilauea on Kauai last year. ... seed-eating birds at Kohala ate about 50 tons of sorghum grain in a 30-acre experimental field that was expected to produce 60 tons" ("Honolulu Advertiser," March 14, 1972, p. B-2). Senate Bill No. 1603-72 appropriated $25,000 to the Department of Agriculture "for the establishment of a system of protection and control of wildlife on the islands of Hawaii, Maui, Lanai, Molokai, and Kauai." The seriousness of the problem was outlined in a statement on Senate Bill No. 1603-72 by Mr. Fred Erskine, Chairman of the Department of Agriculture. Although I have seen no official report on the results of this initial control program, the unofficial report is that it was not very successful.

The House Finch is an abundant species in the West Beach area. During the nonbreeding season in 1973, flocks varying from 25 to 50 birds were not uncommon. Even during the breeding season (April and May 1979), I saw several flocks of 20 or more birds. The birds feed in and along the edges of the cane fields as well as in virtually all other habitats in the area.

Discussion and conclusion. The portion of the West Beach Area that is proposed for development can be classified as an extensively disturbed habitat with no remaining endemic ecosystems. The vast majority of the dominant and subdominant plants (trees, shrubs, vines) consist of more than two dozen introduced species (a detailed discussion of all plant species is given in the "Botanical Survey of the Proposed West Beach Resort Project," by Winona P. Char). The major plant association include sugarcane fields, kiawe thickets, and vegetation (both aquatic and terrestrial) of the shoreline. Numerous species of introduced shurbs and vines grow along cane roads and the edges of the sugarcane fields and the kiawe thickets. These introduced plant species do not provide suitable habitat for the endemic Hawaiian birds (with the possible exception of the Hawaiian Owl, a species not classified as threatened or endangered). As a result, all permanent resident bird species are introduced species. The introduced birds consist of 14 species belonging to six bird families. When compared with the mainland United States, this represents a depauperate bird fauna. As pointed out earlier, some of these species have caused serious damage to agricultural crops in the past and several other seed eaters have the potential of doing so in the future. At the same time, some species (e.g., doves, myna, white-eye, cardinals) give pleasure to many people who enjoy seeing birds around their homes; if the introduced birds were not here, the lowland areas would be virtually devoid of birds most of the year. In additiona, mynas, white-eyes, and cardinals eat insects and their larvae, and, therefore, are beneficial during at least part of their annual cycle.

There are no publications on the distribution, breeding biology, parasites and diseases, or interrelationships of any introduced bird species on an island-wide basis for any of the Hawaiian Islands. Two-year studies of the breeding biology of three species (Common Myna, Japanese White-eye, House Finch) have been confined to the Manoa campus of the University of Hawaii. Most of the published reports on the distribution and spread of introduced birds are my own (Berger, 1974, 1975a, 1975b, 1975c, 1975d, 1975e, 1976, 1977a, 1977b).

There have been no published studies for Hawaii that report on habitat modification and the resultant change in species' abundance. Therefore, one must use his own knowledge and experience in Hawaii gained over the past 15 years to predict the possible changes that would occur in the West Beach area because of the proposed development there. Most of the introduced bird species found in the West Beach area have a wide distribution on Oahu, being found in residential, urban, and rural regions; none are deep forest birds; they are adapted to live in close association with man. A mature sugarcane field does not provide much suitable habitat for any of the introduced species. Consequently, if the cane fields are converted to residential and recreational (e.g., a golf course) use, there will be more available habitat for the introduced bird species and I would anticipate an increase in the populations for nearly all of them. Because all of the birds are introduced species (and some have been pests), however, it appears to me that it would not be of significance whether changes in the habitat resulted in an increase, a decrease, or no change in the populations.

My conclusion is that the proposed West Beach Development Project will have absolutely no deleterious affect on any endemic Hawaiian bird, that it will not affect the few species of winter visitants (Tattler and Golden Plover) to Hawaii, and will have no significant ecological impact on the 14 species of introduced bird species that are known to inhabit the region. The Golden Plover is a common winter resident that finds golf courses and lawns (even at the State Capitol Building) to be excellent habitat during the winter months; the Tattler prefers the shoreline and can be found along rocky and sandy shores in the Waikiki region despite the number of people on the beaches; therefore, development at West Beach should not affect this species adversely.

With regard to the fossil bird bones found near Barber's Point, I will submit an addendum to this report after the archaeologists have completed their work at the proposed West Beach Development Project.

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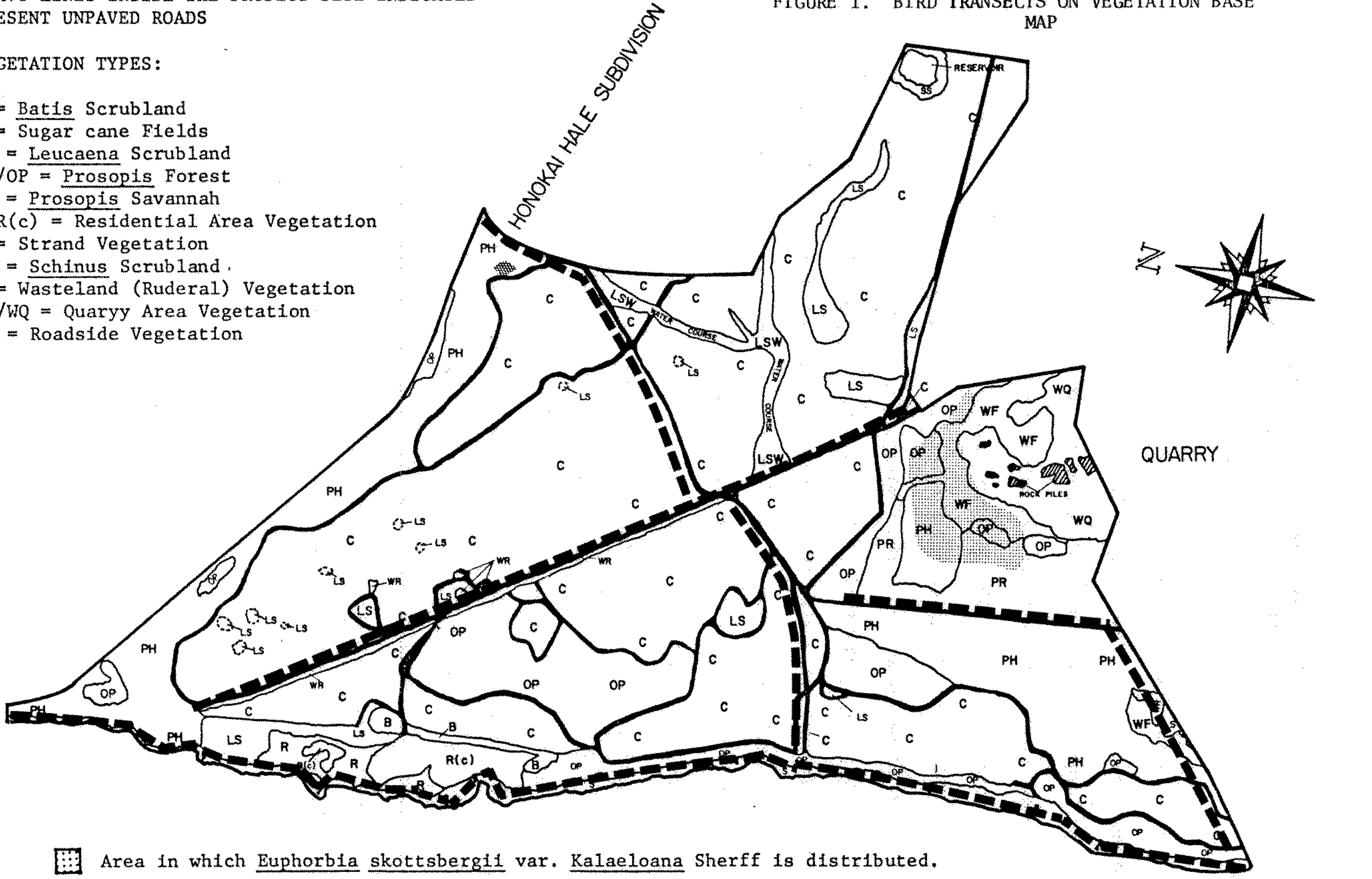
HEAVY LINES INSIDE THE PROJECT SITE INDICATES
PRESENT UNPAVED ROADS

FIGURE 1. BIRD TRANSECTS ON VEGETATION BASE MAP

VEGETATION TYPES:

B = Batis Scrubland
C = Sugar cane Fields
LS = Leucaena Scrubland
PH/OP = Prosopis Forest
PR = Prosopis Savannah
R/R(c) = Residential Area Vegetation
S = Strand Vegetation
SS = Schinus Scrubland
W = Wasteland (Ruderal) Vegetation
WF/WQ = Quaryy Area Vegetation
WR = Roadside Vegetation



Area in which Euphorbia skottsbergii var. Kalaeloana Sherff is distributed.

Area in which Gossypium sandvicense Parl. is distributed.

BIRD TRANSECTS (Trails from which Berger observed avifauna.)

West Beach

FIGURE 1. BIRD TRANSECTS

DATE: JUNE 1979

WEST BEACH RESORT PROJECT

Birds of West Beach, Ewa, Oahu, Region
Statement on possible fossil bird sites
October 5, 1979
Andrew J. Berger

This is an addendum to my Revised Follow-up Report on the Birds of the West Beach region, dated August 27, 1979.

Ms. Jenny Peterson, an employee of the Archeology consultant for the West Beach study, and I visited the limestone region of the West Beach area on October 3, 1979. The limestone formation occurs in the southern (Barbers Point) end of the Campbell Estate property, and it extends on both sides of Malakole Road. The dominant vegetation there is classified as a Prosopis Forest (primarily closed forest) by Winona P. Char in her botanical survey. This also is an area designated to be developed as a lagoon and Hotel-Condo units in the "concept plan only" map dated 5/15/79 and signed by Trustees of the Campbell Estate.

Ms. Peterson and I identified more than 40 sinkholes of various diameters and depths, ranging from small shallow areas to those 6 feet in diameter and 8 to 10 feet in depth. Some of these contained soil sediments similar to those where fossil bird bones have been found previously; others had no soil deposits in them and undoubtedly are unlikely sites for fossil or other prehistoric material. We made no effort to map or locate all of the sinkholes in the limestone formation, nor did we attempt to examine the sediment in those sinkholes that contained a soil deposit because that was not our mission.

Discussion

The discovery of fossil bird bones in limestone sinks in the Barbers Point area adds a complicating factor to an environmental impact statement for the adjacent West Beach area. The possibility of the existence of similar fossil bones in one or more of the sinkholes in the limestone formation of the Campbell Estate land seems high. There is only one way to answer the question: to have the more promising sinkholes examined by a qualified archaeologist in order to determine the presence or absence of fossil bird bones or other prehistoric material.

The first Hawaiian fossilized bird was found on the island of Hawaii in 1926 (Wetmore 1943). Not until 1971, however, were other fossil bird bones found. Mrs. Joan Aidem found fossil goose bones on Molokai that were about 25,000 years old (Stearns 1973; Olson and Wetmore 1976). Additional fossilized bird bones were found on Kauai and Oahu (Barbers Point) during 1976. These bones have not yet been studied and no technical descriptions or ages of the specimens have been published. The ages of the bones and the deposits in which they are found are of critical importance with regard to their value scientifically. For example, are they truly prehistoric in a geological sense or are the deposits of more recent times, perhaps after the first Polynesians reached the Hawaiian Islands.

In addition to their intrinsic scientific value as clues to birdlife during past geological ages, aged fossil bird bones in Hawaii <u>might</u> enable ornithologists to understand much better the evolution and relationships of the living endemic bird species, although there is no certainty that this would be true. There is no way to make reliable predictions until after the fossil bones have been studied thoroughly by a highly competent bird paleontologist.

Hence, one must agree with Storrs L. Olson (letter dated October 18, 1976, to Mr. Aki Sinoto of the Bernice P. Bishop Museum) that the deposits containing fossilized bird bones are of considerable scientific value and should be preserved and studied, even though one doubts the scientific wisdom of some of Dr. Olson's over-exüberant remarks after his "quite perfunctory" examination of the Barbers Point material. As a generalization it is true that the accuracy of the identification of fossil bird bones depends largely on the number of bones that are preserved; only rarely is an entire skeleton preserved; often a single bone, or even a fragment of a bone, is found. Obviously, in the latter case, the placement of that bone as to genus and species is far less accurate than the identification made from a complete, or nearly complete, skeleton.

Conclusions and Recommendations

1. On the basis of the living birds (introduced and migratory) found in the West Beach area, one can say that no detrimental affects on these species would result from development in the area.

2. The discovery of fossil bird bones in the adjacent Barbers Point region suggests a high possibility that similar fossil bird bones also occur in one or more of the limestone sinks on the Campbell Estate land.

3. The following actions are recommended for consideration:

a. An archaeologist should be hired to examine and excavate in the most promising limestone sinks on the Campbell Estate land.

b. If no fossil bird bones are found, a negative statement can be made.

c. If fossil bird bones are found, I see at least two possibilities for action.

1- Excavations could be completed and all fossil material taken to the Bernice P. Bishop for study and/or disposition (e.g., send the material to the Smithsonian Institution in Washington for final study). The limestone sinks have no intrinsic value themselves, so that construction could be continued as planned.

2- If one or more outstanding fossil sites are discovered on the Campbell Estate land, these could be preserved as prehistoric sites and used as a tourist attraction in a way similar to the La Brea Tar pits in Los Angeles, California. These visitor sites also would serve as "fossil banks" for future excavation if and when new archeological techniques are developed (see letter from Dr. Olson to Mr. Sinoto regarding "fossil banks").

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APPENDIX I SECTION 5

TO: F. J. RODRIGUEZ
Environmental Communications, Inc.

FROM: WINONA P. CHAR W. P. Char
Botanical Consultant

20 March 1984

SUBJECT: Status of Euphorbia skottsbergii var. kalaeloana on West Beach Resort Project Site

On March 09, 1984 a visit was made to the Barbers Point Deep Draft Harbor site and adjacent areas with personnel from the State's Department of Transportation (DOT), Harbors Division, and the U.S. Army Corps of Engineers.

A recent aerial photograph (February 1984) was inspected by DOT personnel and myself to familiarize ourselves with the construction that has since taken place. The construction of the harbor has greatly modified the area.

The portion of the proposed West Beach Resort Project which lies immediately adjacent to the deep draft harbor has been cleared of its vegetation and is being used to store basalt and coral boulders which will be used in the construction of the planned breakwater. A huge, flat-topped coral stockpile, 80-100 ft. tall, lies on part of the resort's northeast boundary.

The West Beach Resort Project area in which plants of Euphorbia skottsbergii var. kalaeloana were found (i.e., quarry fringe and open-Prosopis) has been so greatly disturbed that plants no longer occur there. It should be noted that few plants (less than 50) remained in the West Beach area when construction of the deep draft harbor began; the majority of the plants had been removed prior to construction of the harbor during a number of transplant and recovery projects undertaken by Campbell Estate (September 1980), AECOS (ecological and horticultural studies; May 1980-August 1981), and the Army Corps of Engineers (September 1981). A number of plants were also destroyed when the proposed West Beach area was being actively quarried by the cement company.

TO: F. J. Rodriguez
Environmental Communications, Inc.

FROM: Winona P. Char
Botanical Consultant

07 November 1983

SUBJECT: Up-date of Botanical Survey for the proposed West Beach Resort project with reference to endangered plants.

During the course of the botanical survey for the proposed West Beach Resort Draft Environmental Impact Statement, two species of government were found in the project site. They are Gossypium sandvicense (syn. G. tomentosum), the Hawaiian cotton, and Euphorbia skottsbergii var. kalaeloana, the Ewa Plains 'akoko.

Since the June 1980 EIS the status of these two plants species has changed considerably. The Gossypium is no longer being considered for listing as Endangered or Threatened as the species has proven to be more abundant or widespread than was previously believed. (Federal Register. 1980, Vol. 45, No. 242). The Euphorbia, on the other hand, has been determined to be an Endangered species by the U.S. Fish and Wildlife Service, Department of the Interior (Federal Register, 1982. Vol. 47, No. 164). The action was taken because of the the present destruction and modification of the plant's habitat.

Approximately 1,300 plants of Euphorbia were found on the western boudary of the resort's proposed marina and golf course area during the botanical survey. The majority of these plants were later removed and transplanted by Campbell Estate to another site within the Campbell Industrial Park. A number of plants were also removed during the horticultural and ecological studies conducted by AECOS under a U.S. Army Corps of Engineers contract. The western boundary of the proposed resort project has also been greatly modified due to the present construction of the deep draft harbor.

There is still some possibility that a few plants (or seedlings) of Euphorbia may be present within the proposed resort project site. If so, the plants would be protected under both the Federal and State Endangered Species Act. Coordination with the endangered species directors of the State and Federal governments would then become necessary as part of the permit evaluation process for the proposed resort project.

BOTANICAL SURVEY
OF THE PROPOSED WEST BEACH RESORT PROJECT

Honouliuli, Ewa, Island of O'ahu

June, 1979

Prepared By:
Winona P. Char, B.A., M.A.

BOTANICAL SURVEY OF THE PROPOSED WEST BEACH RESORT PROJECT

Honouliuli, Ewa, Island of O'ahu

Table of Contents

I. INTRODUCTION

A comprehensive inventory of the flora and an investigation of the vegetation types found within the study site were made over a six-day period from April to May, 1979. Although sugarcane covers most of the project area (580 acres), there are large tracts of Prosopis (kiawe) thickets (240 acres) in which remnants of the native flora can still be found. Seven (7) plants listed on the Department of Interior's proposed endangered and threatened species list (1976) have been collected or are known from the Ewa plains area. Two of these species, Euphorbia skottsbergii var. kalaeloana and Gossypium tomentosum, were found in the study area during the course of this survey.

II. LITERATURE REVIEW

There are no reports that deal specifically with the project area proper; however, two (2) reports (Herbst, 1976; Environment Impact Study Corp., November, 1977) dealing with the adjacent area for the construction of a deep draft harbor does include part of the West Beach site in its survey. The vegetation in the area is composed mostly of exotic species. However, two species of plants identified on the proposed list of endangered and threatened species in the Federal Register were also found. It was during the 1976 survey that Euphorbia skottsbergii var. kaleloana was found. The species was thought to have been extinct since the type locality, the Ewa plains area, has been greatly disturbed in recent times. The primary aims of the 1977 survey that followed were to undertake a count of the Euphorbia population, to map these plants, to define their critical habitat, to describe the associated vegetation types, and to recommend mitigative actions for the preservation of this endangered species. A large colony of Euphorbia was found on the western boundary of the quarry. This colony lies within the proposed West Beach project area. During this survey, a small colony of Achyranthes splendens var. rotundata, also an endangered species, was found; however, the colony is outside West Beach.

III. METHODOLOGY

A study of recent aerial photographs was made to delineate the different vegetation types present within the study site. Field work was carried out to confirm these observations and to take notes on representative vegetation types. A walk-through survey method was employed. The field investigation involved four (4) field botanists: Winona Char, N. Balakrishnan, Evangeline Funk, and Paul Higashino. Species observed in the field were noted and given an abundance rating. Plants that could not be positively identified in the field were collected for identification later in the laboratory and herbarium. Areas that were less disturbed received more intensive field investigation since these areas were more likely to harbor native plants.

Rare and endangered plants were vouchered, their locations plotted on a map, and a general survey of the population taken.

IV. VEGETATION TYPES

There are three (3) broad vegetation zones that occur in the Hawaiian Islands, and each of these zones is in an area of uniform macroclimate (Mueller-Dombois & Gagne, in press). The three (3) major vegetation zones are xerotropical (coastal flats and lowlands to submontane), pluviotropical (windward lowland to upper montane), and cool tropical (upper montane to alpine; these occur only on the islands of Maui and Hawaii).

The study site lies within the xerotropical vegetation zone which is characterized by low rainfall (20 inches/annum). Because of low rainfall, this zone supports only a sparse vegetation. Within this zone a number of different plant communities or vegetation types can be delimited. These mosaics of plant communities are controlled largely by edaphic factors such as substrate, run-off, salinity, et cetera, and partly by past and present human activities- these include agriculture, ranching, military activities, et cetera.

The dominant species in these vegetation types are predominantly introduced species (exotics) such as Prosopis (kiawe), Leucaena (koa haole), and Chloris (swollen fingergrass). Remnants of the original native flora can be found scattered throughout the area, usually in small numbers. The activities of man and the grazing animals he introduced have been the primary causes for the degradation of the native flora in the xerotropical zone (St. John, 1957).

The vegetation types found within the study site are presented in Figure 1. These vegetation types are defined by structural (dominance, height, number of plant layers, abundance, et cetera) and floristic criteria.

A. CULTIVATED AREAS

Approximately 580 acres are presently in sugarcane cultivation. The Alice Kamokila Campbell Estate, containing 5 single family residential units, covers 10 acres.

1. Sugarcane Fields

The sugarcane fields are denoted as "C" on the vegetation map. The fields cover roughly 60% of the study site and are located on fairly deep, well-drained soils overlaying a coralline base. Irrigation ditches provide water for the growing cane. A number of weedy species were recorded along these ditches and along the roadsides of the sugarcane fields. These weedy species are listed under the wasteland or ruderal vegetation type column in the species checklist.

2. Residential Area

The area is presently being used for residential and recreational purposes. The property is also used for private luaus and parties. Caretakers for the property live in some of the homes on the property. Most of the area is landscaped and a distinct canopy of coconut (Cocos nucifera) and milo (Thespesia populnea) trees can be recognized from the aerial photographs. This is designated as "R(c)" on the vegetation map. The remainder of the property is open and grassy, with a few scattered trees, and is denoted as "R" on the vegetation map. Besides milo and coconut, the area contains a number of other tropical, ornamental plants such as oleander (Nerium oleander), Chinese banyan (Ficus microcarpa), sea grape (Coccoloba uvifera), hala (Pandanus sp.), ti leaf (Cordyline terminalis), and a number of Heliconia species. A small student garden with examples of plants grown by early Hawaiians is also located on the property and contains such plants as the ipu or bottle gourd vine (Lagenaria siceraria), different cultivars of kalo or taro (Colocasia esculenta), ko or sugarcane (Saccharum officinarum), and mai'a or banana (Musa sp.). A checklist for this area was not made.

B. UNDEVELOPED AREAS

Approximately 240 acres of the 830± acres planned for development are at present undeveloped and not under cultivation. The beach areas in these undeveloped portions support a strand vegetation strongly influenced by the sea. The inland area is characterized by a vegetation composed largely of Prosopis, which is common to the dry, leeward areas of the islands.

1. Strand Vegetation

This vegetation type is denoted as "S" on the vegetation map and in the species checklist. The strand vegetation is influenced strongly by the sea, and there is usually a sharp demarcation between the strand and the inland vegetation. The strand vegetation is a narrow, uniform belt from 3 to 10 meters in width, and occurs between the barren zone from the high tide mark and the beginning of the inland vegetation.

The vegetation here is sparse and usually of low stature. Several species characteristic of the strand vegetation are Sporobolus virginicus ('aki 'aki), Cynodon dactylon, Atriplex semibaccata, Ipomoea brasiliensis (pohuehue), Tribulus cistoides (nohu), Sesuvium portulacastrum ('akulikuli), and Scaevola taccada (naupaka). A number of weedy species also common to the wasteland areas are also found here. Sporobolus and Cynodon can be found where there is a thin accumulation of sand on the rocky areas in very disturbed sites, and in sandy areas where under certain conditions these two species form a fairly extensive turf 10 to 15 cm. high.

A small clump of the indigenous Vitex ovata (pohinahina) was found in the strand vegetation where there was an accumulation of unconsolidated sand. This species forms a creeping mat with ascending branches 15 cm. or more high.

The plants occurring naturally in the strand vegetation are well adapted to the high salinity, intense solar radiation, and the loose substrate. The range and abundance of many of the strand species has been greatly affected by direct disturbances and indirectly by the seaward encroachment of the introduced Prosopis.

2. Batis Scrubland

This vegetation type is denoted as "B" on the vegetation map and in the checklist. The Batis community is essentially a mono-specific one. Batis maritima is a brackish-water loving plant which is semi-herbaceous, with woody prostrate stems and small succulent leaves, oval in cross-section. This vegetation type almost resembles a flat, green meadow. The mat of prostrate, intertwined Batis stems may be 1 meter thick in some places. Batis is characteristic of saline areas, and a few patches roughly 100 meter square can be found near the Alice Kamokila Campbell Estate. A dense thicket of Pluchea can usually be found around the perimeters of such Batis patches.

3. Prosopis Forest

The Prospis forest is the dominant vegetative cover within the study site and the surrounding Ewa plains area in places that are undeveloped. Large tracts of Prosopis can be found along the mauka boundary along Farrington Highway of the study site, and along the western boundary near the quarry area. Prosopis pallida (kiawe) can grow to a height of 20 meters under optimum conditions, but generally reaches 10 to 12 meters in the study site. This introduced monodominant forest has replaced the original native dryland sclerophyllous forest. A few remnant native species such as Erythrina sandwicensis (wili wili) and Myoporum sandwicense (naio) can still be found in the study site.

The canopy cover of the Prosopis forest may vary from closed (the crowns of the trees touching) to open (the trees more widely spaced) to highly scattered (savannah). Prosopis may form shrubs 2 meters tall or trees 10 meters or more tall. Based on these structural differences and on the plant species associated with these differences, the areas dominated by Prosopis can be broken down further into more distinct vegetation types. These vegetation types can be delineated from the aerial photographs.

a. Closed Prosopis Forest

This vegetation type is denoted as "PH" on the vegetation map and in the species checklist. Here the Prosopis reaches 10 to 12 meters or more in height, and forms a thick stand with a closed canopy. These closed Prosopis forests generally have sparse ground cover due to the heavy shade and lack of soil. The substrate is usually coralline rock and outcroppings. Sometimes these closed stands may contain ground cover made up of more shade tolerant herbs. A ground cover dominated by sprawling Asystasia is associated with this vegetation type. Malvastrum and Setaria verticillata also appear to be generally restricted to the shade of the Prosopis.

In areas where the canopy is less dense, koa-haole (Leucaena leucocephala) may form a dense thicket of slender stemmed trees 10 meters tall. Under this subcanopy, a rather thick layer of leaf litter can be found. In areas where Prosopis trees have fallen over, Acacia farnesiana (klu) may be found; other shrubs are rare.

b. Open Prosopis Forest

This vegetation type is designated as "OP" on the vegetation map. Since the open Prosopis forest and the closed Prosopis forest both have many species in common, these two vegetation types have been combined into one column in the species checklist. The Prosopis trees reach a height of 5 meters or more here, and the canopy is open. This can be partly attributed to the cutting of the Prosopis for firewood and charcoal making purposes. Many of the trees exhibit signs of coppicing- a number of branches coming from the stump remaining after cutting. Some of these disturbed areas are in the process of reverting back to the closed Prosopis forest through various successional stages. Because these stands are open and there is less shading, there usually is a large number of shrubs, especially Acacia fernesiana, grasses, and herbs present. The annual vine Sicyos microcarpus (kupala) is common here during the rainy season, but dies back during the dry season.

c. Prosopis Savannah

This vegetation type is designated as "PR" on the vegetation map and in the species checklist. Only a small tract of this vegetation type is present within the study site close to the harbor area. The Prosopis trees are widely scattered, resulting in a canopy cover of 10 to 15%. Roughly 50% of the ground is bare with the remaining covered by weedy species such as Chenopodium album, Atriplex spp., and Chloris spp.

4. Leucaena Open Scrubland

This vegetation type is designated as "LS" on the vegetation map and in the species checklist. Leucaena leucocephala (koa-haole) is the dominant shrub with 10 to 15% cover. Occasionally, Prosopis and Acacia shrubs are found here. Ground cover is made up chiefly herbaceous species and is usually about 50%. The weedy species that form the ground cover here are similar to those found in the wasteland area. In areas where there is deeper soil, Panicum maximum (Guinea grass) may form dense masses about 2 meters tall. Similarly, in areas where there is deep soil and sufficient moisture (usually in areas where run-off accumulates), Brachiaria mutica (Californiagrass) forms dense masses.

A variant of the Leucaena Scrubland forms a small tract of higher stature scrubland, 4 to 5 meters tall, on either side of two watercourses makai of the Honokai Hale subdivision. This is denoted as "LSW" on the vegetation map. A luxuriant growth of Panicum and Brachiaria about 2 meters tall forms an almost impenetrable mat along the watercourse under the Leucaena.

5. Schinus Scrubland

This vegetation type is indicated as "SS" on the vegetation map, and is found only around the water reservoir near the eastern boundary. Schinus terebinthifolius (Christmas berry) is the dominant shrub here. Other associates include Leucaena and Prosopis spp. The weeds that are found here are similar to those found along the roadsides. This vegetation type is not included in the species checklist since it is a minor vegetation type in the study area, and many of the species here are also common to those found along the roadsides of the study area.

6. Wasteland or Ruderal Vegetation

The wasteland or ruderal vegetation is very characteristic of highly disturbed areas. Such areas support annual species and a few shrubs.

Vegetation cover may be sparse if the disturbance is recent. There are three (3) variants of the wasteland vegetation type within the study area. They are as follows:

a. Roadside Vegetation

The roadside vegetation is denoted as "WR" on the vegetation map. This vegetation type is found along both the paved and unpaved roads, along the irrigation ditches for sugarcane, and recently abandoned or disturbed areas. The vegetation here is often a mixture of weedy species, shrubs and grasses.

b. Quarry Area Vegetation

This is designated as "WQ" on the vegetation map, and is found in the area of the quarry proper. The quarry has been in use for many years and subsequently, the original vegetation has been removed long ago. On the exposed hard coralline substrate, a number of pioneer species such as *Chenopodium album* and *Setaria verticillata* form an open community with a sparse ground cover (20%). This area will always have a pioneer community as long as the disturbance factor is maintained.

Several mounds of coralline rock found in the quarry area have shrubs such as *Pluchea*, *Sida* and *Nicotiana* growing on them because they have not been disturbed for some time.

c. Fringe Area Vegetation

This is denoted as "WF" on the vegetation map, and lies between the highly disturbed quarry proper and the *Prosopis* forest. The vegetation cover is about 50%; *Cenchrus ciliaris* and *Verbesina enceloides* are the most abundant species in this area.

The species found in the three variants of the wasteland vegetation type have all been combined under the wasteland column in the species checklist.

V. DISCUSSION

A. RARE AND ENDANGERED PLANTS

Seven (7) species listed in the Federal Register of Proposed Endangered and Threatened plant species (1976) have been collected or are recorded from the Ewa plains area. They are:

- Eragrostis paupera, an annual grass;
- Marsilea villosa, a fern;
- Euphorbia skottsbergii var. skottsbergii, a small shrub, probably extinct;
- Euphorbia skottsbergii var. kaleloana, a small shrub, recently rediscovered;
- Achyranthes splendens var. rotundata, a shrub, endemic to the island of O'ahu;
- Scaevola coriacea, a decumbent shrub, restricted to the strand vegetation; and
- Gossypium sandvicense, (synonym G. tomentosum)a shrub, native Hawaiian cotton.

During the course of the survey, two of these plant species, Euphorbia skottsbergii var. kaleloana and Gossypium sandvicense, were found within the study site.

Euphorbia skottsbergii var. kaleloana Sherff

Euphorbia skottsbergii var. kaleloana, 'akoko, is endemic to the island of O'ahu, and was thought to have been extinct until recently (Herbst, 1976). A biological survey for the proposed Deep Draft Harbor for Barber's Point found two (2) large colonies of the Euphorbia and a number of smaller scattered colonies. The large colony on the western boundary of the quarry will be directly affected by the development plans of the resort's proposed marina and golf course (Figure 1). A rough inventory taken of the colony found approximately 1,300 plants ½ to 1 meter tall in this area. Many seedlings were found in a recently disturbed area. The mature plants had only a few flowers on them at this time. The plants are found primarily in the open *Prosopis* community and in the wasteland area near the fringes of the quarry. The species prefers the more open, exposed areas where it is exposed to full or partial sun.

Gossypium sandvicense Parl. (syn. *Gossypium tomentosum* Nutt.)

Gossypium sandvicense, ma'o or the native Hawaiian cotton, is endemic to the Hawaiian Islands. About half a dozen plants were found in the study site near the highway and subdivision (Figure 2). Fosberg and Herbst (1975) considered the species to be rare (total population low), depleted (much less common over all or most of its former range), and endangered (in considerable danger of disappearance). It is in cultivation by a few botanic gardens and some private individuals. It makes a handsome ornamental plant with silvery, tomentose leaves and bright yellow flowers. The fibers around the seed are short and of no economic use. The native cotton is resistant to some of the diseases that affect the commercial cotton and thus is a potential candidate for breeding experiments. At present Dr. Margaret Y. Menzel, Florida State University, is obtaining seeds from several populations of native cotton from different islands. Dr. Menzel is conducting a number of cross-breeding experiments and is doing research on the genetic relationships of *G. sandvicensis* and the cultivated cottons. Seeds collected from the plants found during the survey will be sent to Dr. Menzel.

B. LIMITATIONS OF THE SURVEY

A large part of the survey work was done during the earlier part of April, 1979, following a late rainy season. Surveys taken at different times will no doubt yield variations in the species list and abundance ratings since many of the plants found in the xerotropical zone are weedy, herbaceous species or perennials that may shed some of their leaves and become semi-dormant. For example, the endemic annual vine *Sicyos microcarpus*, kupala, forms almost an impenetrable blanket over the low growing shrubs near the perimeters of the *Prosopis* forests, but with the onset of the dry season, the plants die back and the only trace left of the kupala are several dried up straw-colored threads left hanging from the shrubs.

VI. RECOMMENDATIONS

The proposed West Beach Resort Project will have no great impact on the vegetation of the area since more than half the area is already in cultivation and the plants found in the undeveloped areas or uncultivated areas are largely weedy introduced species. However, the project will have an impact on two (2) endangered plant species found within the study site.

Euphorbia skottsbergii var. kaleloana Sherff

E. skottsbergii var. kalaeloana is considered endangered. It was thought to have been extinct, limited to type locality, Ewa plains. An endangered species is defined as "any specie which is in danger of extinction throughout all or a significant portion of its range."

The only known habitat for this Euphorbia species is the Ewa plains area where it is restricted to the coralline areas. The only known large concentrations of the plant are around the quarry area. The species is anticipated to be legally declared as endangered in the near future. It is, therefore, critical that the project does not jeopardize the continued existence of this species. The following recommendations are made for the preservation of the Euphorbia species:

1. The area where the plants are located should be left as it is and serve as a buffer zone between the deep draft harbor and the industrial complex that will be built around it. Since the main purpose of the resort is to attract tourists and is tourist-oriented, it would be to the advantage of the resort to block out the view of the industrial area, especially the oil refineries.

2. If it is impossible to change the configuration of the project plan, then as many of the plants that can be moved should be used for the landscaping or perhaps moved to the woods that are planned for the golf course. The advantages of using the Euphorbia as a landscape plant are many. It is adapted to the hot, dry coralline area and will not need much topsoil, if any, or much watering. It

is attractive. Other lowland plants should also be grown: these include wili wili; nohu, pohinahina; et cetera. They would also cost less to maintain in the long run. They are attractive and can be used for Hawaiiana exhibits. Several botanic gardens, among them the Honolulu Botanic Gardens and the Maui Botanical Garden, have had excellent results with landscaping with native lowland plants.

Gossypium sandvicense Parl.

G. sandvicensis is a proposed threatened specie; in accordance to the Endangered Species Act, 1973, a threatened specie is "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

Other populations of Gossypium are known from O'ahu and the other islands where they are found along the coasts and lowlands. The status of this species is not as critical as that of the Euphorbia. About half a dozen plants can be found in the study site. These plants or seeds from the plants can be easily cultivated and should be used in the landscaping plans since it has potential as a landscaping plant.

VII. CHECKLIST OF THE VASCULAR PLANTS FOUND IN THE PROPOSED WEST BEACH RESORT PROJECT SITE

Families are arranged in alphabetical order within each of two groups: Monocotyledonae and Dicotyledonae. Genera and species are also arranged alphabetically. Taxonomy and nomenclature follow St. John (1973) except where more commonly accepted names are used. Hawaiian names used in the following checklist follow St. John (1973) or Porter (1972).

The following information is provided for each species:

1. Scientific name
2. Common name and/or Hawaiian name, when known.
3. Status of the species. The following symbols are used:

E = endemic to the Hawaiian Islands, i.e., occurring naturally nowhere else in the world.

I = indigenous, i.e., native to the Hawaiian Islands, but also occurring naturally (without the aid of man) elsewhere.

X = exotic, i.e., plants of accidental or deliberate introduction after the Western discovery of the Hawaiian Islands.

P = Polynesian introduction, i.e., it includes those plants brought to the islands prior to Captain Cook's discovery of the islands.

4. Vegetation types. The following symbols are used for vegetation types; (see text for description):

S = Strand vegetation
B = Batis Scrubland
PH/OP = Prosopis Forest
PR = Prosopis Savannah
LS = Leucaena Open Scrubland
W = Wasteland (Ruderal) Vegetation

5. Relative Abundance. The abundance rating given for each species in the following checklist is based on the frequency in which the species occurs in each vegetation type within the study area during the period the survey was taken. The following symbols are used:

A = abundant, the major or dominant species in a given area.

C = common, generally distributed throughout a given area in large numbers.

O = occasional, generally distributed through a major portion of a given area in small numbers.

U = uncommon, observed uncommonly in a given area, but more than 10 times.

R = rare, observed infrequently in a given area, more than 2 times but less than 10 times.

S = single, only 1 specimen seen.

L = locally common, restricted to a small area although within that area it may occur in large numbers.

A Checklist of the Vascular Plants found in
the Proposed West Beach Resort Project Site, O'ahu

Scientific Name	Common Name	Status	Vegetation Types S	B	PH/OP	PR	LS	W
MONOCOTYLEDONAE								
COMMELINACEAE								
Commelina diffusa Burm. f.	Honohono	X	–	–	U	–	U	U
CYPERACEAE								
Cyperus rotundus L.	Nut grass, kili'o'opu	X	R	–	–	–	U	C
GRAMINEAE								
Andropogon pertusus (L.) Willd.		X	–	–	–	–	–	O
Brachiaria mutica (Forsk.) Stapf	Californiagrass, paragrass	X	R	–	–	R	–	L
Cenchrus ciliaris L.	Buffelgrass	X	–	–	U	A	C	C
Cenchrus echinatus L.	Common sandbur, 'ume 'alu	X	U	–	–	–	–	O
Chloris inflata Link	Swollen fingergrass	X	O	U	U	C	O	C
Chloris virgata Sw.	Feather fingergrass	X	–	–	R	–	O	O
Coix lachryma-jobi L.	Job's tears	X	–	–	–	–	–	S
Cynodon dactylon (L.) Pers.	Bermuda grass, manienie	X	C	–	–	–	O	C
Dactyloctenium aegypticum (L.) Willd.	Beach wiregrass	X	O	–	–	–	R	–
Eleusine indica (L.) Gaertn.	Wiregrass, manienie ali'i	X	–	–	R	U	–	O
Eragrostis cilianensis (All.) Vignolo-Lutati	Stinkgrass	X	–	–	–	U	U	U
Eragrostis pectinacea (Michx.) Nees	Carolina lovegrass	X	–	–	R	–	U	O
Eragrostis tenella (L.) R. & S.	Japanese lovegrass	X	–	–	–	–	–	O
Leptochloa uninervia (Presl.) Hitchc. & Chase		X	–	U	–	–	U	O
Panicum maximum Jacq.	Guinea grass	X	U	–	O	C	O	O
Rhynchelytrum repens (Willd.) C.E. Hubb	Natal redtop	X	R	–	R	U	O	O
Saccharum officinarum L.	Sugarcane, ko	P	–	–	–	–	–	U
Setaria verticillata (L.) Beauv.	Bristly foxtail, mau'u pilipili	X	O	–	C	C	C	C

Scientific Name	Common Name	Status	S	B	PH/OP	PR	LS	W
			Vegetation Types					
MONOCOTYLEDONAE								
(*GRAMINEAE* continued)								
Sporobolus virginicus (L.) Kunth	Beach dropseed, 'aki 'aki	I	C	–	–	–	–	–
Tricachne insularis (L.) Nees	Sourgrass	X	U	–	O	O	O	O
LILIACEAE								
Aloe vera L.	Aloe, panini 'awa 'awa	X	–	–	–	–	L	–
PALMAE								
Cocos nucifera L.	Coconut, niu	P	L	–	–	–	–	–
DICOTYLEDONAE								
ACANTHACEAE								
Asystasia gangetica (L.) T. Anders.	Asystasia	X	U	–	C	O	R	R
AIZOACEAE								
Sesuvium portulacastrum (L.) L.	'Akulikuli	I	U	–	–	–	–	–
AMARANTHACEAE								
Achyranthes indica (L.) Mill.		X	–	–	O	O	O	O
Amaranthus spinosus L.	Spiny amaranth, pakai-kuku	X	U	–	U	O	O	O
Amaranthus viridis L.	Slender amaranth, pakai	X	R	–	–	U	U	U
ANACARDIACEAE								
Schinus terebinthifolius Raddi	Christmas berry, wilelaiki	X	R	U	U	–	O	–
APOCYNACEAE								
Thevetia peruviana (Pers.) K. Schum. forma *peruviana*	Be-still tree, nohomalie	X	–	–	R	–	–	–

Scientific Name	Common Name	Status	S	B	PH/OP	PR	LS	W
			Vegetation Types					
DICOTYLEDONAE								
ARALIACEAE								
Brassaia actinophylla Endl.	Octopus tree, umbrella tree	X	-	-	U	-	-	-
ASCLEPIADACEAE								
Gomphocarpus physocarpus E. Mey.	Balloon plant	X	-	-	-	-	-	R
BATIDACEAE								
Batis maritima L.	Pickle weed, 'akulikuli-kai	X	U	A	-	-	-	-
BIGNONIACEAE								
Spathodea campanulata Beauv.	African tulip tree	X	-	-	U	-	-	-
BORAGINACEAE								
Heliotropium curassavicum L.	Hinahina, kipukai, nena	I	-	-	-	U	-	R
CACTACEAE								
Opuntia megacantha Salm-Dyck	Prickly pear, pa-nini	X	-	-	S	-	-	-
CAPPARACEAE								
Capparis sandwichiana var. *Zoharyi* Deg. & Deg.	Maiapilo, pua-pilo	E	-	-	U	-	-	-
Gynandropsis gynandra (L.) Briq.	African spider flower, honohina	X	-	-	-	-	U	O
CARICACEAE								
Carica papaya L.	Papaya, mikana	X	-	-	R	R	-	-
CHENOPODIACEAE								
Atriplex muelleri Benth.		X	U	-	-	O	U	O
Atriplex semibaccata R. Br.	Australian salt bush	X	O	-	R	O	U	O
Chenopodium album L.	Lamb's quarters, 'aheahea	X	O	-	R	O	U	O
Chenopodium carinatum R. Br.	Keeled goosefoot, 'aheahea	X	-	-	R	-	R	-

Scientific Name	Common Name	Status	S	B	PH/OP	PR	LS	W
			Vegetation Types					
DICOTYLEDONAE								
COMPOSITAE								
Ageratum conyzoides L.	Ageratum, maile-hono-hono	X	-	-	U	-	O	O
Bidens cynapifolia HBK.	West Indian beggar's tick	X	-	-	U	-	R	-
Bidens pilosa L.	Spanish needle, beggar's tick, ko'oko'olau	X	-	-	U	U	O	O
Emilia javanica (Burm. f.) C.B. Robins	Red pua-lele	X	U	-	-	-	-	U
Emilia sonchifolia (L.) DC.	Lilac, pua-lele	X	-	-	R	-	-	U
Lactuca scariola L.		X	-	-	-	-	-	U
Pluchea x fosbergii Cooperrider & Galang	Pluchea hybrid	X	-	O	U	-	U	O
Pluchea indica (L.) Less.	Indian pluchea	X	R	R	-	-	O	U
Pluchea odorata (L.) Cass	Pluchea	X	-	-	R	O	U	O
Reichardia picroides (L.) Roth	Picridium	X	O	-	-	-	-	-
Sonchus oleraceus L.	Sow thistle, pua-lele	X	O	-	U	O	O	O
Tridax procumbens L.	Coat buttons	X	-	-	-	-	-	O
Verbesina encelioides (Cav.) Gray	Golden crown-beard	X	O	-	U	C	O	C
Vernonia cinerea (L.) Less	Ironweed	X	-	-	R	R	-	-
Xanthium saccharatum Wallr.	Cocklebur, kikania	X	-	-	-	U	U	U
CONVOLVULACEAE								
Ipomoea brasiliensis (L.) Sweet	Pohuehue	I	O	-	-	-	-	-
Ipomoea cairica (L.) Sweet	Koali-'ai	I	-	-	U	O	U	O
Ipomoea congesta R. Br.	Koali-'awania, koali-awa	I	-	-	O	O	O	U
Ipomoea obscura (L.) Ker-Gawl		X	-	-	-	U	O	U
Ipomoea triloba L.	Little bell	X	-	-	-	-	O	U
Merremia aegyptia (L.) Urban	Hairy merremia, koali-kua-hulu	X	U	-	U	O	O	O
CUCURBITACEAE								
Cucumis dipsaceus Spach.	Wild cucumber	X	-	-	-	-	U	U

Scientific Name	Common Name	Status	S	B	PH/OP	PR	LS	W
			Vegetation Types					
DICOTYLEDONAE								
(CUCURBITACEAE continued)								
Momordica charantia var. parvel Crantz	Balsam apple	X	R	–	U	O	U	U
Sicyos microcarpus Mann	Kupala	E	U	–	O	O	O	U
EUPHORBIACEAE								
Euphorbia geniculata Ortega	Wild spurge, kaliko	X	–	–	O	O	O	O
Euphorbia glomerifera (Millsp.) L.C. Wheeler		X	–	–	–	–	U	U
Euphorbia hirta L.	Hairy spurge, koko-kahiki	X	U	–	–	O	O	O
Euphorbia prostrata Ait.	Prostrate spurge	X	–	–	–	–	–	O
Euphorbia skottsbergii var. kalaeloana Sherff	'Akoko	E	–	–	U	L	–	L
Euphorbia sp.		X	–	–	U	–	–	–
Ricinus communis L.	Castor bean, koli	X	U	U	U	O	O	O
GOODENIACEAE								
Scaevola taccada (Gaertn.) Roxb.	Beach naupaka, naupaka-kahakai	I	U	–	–	–	–	–
LABIATAE								
Leonotis nepetaefolia (L.) Ait. f.	Lion's ear	X	U	–	U	–	U	U
Ocimum basilicum L.	Basil	X	–	–	U	–	–	–
LEGUMINOSAE								
Acacia farnesiana (L.) Willd.	Klu	X	O	–	R	O	O	O
Caesalpinia bonduc (L.) Roxb.	Kakalaioa	X	–	–	R	–	–	–
Cassia leschenaultiana DC.	Partridge pea, lauki	X	–	–	–	R	–	R
Crotalaria incana L.	Fuzzy rattle-pod, kukae-hoki	X	–	–	–	R	U	U
Desmanthus virgatus (L.) Willd.	Virgate mimosa	X	O	–	U	O	O	O
Desmodium uncinatum (Jacq.) DC.	Spanish clover	X	–	–	–	–	–	R
Erythrina sandwicensis Deg.	Wiliwili	E	–	–	S	–	–	–

Scientific Name	Common Name	Status	S	B	PH/OP	PR	LS	W
			Vegetation Types					
DICOTYLEDONAE								
(*LEGUMINOSAE* Continued)								
Indigofera suffruticosa Mill.	Indigo, 'iniko	X	–	–	–	U	U	U
Leucaena leucocephala (Lam.) de Wit	Koa-haole	X	U	–	C	O	A	U
Phaseolus lathyroides L.	Cow pea, papaya	X	–	–	–	–	U	U
Phaseolus vulgaris L. var.	Long bean	X	–	–	–	–	–	R
Prosopis pallida (Willd.) HBK. forma *pallida*	Algaroba, kiawe	X	–	–	R	R	–	R
Prosopis pallida forma *armata* Fosb.	Algaroba, kiawe	X	O	U	A	C	C	R
MALVACEAE								
Abutilon grandifolium (Willd.) Sweet	Hairy abutilon, ma'o	X	R	–	U	–	U	U
Abutilon incanum (Link) Sweet	Hoary abutilon, ko'oloa	I	–	–	U	–	U	R
Gossypium barbadense L.	Cotton plant, pulu pulu-haole	X	–	–	–	–	U	–
Gossypium sandvicense Parl.	Ma'o	E	–	–	R	–	–	–
Hibiscus esculentus L.	Okra, gumbo	X	–	–	–	–	R	–
Malva parviflora L.	Cheese weed	X	–	–	U	O	U	U
Malvastrum coromandelianum (L.) Garcke	False mallow	X	–	–	O	O	U	O
Sida fallax Walp.	'Ilima	I	–	–	O	O	O	O
Sida rhombifolia L.	Cuba jute	X	–	–	–	–	R	R
Sida spinosa L.	Prickly sida	X	–	–	U	–	U	O
Thespesia populnea (L.) Correa	Milo	P	L	–	R	–	–	–
MENISPERMACEAE								
Cocculus ferrandianus Gaud.	Huehue, hue'ie	E	–	–	U	–	–	–
MORACEAE								
Ficus microcarpa L.f.	Chinese banyan	X	–	–	R	–	–	–

Scientific Name	Common Name	Status	Vegetation Types S	B	PH/OP	PR	LS	W
DICOTYLEDONAE								
MORINGACEAE								
Moringa oleifera Lam.	Horseradish tree, kalamungay	X	–	–	–	–	R	–
MYOPORACEAE								
Myoporum sandwicense var. *stellatum* Webster	Naio	E	–	–	U	–	–	–
NYCTAGINACEAE								
Boerhavia coccinea Mill.		X	–	–	–	U	–	R
Boerhavia diffusa L.	Alena	I	O	–	–	–	R	R
Mirabilis jalapa L.	Common four o'clock, nani-ahiahi	X	–	–	R	–	R	–
PASSIFLORACEAE								
Passiflora foetida L.	Poha poha	X	R	–	U	O	O	U
PLUMBAGINACEAE								
Plumbago zeylanica L.	'Ilie'e, hilie'e	I	–	–	O	U	R	–
POLYGONACEAE								
Antigonon leptopus H. & A.	Mexican creeper	X	–	–	–	–	–	R
PORTULACACEAE								
Portulaca oleracea L.	Common purslane, 'akulikuli kula	X	U	R	U	O	O	O
RHIZOPHORACEAE								
Rhizophora mangle L.	American mangrove	X	S	–	–	–	–	–
SOLANACEAE								
Capsicum annuum L.	Red pepper, chili pepper, nioi	X	–	–	U	–	–	–
Datura stramonium L.	Jimson weed, kikania	X	–	–	–	–	U	U

Scientific Name	Common Name	Status	S	B	PH/OP	PR	LS	W
					Vegetation Types			
DYCOTYLEDONAE								
(*SOLANACEAE* Continued)								
Lycopersicon pimpinellifolium Mill.	Current tomato, 'ohi'a-ma-kana-hele	X	R	-	-	U	O	-
Nicandra physalodes (L.) Gaertn.	Apple-of-Peru	X	-	-	-	U	U	-
Nicotiana glauca Grah.	Tree tobacco, makahala	X	-	-	-	U	-	U
Solanum nigrum L.	Popolo	I	R	-	O	O	O	O
Solanum seaforthianum Andr.		X	-	-	O	-	-	-
STERCULIACEAE								
Waltheria americana L.	Hi'a-loa, 'uha-loa	I	O	-	-	O	U	O
VERBENACEAE								
Lantana camara L.	Lantana, lakana	X	-	-	-	U	-	-
Vitex ovata Thunb.	Pohinahina, polinalina	I	R	-	-	-	-	-
ZYGOPHYLLACEAE								
Tribulus cistoides L.	Nohu	I	R	-	-	-	-	-

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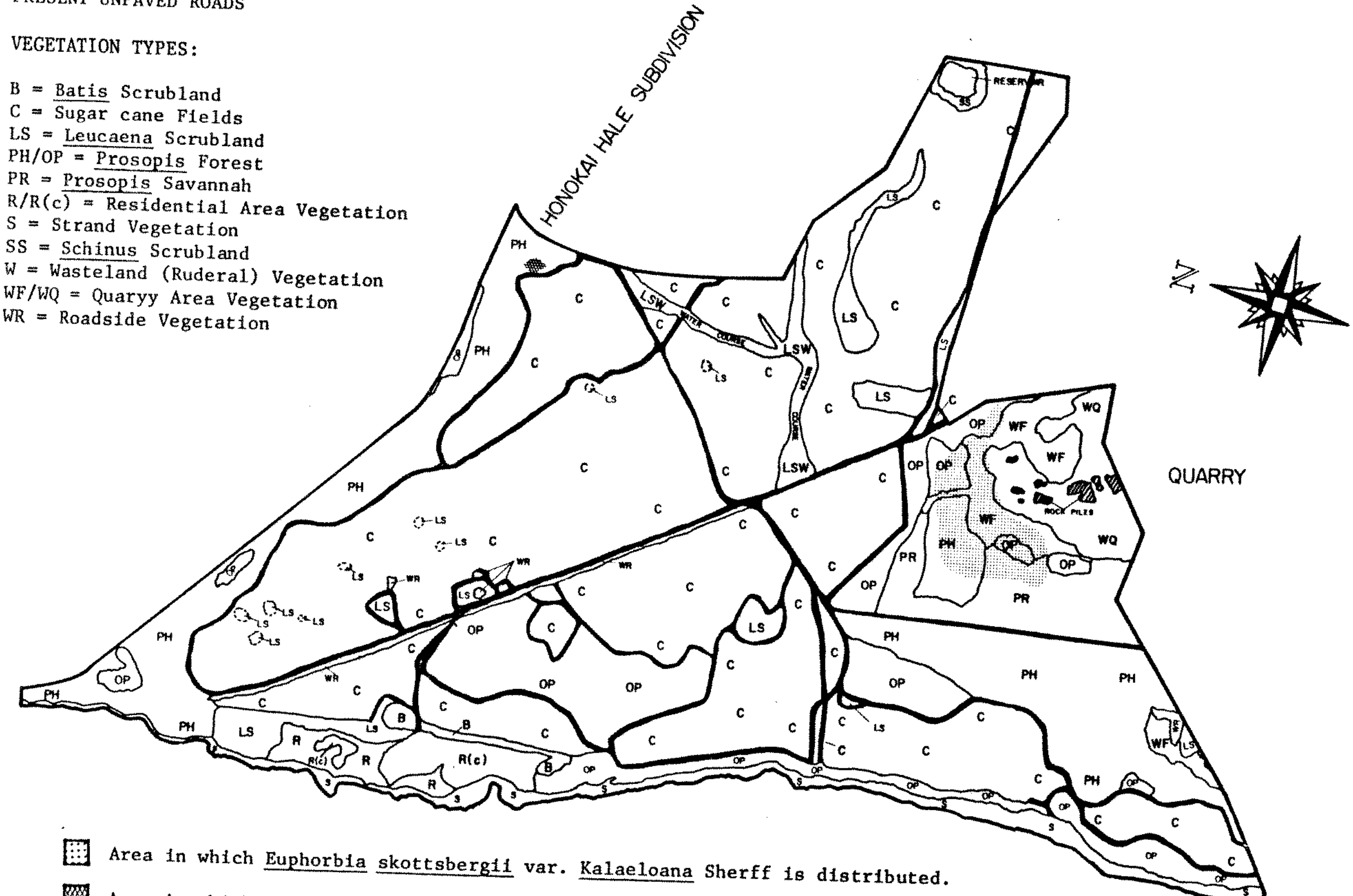
HEAVY LINES INSIDE THE PROJECT SITE INDICATES PRESENT UNPAVED ROADS

VEGETATION TYPES:

B = Batis Scrubland
C = Sugar cane Fields
LS = Leucaena Scrubland
PH/OP = Prosopis Forest
PR = Prosopis Savannah
R/R(c) = Residential Area Vegetation
S = Strand Vegetation
SS = Schinus Scrubland
W = Wasteland (Ruderal) Vegetation
WF/WQ = Quaryy Area Vegetation
WR = Roadside Vegetation



Area in which Euphorbia skottsbergii var. Kalaeloana Sherff is distributed.

Area in which Gossypium sandvicense Parl. is distributed.

West Beach

Figure 1 VEGETATION MA

DATE: JUNE 1979

WEST BEACH RESORT PROJECT

APPENDIX I SECTION 6

ALAN C. ZIEGLER, Ph.D.
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Telephone:
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MEMORANDUM

DATE: 10 August 1984

TO: Environmental Communications, Inc., Frederick J. Rodriguez, Pres.

FROM: Alan C. Ziegler, Consultant

SUBJECT: Occurrence and significance of palaeontological and archaeological remains in the West Beach Resorts development area, O'ahu, with recommendations for their location, recovery, and treatment.

DEFINITIONS

Certain terms used in this memorandum sometimes cause confusion, so a short explanation may be helpful. As you already know, the terms Botany and Zoology are usually used to mean only the study of <u>living</u> species of plants and animals, while Anthropology is understood to be the study of relatively modern or living man and his activities. If, however, we are studying <u>extinct</u> or prehistoric wild species of plants and animals (especially those of relatively great age) the discipline is called Palaeontology; and if early or prehistoric man, along with his artifacts and domestic plants and animals, is the subject the field is termed Archaeology.

Thus, it is easy to explain the difference between the two sciences of Palaeontology and Archaeology, and even to study them separately in many places around the world. But, in the general Barbers Point area, remains representing both of these two scientific fields are often found intermingled or overlapping in soil deposits, and thus have to be considered together. Previous environmental studies related to the deep-draft harbor project immediately to the south of the proposed West Beach Resorts development area have shown that evidence of prehistoric (or "fossil") animals--bones of such extinct birds as a flightless goose and a Hawaiian eagle (see examples in Fig. 1), shells of extinct land snails, etc.; i.e., palaeontological items--may be found in the lower levels of the deposits unaccompanied by any evidence of man; and signs of only a prehistoric

Hawaiian culture--bone fish hooks, volcanic glass flakes, old stone walls, etc.; i.e., archaeological items--may be found in upper levels as well as on the surface around the area; while at intermediate levels may be found the remains of prehistoric birds and snails in apparent association with artifacts, bones of Polynesian-introduced animals, and similar culturally related items. (One such association in the proposed harbor area has been radiocarbon dated at approximately 800 years before the present time.

OCCURRENCE OF PALAEONTOLOGICAL AND ARCHAEOLOGICAL REMAINS

In the general Barbers Point area, these remnants of the past are usually found in sinks or solution pits formed by the dissolving action of rain or ground water on numerous spots in an ancient coral reef now situated some 10 to 80 feet above sea level. (This emergent reef formation once extended from the Wai'anae Coast to Waikīkī but the Barbers Point area now contains essentially the only part not already destroyed by construction and other modern activities.) Through thousands of years, long before the discovery of Hawai'i by Polynesians, dust and mud gradually settled in these sinks, covering the bones and shells of prehistoric birds and land snails that occasionally died in them. Upon arrival of Hawaiians in this area perhaps a thousand years ago, additional remains of at least some of these animals, as well as those of other possible food items along with Hawaiian artifacts, were added to the deposits of certain sinks.

FINDINGS OF RECENT SURVEYS

Such sinks undoubtedly once occurred over the entire West Beach Resorts planned development area but most have been irretrievably lost as a result of massive land-altering operations such as topsoil-filling of sugar cane fields and bulldozing for construction of former military facilities. William M. Barrera, Jr., in a 1979 study of the entire 640-acre project area (West Beach, Oahu: An Archaeological Survey, Chiniago, Inc.), found only one region where any significant number of sinks was still locatable: his Area IV, shown here in Fig. 2. And, as of July, 1984, he estimated that even about 50% of this area's surface was too disturbed to permit detection of sinks.

I visited the Area IV site in the same month and was shown representative examples of the remaining sinks as well as the general site area by Barrera and an assistant. The area appears to have almost exactly the same characteristics as that in the deep-draft harbor project area immediately to the south, in which were located many sinks containing either or both prehistoric bird bones and Hawaiian cultural remains. Later, using rough graph-grid planimetry applied to an aerial photograph, I calculated that Barrera's Area IV represents about 18% of the entire 640-acre West Beach Resorts project area, or about 115 acres--and, as noted earlier, only about half of this, or approximately 60 acres, contains locatable sites.

Barrera recently made a rough count of accessible sinks (i.e., those with a surface opening greater than about half a meter) on approximately 10% of this 60-acre area, and found about 75 such sinks. This means a density of accessible sinks in this region of approximately 12.5 per acre, and an estimated total of 750 accessible sinks within the boundaries of the entire West Beach Resorts proposed development, essentially all restricted to the northern and western parts of Barrera's Area IV along the south-central border of the project.

Additionally, by the end of last July, Barrera had sampled six of the accessible sinks by means of half-meter-square test pits dug to bedrock in order to obtain some idea of how many of the estimated total of 750 might be expected to contain palaeontological and/or archaeological remains. This sample, unfortunately statistically rather small, indicated that about 50% of accessible sinks may contain significant amounts of palaeontological/archaeological material. Three of his six sinks proved sterile as regards such remains; but two others contained (only) bird and rodent remains; while the final one showed remains of rodents and one bird bone along with relatively abundant fish bones and other evidence of marine animals, almost surely indicating a Hawaiian cultural deposit. I performed a preliminary analysis of the vertebrate material from these latter three sinks, and tentatively identified bird species from the first two as including a totally extinct flightless goose, as well as a petrel now found only on the islands of Maui and Hawai'i. The rodent found in all three sinks is the Polynesian-introduced Hawaiian Rat. The fish represented in the last sink is still unidentified but the bird bone fragment accompanying it could prove to belong to an extinct species of crow when an opportunity arises to directly compare the fragment with identified skeletal material in the Bishop Museum. The type and general frequency of these animal remains in this limited sample seem similar to those characteristic of sinks previously excavated in the deep-draft harbor project area.

At least one additional accessible sink outside of Area IV, as well as three presumed Hawaiian habitation sites in sand dune areas along the ocean shore, were found or noted by Barrera in his 1979 survey (see general locations of these sites in Fig. 2).

DISCUSSION

I sought figures on the density of similar sinks as well as on percentages of sinks yielding palaeontological/archaeological remains in various reports concerning the deep-draft harbor area to compare with those found by Barrera in the West Beach Resorts area. The only pertinent figures encountered were those for a proposed dredged-material disposal site in the far southeastern portion of the harbor project (near the junction of Malakole Road and Kalaeloa Boulevard) presented by Aki Sinoto (Cultural Resources Survey of New Dredged Material Disposal Sites at Barbers Point, O'ahu, Hawai'i, MS 050179 of the Bishop Museum Anthropology Department, prepared for the U.S. Army Engineer Division, Pacific Ocean, November, 1979). The southern portion of this site was systematically surveyed for accessible, archaeologically unmodified, sinks, and Sinoto found a mean of 104 such sinks per 10,000 m^2, or approximately 40 per acre. (However, the range to either side of this mean figure was great: 0 to 276 sinks per 10,000 m^2, indicating the density of sinks may vary widely over this entire Barbers Point limestone reef area, including, presumably, also the West Beach Resorts development portion.)

Sinoto's average of 40 sinks per acre is noticeably higher than the figure of 12.5 sinks calculated from Barrera's West Beach Resorts data. But note that Sinoto's figure was simply an average and that certain parts of his area had no appropriate sinks. Also, as he himself states, the density of sinks in the surveyed portion of his site was "extremely high" and , the number of sinks "decreased markedly" in the remaining portion of the area. I was unable to similarly calculate densities of sinks in surrounding parts of the deep-draft harbor project, primarily because of lack of reported dimensions of other harbor project areas found to contain stated numbers of sinks. However, after studying mapped site areas and related environmental-report data, my subjective impression is that the usual density of bone-containing sinks in the overall harbor area is, as intimated by Sinoto, normally much less than about 40 per acre, and that it may well be even less than the 12.5 per acre obtained from Barrera's data. So, there presently seems no compelling reason to think that this proposed figure of 12.5 sinks per acre for the West Beach Resorts property is inaccurate and, thus, it will tentatively be accepted for use in further calculations.

As to determining the fraction of the estimated total number of 750 accessible West Beach Resorts sinks that might contain palaeontological and/or archaeological remains, it may be recalled that Barrera's recent investigations indicated that 50% of the total could be expected to contain such material. However, because this sample was so small and thus susceptible to so great a potential sampling error, I compared this 50% figure with that found by Sinoto in his previously mentioned work involving part of the harbor dredged-material disposal area.

There, 24 archaeologically unmodified sinks systematically chosen (one from each of 24 ten-thousand-meter-square grids) and sampled revealed that 19, or almost 80%, contained bird bones. I do not know how to account for this relatively great discrepancy in percentage of bone-bearing sinks in different areas, unless it is simply chance; that is, due to the probable sampling error suggested above in the case of the West Beach Resorts site. (In this regard, it should be realized that the occurrence of bone in only one more of Barrera's sinks would have increased his percentage to 67%, and in only two more to 83%.) Alternatively, it could be that there is a real difference in percentage of sinks containing bone in various parts of the overall Barbers Point region and/or even within the West Beach Resorts portion of it. Thus, until and unless further sampling is undertaken, and such work indicates a necessary change, I would suggest considering

Barrera's figure of 50% as representative of the approximate frequency of bone-containing sinks among the total number of such formations. This would mean that about 375 West Beach Resorts area sinks can be expected to contain palaeontological and/or archaeological remains.

The problem now remaining is twofold: how to locate the possible 375 sinks that contain the bone or cultural remains among the estimated total of 750; and, once identified, what to do with these particular sinks as regards possible excavation and preservation.

It seems the bone-containing sinks can most efficiently and economically be located by means of a program of test-pitting. In this procedure, to accommodate at least part of any possible geographic variation in both density and bone-bearing potential of sinks at the site, broad transects should be laid out traversing the entire sink area--perhaps running from the seaward to the inland side of the area. Every second sink along each of these transects should then be sampled by, say, excavation of a quadrant in smaller sinks or a half-meter-square test pit in larger ones, until either the first bird bone is recovered or the bottom of the sink is reached. Thus, in the West Beach Resorts project area, every other one of about 750 accessible sinks would be so test-pitted, and approximately half of these 375 tested sinks--or 188--might be found to contain palaeontological and/or archaeological items. These 188 sinks, once so identified, should be marked both on the ground and on a map, and considered eligible for complete excavation.

With regard to what should be done with such identified sites--more specifically, what percentage of them should be completely excavated and/or preserved--the sort of salvage palaeontology/archaeology indicated proves to be, for once, a relatively satisfactory procedure. That is, in contrast to the case of a just-discovered or recently excavated heiau or Hawaiian house site facing imminent destruction from development activities, the bone-containing sinks themselves are expendable (or at least most of them are) once the contents of an adequate number of them are properly recorded and removed for educational and scientific purposes. To restate this, it is primarily the sink contents and recorded associations that are important, not the sinks themselves. If all of the 188 sinks under consideration were completely excavated, this would represent an approximate 25% excavation of the total available sinks occurring on the West Beach Resorts project area.

The relation of this percentage to other somewhat similar excavation figures should be briefly examined. An excavation figure of 10% is often mentioned as a minimally acceptable one for examination of many archaeological sites. For example, in the study of an open and relatively extensive site such as one thought to represent a former small village, the total areal extent of which is judged to be about 1000 m^2, it would be desirable to excavate at least 100 one-meter-square pits scattered over the entire site surface. But this amount of excavation (i.e., 10%) would be aimed primarily only at discovering if the site did, in fact, represent a former village and, if so, what activities might have taken place in different parts of this habitation area. The major objective would not be to recover a maximum--or even a necessarily significant--number of artifacts or other items from the site for subsequent scientific study or display purposes. If, however, total destruction of the site was imminent, a great effort would undoubtedly be made to gather as much more site material as could feasibly be excavated in the remaining time available.

Thus, in the case of the West Beach Resorts area sinks, most or all of which will be lost as development proceeds, a suggested excavation figure of about 25% does not, in my opinion, seem at all unreasonable. This would mean the total excavation of an estimated 188 sinks. However, because various improved dating methods and other palaeontological/archaeological techniques will undoubtedly be developed in the future, a few of these bone-containing sinks--say, 10 or 15--should be preserved intact for use in future investigations. These few sinks could also serve as a minor visitor attraction in the eventual resort area if suitably marked and interpreted; and might conveniently be located out of the way of development among those sinks that still appear to be locatable along the old railroad right-of-way passing through the West Beach Resorts area.

In addition, the sink discovered by Barrera outside of the primary sink area, as well as the few sand-dune habitation sites, may yield bones of extinct and still-extant bird species. These remains would serve as sources of information complementary to data derived from sink excavations. Finally, it seems the scientific and educational value of recovered West Beach Resorts development area palaeontological and archaeological specimens could best be realized by deposition of most or all of such material, along with appropriate documentation, in the Bishop Museum rather than in some out-of-state institution.

SUMMARY

Soil-filled limestone sinks containing apparently significant amounts of palaeontological and archaeological material are now locatable on only about a fifth of the proposed 640-acre West Beach Resorts project area. This sink-bearing portion of the land is situated almost entirely in the south-central portion of the planned development. The density of sinks, as well as their contents, may prove to differ geographically over the site region. An estimated 750 sinks are accessible for purposes of excavation (i.e., have surface openings greater than 0.5 meters). Possibly half of these can be expected to contain palaeontological and/or archaeological remains such as bones of prehistoric birds and shells of extinct land snails, as well as items indicating early Hawaiian culture. Thus, if about half of the total number of 750 sinks were test-pitted to determine presence or absence of such remains, and the resultant 50% found positive in this respect were subsequently completely excavated, about 188 sinks--or approximately 25% of the total sink number--would have been examined about as thoroughly as presently appears possible and feasible. After completion of this suggested amount of excavation, in almost all cases, the sinks themselves (both excavated and unexcavated) would seem expendable, and any planned development of the sink area could then proceed. A few sinks, shown by test-pitting to contain prehistoric bird bones, should be preserved intact in a limited geographic area for their educational and future scientific value.

RECOMMENDATIONS

(1) Locate and appropriately mark--on both ground and map--all accessible (diameter greater than 0.5 meters) sinks in the pertinent south-central portion of the proposed West Beach Resorts development area. (Estimated total sink number = 750.)

(2) Establish several broad transects, oriented mauka-makai, through the entire sink-bearing area, and test-pit every second accessible sink encountered along each of the transects. (Estimated test-pitted sink number = 375.)

(3) Completely excavate essentially all of the 50% of test-pitted sinks that will probably be found to contain bones of extinct birds and/or Hawaiian cultural remains. (Estimated excavated sink number = 188.)

(4) After completion of this excavation procedure, consider essentially all of the primary sink area, including both excavated and unexcavated sinks, available for any desired construction or other development purpose.

(5) Preserve a few--perhaps a dozen or so--intact sinks in a convenient non-development location to serve as a minor visitor attraction as well as for possible future scientific study.

(6) Excavate the single presently accessible sink known to be situated outside of the primary sink area, as well as the few sand-dune habitation sites along the shore.

(7) Deposit most or all palaeontological and archaeological material recovered in the Bishop Museum, Honolulu.

# # #

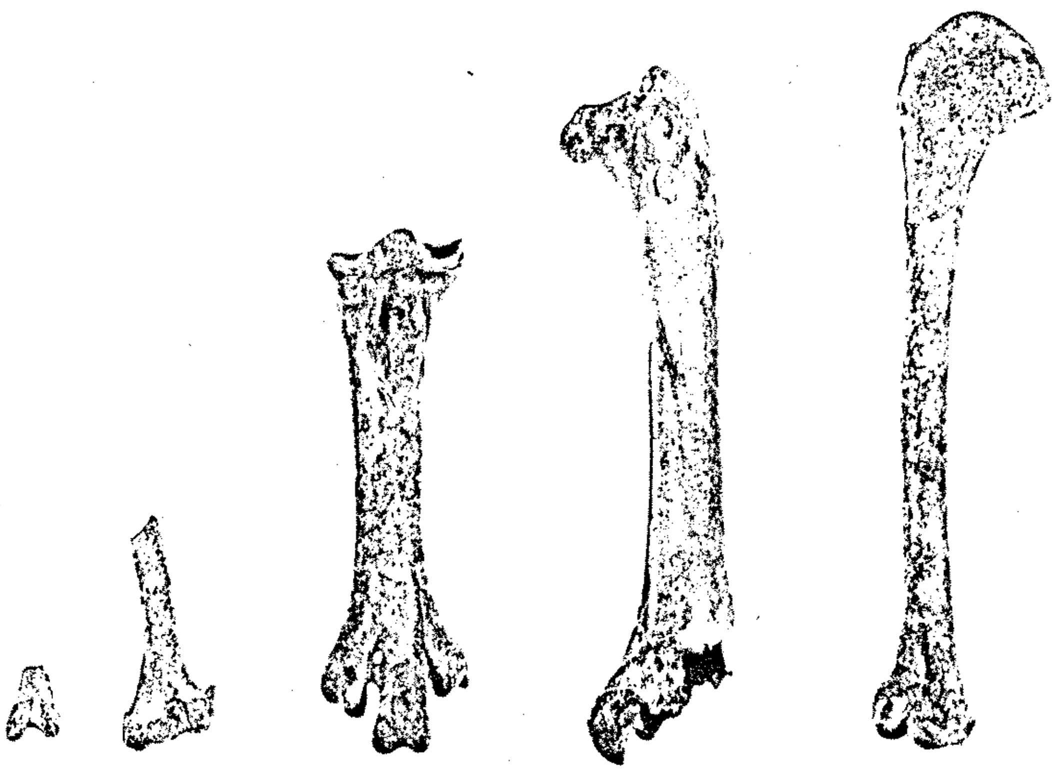


Fig. 1. Bird bones from sinks in deep-draft harbor project area, Barbers Point region, O'ahu, Hawai'i. Left to right: extinct long-legged owl; extinct O'ahu crow; extinct flightless goose; extinct Hawaiian eagle; flighted goose, possible nēnē (length of this bone = 12.5 cm or approximately 5 inches). (Reproduced, with permission, from unnumbered figure immediately preceding page 67 in: Sinoto, A., 1976, A Report on Cultural Resources Survey at Barbers Point, Island of Oahu, MS 122476 of Bishop Museum Anthropology Department, prepared for Department of the Army, Corps of Engineers, Pacific Ocean Division, Honolulu, Hawaii.)

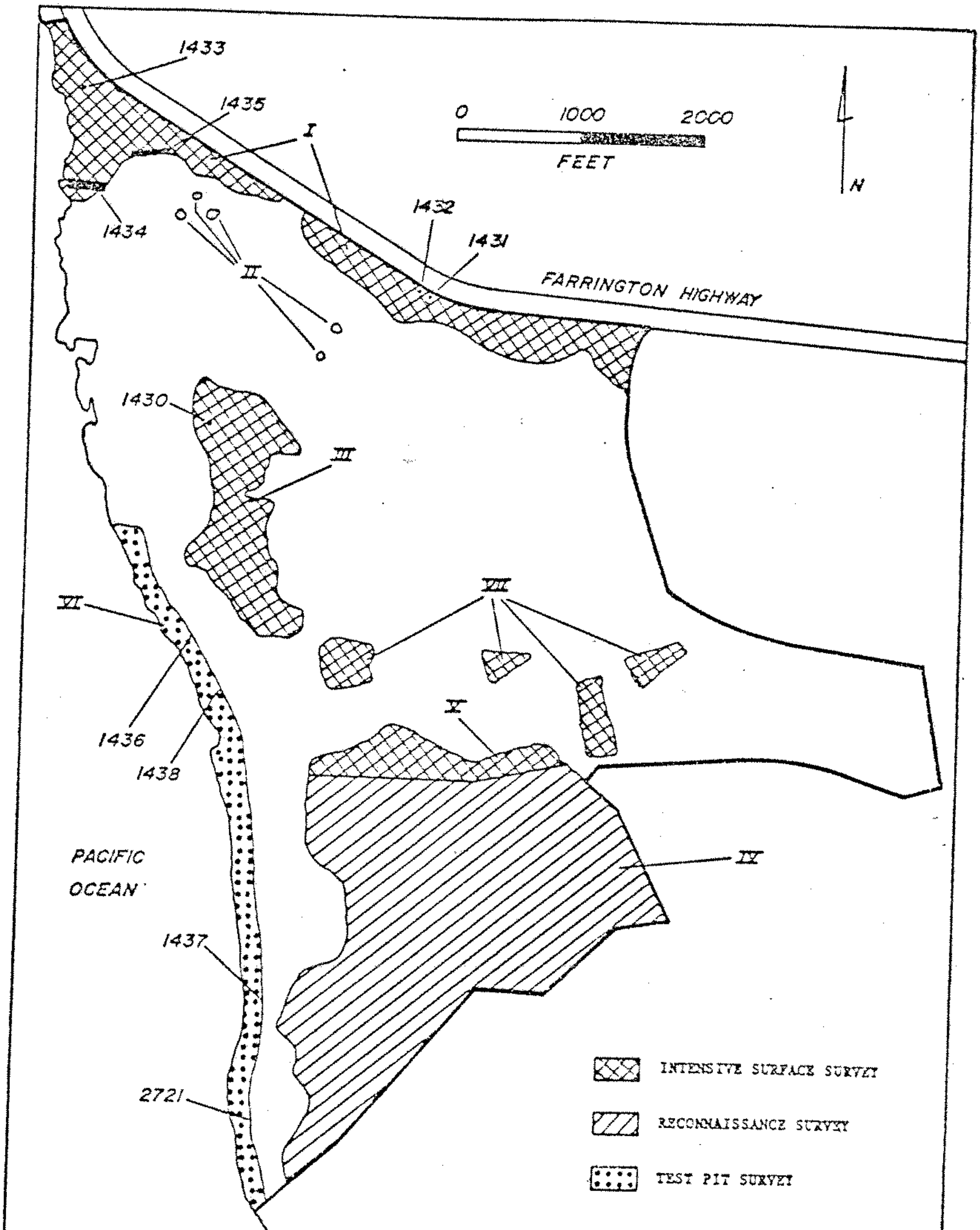


Fig. 2. Map of West Beach Resorts proposed development area, Barbers Point region, O'ahu, Hawai'i. The portion labeled IV is the primary sink area. A single sink occurs in Area III, and three Hawaiian sand-dune habitation sites are located in VI. (Reproduced, with permission, from Fig. 2 of: Barrera, W., Jr., 1979, West Beach, Oahu: An Archaeological Survey, Chiniago, Inc.

APPENDIX I SECTION 7

WEST BEACH RESORT

TRAFFIC IMPACT ANALYSIS

PREPARED FOR: WEST BEACH ESTATES

PREPARED BY: COMMUNITY PLANNING, INC.

DECEMBER, 1983

REVISED: JULY, 1984

T A B L E   O F   C O N T E N T S

LIST OF TABLES

LIST OF EXHIBITS

WEST BEACH RESORT TRAFFIC ANALYSIS

PURPOSE

The purpose of this study is to assess the traffic impacts from the proposed West Beach Resort project on the existing highway system within the influence of the project site. This report includes an analysis of existing and projected traffic volumes, assesses the adequacy of the highway system to accommodate future traffic volumes, discusses alternative mitigating actions and analyzes the proposed intersection conditions at Farrington Highway fronting the West Beach project site. The mitigating actions address alternatives which can be pursued to alleviate adverse impacts resulting from the proposed development.

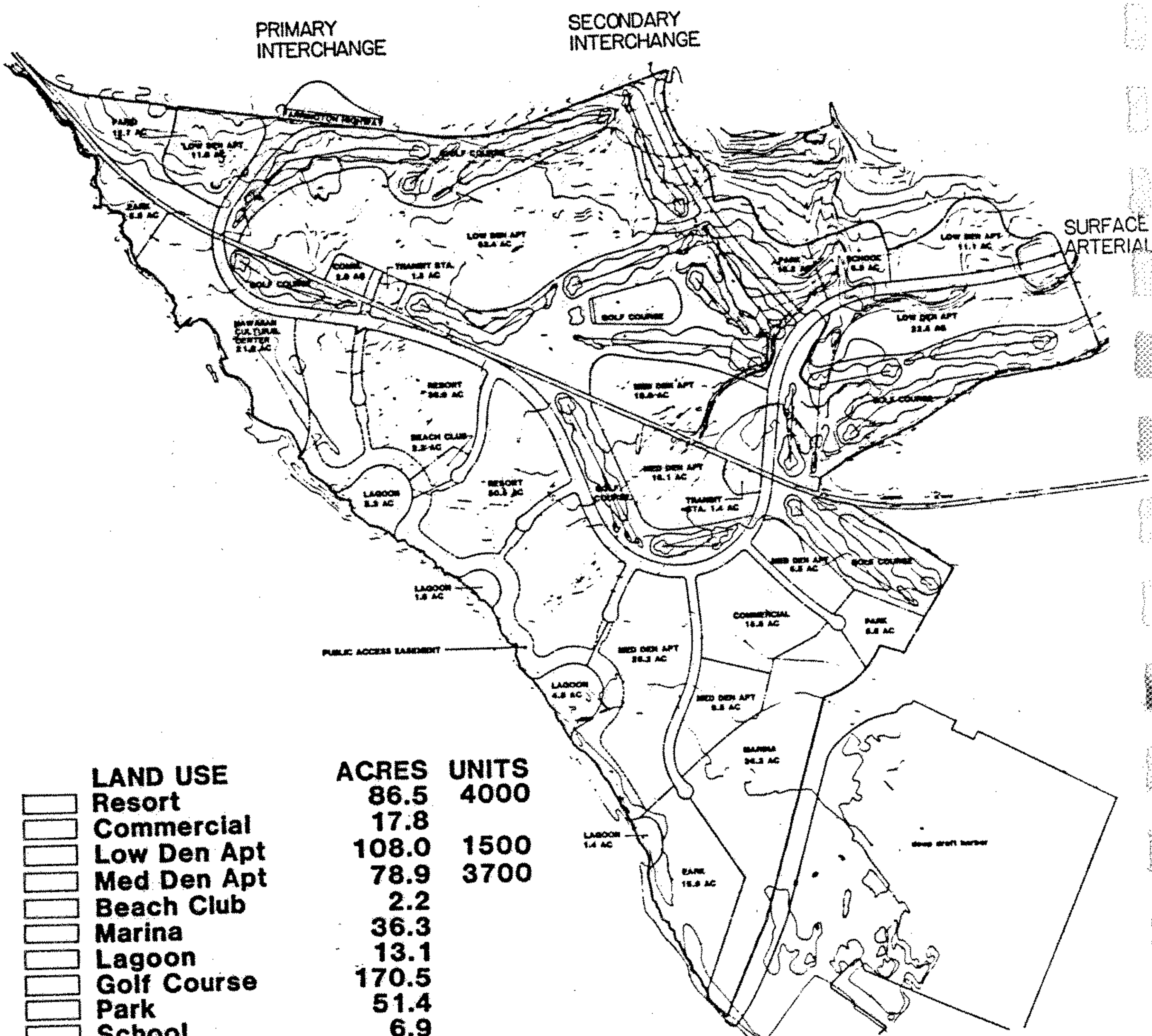
INTRODUCTION

One of the most important considerations in a project of the magnitude of West Beach is traffic. West Beach is fortunate in that it adjoins Farrington Highway, a four-lane divided highway, along its north boundary between Kahe Point and Palailai Interchange. Less than a mile toward Honolulu, Farrington Highway becomes Interstate Highway H-1, a four-lane limited access freeway, and expands to eight lanes east of Kunia Interchange at Waipahu.

Internally, West Beach will have a major loop road system which will connect with Farrington Highway at two intersection points as shown on Exhibit A. Secondary streets will be served from the major loop road to accommodate traffic within the project. An extension of the major loop road will ultimately be developed toward Ewa, with connections to Interstate Highway H-1 at the Palailai Interchange.

The analysis of the traffic implications of the West Beach project was based upon the following data and assumptions:

1. The primary traffic impact from West Beach will occur on Farrington Highway and Interstate Highway H-1 between Kahe Point and Kunia Interchange in Waipahu. Beyond Kunia, the amount of traffic generated from West Beach is minimal in comparison to H-1 volume and Honolulu-bound traffic entering H-1 at Kunia Interchange.



LAND USE	ACRES	UNITS
Resort	86.5	4000
Commercial	17.8	
Low Den Apt	108.0	1500
Med Den Apt	78.9	3700
Beach Club	2.2	
Marina	36.3	
Lagoon	13.1	
Golf Course	170.5	
Park	51.4	
School	6.9	
Circulation	46.1	
Transit Station	2.7	
Hawn Cult Center	21.8	
TOTAL	642.2	9200

0 400 800 1600

WEST BEACH RESORT

MASTER PLAN

EXHIBIT A

2. Existing traffic counts on Farrington Highway and Interstate Highway H-1 are based on 1982 data from the Department of Transportation.

3. The projection period used for analysis is ten years and assumes full development of the 642.2 acre West Beach project.

4. West Beach will become a significant employment center in the Ewa District. It is expected that a high percentage of the jobs will provide employment for residents of Waianae and Ewa communities.

5. The West Beach project will be a somewhat self-contained center with a full range of urban activities. This will tend to reduce the amount of external trips made by West Beach residents for employment, shopping and recreation.

6. The Department of Transportation plans to improve Interstate Highway H-1 from Palailai to Kunia Interchange by adding one lane in each direction to the existing four-lane facility. This will significantly improve the carrying capacity to serve future traffic as Ewa grows to become the secondary urban center.

7. The City and County is planning to improve express transit service to Ewa and Waianae in the near future. In addition, the West Beach master plan provides for a transit right-of-way and two stations within the project area to accommodate City plans for future mass transit improvements.

WEST BEACH TRAFFIC GENERATION

A preliminary trip generation study has been made of the planned West Beach development. It includes projections of the traffic to be generated by the major uses, residential and resort.

Residential Development

The proposed 5,200 residential units and supporting facilities are expected to generate 7.5 auto trips per unit for a total of 39,000 trips. The comprehensive plan of development, complete with schools, shopping, community and recreation facilities, and job opportunities will reduce the amount of external traffic. It is estimated that two-thirds of the total trips, 25,740, will be external to the project area. This traffic will use Farrington Highway, with 90 percent or 23,166 trips assumed to be Honolulu-bound and 10 percent or 2,574 trips Waianae-bound. In the future, access to West Beach will also be available by a new surface arterial parallel to the existing highway. This route will connect West Beach to other areas of Ewa and provide an alternate means of ingress and egress. It can be anticipated that traffic to and from West Beach will be split between the existing highway and the new arterial.

Resort Development

Self-sufficiency best describes the resort development proposed for West Beach. The proposed 4,000 hotel rooms will be complemented by commercial, entertainment and dining facilities, marina and recreational amenities. Traffic generation for resort complexes is typically composed of high occupancy vehicle types such as buses, vans and limousines. In addition, most of the traffic generated by the resort will occur during off-peak hours. Based on these factors, the resort complex will generate 2.5 vehicle trips a day per unit or 10,000 total daily trips. It is estimated that 90 percent, or 9,000 trips, will be external. This traffic will also use Farrington Highway, with 90 percent or 8,100 trips Honolulu-bound and 10 percent or 900 trips Waianae-bound. In the future, this traffic will also be split between the existing highway and the future surface arterial.

Total Trip Generation and Traffic Assignments

The West Beach project, when fully developed, will generate approximately 34,740 external auto trips per day (25,740 residential and 9,000 resort). Much of this traffic will be destined to and from Honolulu. Further, portions of the traffic on Farrington Highway from Waianae will be destined for West Beach because of the jobs to be created there and the various amenities and recreational facilities.

The following distributions of the West Beach daily external traffic and traffic originating from Waianae is assumed:

1. Farrington Highway to Waianae: 10 percent or 3,474 vehicles per day (VPD)

2. Farrington Highway to Honolulu

   a. Palailai (Makakilo, Barber's Point, Campbell Industrial Park):

      5 percent or 1,737 VPD

b. Ewa Beach, Waipahu: 15 percent or 5,211 VPD

c. Pearl City, Honolulu: 70 percent or 24,318 VPD

3. Waianae traffic to West Beach: 5 percent of the projected highway volume plus 40 percent of the employment trips generated by West Beach

Therefore, two-way traffic generated on the highway system toward Honolulu from West Beach is summarized below:

1. Farrington Highway: West Beach entrance to Palailai Interchange is 34,740 VPD - 3,474 VPD = 31,266 VPD

2. Interstate Highway H-1: Palailai to Makakilo Interchange is 31,266 VPD - 1,737 VPD = 29,529 VPD

3. Interstate Highway H-1: Makakilo to Kunia Interchange is 29,529 VPD

4. Interstate Highway H-1: East of Kunia Interchange is 29,529 VPD - 5,211 VPD = 24,318 VPD

Peak Hours

Since the demand for highway use will be greatest during the morning hours, the a. m. peak will be used as the basis for analyzing the peak flow. A peak-hour factor of 10 percent for the residential portion of the West Beach traffic is assumed, and the resort traffic is discounted since it occurs during off-peak periods. The directional distribution of peak-hour traffic assigns 10 percent toward Waianae and 90 percent toward Honolulu.

Therefore, residential traffic destined to Honolulu from West Beach during the a. m. peak are computed as follows, based on 90 percent of the residential external traffic, or 23,166 VPD travelling toward Honolulu:

Farrington Highway from West Beach to Palailai Interchange:
(25,740 x 0.90) x 0.10 = 2,317 vehicles

Palailai to Makakilo Interchange:
(25,740 x 0.85) x 0.10 = 2,188 vehicles

Makakilo to Kunia Interchange:
2,188 vehicles

Kunia to Waiawa Interchange:
(25,740 x 0.70) x 0.10 = 1,802 vehicles

TRAFFIC PROJECTIONS

The following analysis evaluates each section of the affected highway system based upon the projected increase in traffic over the next ten years and the additional traffic generated by the West Beach project.

Factors used for traffic growth assume a 7 percent annual increase of the 1982 Department of Transportation traffic counts along Farrington and H-1 Highways. This situation will be consistent except for traffic generated to West Beach from the Waianae Coast where growth is assumed to increase at an annual rate of 4 percent due to the population growth guidelines included in the City and County General Plan and Development Plan policies and objectives. Further, it is assumed that 5 percent of the traffic from Waianae is destined for West Beach.

West Beach will become an important employment center in the Ewa area. It is anticipated that a high percentage of the jobs created at West Beach will be filled by residents of Waianae and Ewa communities. Since employee work trips will be a significant factor in the morning peak-hour traffic, estimates have been made of the origin of employee trips and the percentage occurring during the peak hour. These estimates are provided in Table 1 and incorporated into the analysis of each highway segment discussed below.

Table 2 on page 8 summarizes the traffic projections.

<u>Farrington Highway: Kahe Point to West Beach</u>

1. 24-Hour

   The existing traffic is 20,910 VPD passing the project site on Farrington Highway. Traffic volume along this segment will increase to 29,274 VPD, based on 4 percent annual growth over the next ten years (20,910 VPD x 1.4). West Beach traffic will add 3,474 VPD based on 10 percent destined toward Waianae. Therefore, the total traffic volume is estimated at 32,748 VPD (29,274 VPD + 3,474 VPD), significantly less than the 57,600 VPD capacity based on a Level of Service "C" for stable flow which assumes a design capacity of 1,200 vehicles per hour per lane per 12-hour day for the existing four-lane highway.

TABLE 1 - TRIP GENERATION FROM WEST BEACH EMPLOYMENT

USE	UNIT	BASIS	EMPLOYMENT	% PEAK HOUR	AM PEAK HOUR TRIPS
Deluxe Hotel	400 rooms	1.5/rm.	600	.55	330
First Class Hotel	1,600 rooms	.7/rm.	1,120	.55	616
Resort Condo	2,000 units	.5/rm.	1,000	.80	800
Residential Condo	5,200 units	.05/rm.	260	.80	208
Commercial Retail	185,000 sq. ft.	.005/sq. ft.	925	.70	648
Restaurants	35,000 sq. ft.	40/rest.	280	0	0
Golf Course	18 hole		125	.60	75
Beach Club			150	0	0
Maintenance/Security			30	.80	24
Management			20	1.00	20
Yacht Club			50	0	0
Marina			200	.50	100
Hawaiian Cultural Center			125	.70	88
Luau			175	0	0
			5,060		2,909
				Say	3,000[1]

		Peak Hour	Daily
Origin of trips:	From Honolulu	.60 x 2,850 = 1,710	.60 x 4,807 = 2,884
	From Waianae	.40 x 2,850 = 1,140	.40 x 4,807 = 1,923
	On-Site	.05 x 3,000 = 150	.05 x 5,060 = 253

Origin of trips with surface arterial:

From Honolulu via Farrington-H-1	.50 x 1,710 = 855
From Honolulu via Surface Arterial	.50 x 1,710 = 855
From Waianae	.40 x 2,850 = 1,140
On-Site	.05 x 3,000 = 150

[1] Based on investigation and estimates of Pannell Kerr Forster, resort consultants for the West Beach project.

TABLE 2 - SUMMARY OF TRAFFIC VOLUME PROJECTIONS

HIGHWAY SEGMENT	EXISTING AND PLANNED LANES	1982 DOT TRAFFIC COUNT		NORMAL INCREASE[1] (70%±)		TOTAL VOLUME IN 10 YEARS		WAIANAE TRIPS[2] TO WEST BEACH		EXTERNAL TRIPS[3] FROM WEST BEACH		TOTAL TRAFFIC VOLUME	DESIGN[4] CAPACITY	LEVEL OF SERVICE
Farrington Highway: Kahe Point to West Beach														
24-Hour Volume	4	20,910	+	8,364	=	29,274		--	+	3,474	=	32,748	57,600	"C"
AM Peak-Hour Volume	2	1,310	+	524	=	1,834		--		--	=	1,834	2,400	"C"
Farrington Highway: West Beach to Palailai Interchange														
24-Hour Volume	4	22,280	+	15,596	=	37,876	-	3,387	+	31,266	=	65,755	72,000	"D"
AM Peak-Hour Volume	2	1,410	+	987	=	2,397	-	1,232	+	2,317	=	3,482	4,000	"E"
Interstate Highway H-1: Palailai Interchange to Makakilo Interchange														
24-Hour Volume	6	19,230	+	13,461	=	32,691	-	3,387	+	29,529	=	58,833	86,400	"C"
AM Peak-Hour Volume	3	990	+	693	=	1,683	-	1,232	+	2,188	=	2,639	3,600	"C"
Interstate Highway H-1: Makakilo Interchange to Kunia Interchange														
24-Hour Volume	6	30,660	+	21,462	=	52,122	-	3,387	+	29,529	=	78,264	86,400	"C"
AM Peak-Hour Volume	3	1,670	+	1,169	=	2,839	-	1,232	+	2,188	=	3,795	4,500	"D"
Interstate Highway H-1: Kunia Interchange to Waiawa Interchange														
24-Hour Volume	8	43,260	+	30,282	=	73,542	-	3,387	+	24,318	=	94,473	115,200	"C"
AM Peak-Hour Volume	4	2,560	+	1,792	=	4,352	-	1,232	+	1,802	=	4,922	6,000	"D"

[1] Based on 7 percent per year increase for 10 years.

[2] Waianae trips destined to West Beach based on 5 percent of projected volume plus 40 percent of employment trips originating in Waianae:

24-hour volume (29,274 x .05) + (4,807 x .40) = 1,464 + 1,923 = 3,387

AM peak-hour volume (1,834 x .05) + (2,850 x .40) = 92 + 1,140 = 1,232

[3] Based on full project development. See page 5 for 24-hour volumes and AM peak-hour volume.

[4] Based on following definitions of Level of Service:

"C"	1200 VPH/L x 4L x 12 H/D = 57,600 VPD 1200 VPH/L x 2L = 2,400 VPH	"C"	1200 VPH/L x 6L x 12 H/D = 86,400 VPD 1200 VPH/L x 3L = 3,600 VPH	"C"	1200 VPH/L x 8L x 12 H/D = 115,200 VPD 1200 VPH/L x 4L = 4,800 VPH
"D"	1500 VPH/L x 4L x 12 H/D = 72,000 VPD 1500 VPH/L x 2L = 3,000 VPH	"D"	1500 VPH/L x 6L x 12 H/D = 108,000 VPD 1500 VPH/L x 3L = 4,500 VPH	"D"	1500 VPH/L x 8L x 12 H/D = 144,000 VPD 1500 VPH/L x 4L = 6,000 VPH
"E"	2000 VPH/L x 2L = 4,000 VPH				

2. AM Peak Hour

Existing Honolulu-bound traffic is 1,310 vehicles during the morning peak hour. This volume will increase to 1,834 vehicles, based on 4 percent growth annually (1,310 x 1.4). There is no impact from West Beach traffic at this point in the Honolulu direction. This traffic volume is also significantly below the peak-hour capacity of 2,400 based on Level of Service "C," or 1,200 vehicles per hour per lane for the two-lane Honolulu-bound.

Farrington Highway: West Beach to Palailai Interchange

1. 24-Hour

Existing traffic is 22,280 VPD along this portion of Farrington Highway. The annual growth to 37,876 VPD is assumed at 7 percent annually, less 5 percent of the Waianae volume (29,274 VPD x 0.05) or 1,464 VPD destined for West Beach. Therefore, future traffic volume will increase to 36,412 VPD (37,876 VPD - 1,464 VPD). The amount of traffic destined for West Beach from Waianae, or 1,464 vehicles, will be subsequently deducted from the analysis of the other highway segments.

Additionally, 40 percent of the employment trips generated by West Beach are estimated to originate in Waianae. Therefore, 1,923 employee trips are also deducted from the Waianae volume (36,412 - 1,923 = 34,489) and subsequently deducted in the analysis of the other highway segments.

West Beach traffic will add 31,266 VPD to this highway segment. The total traffic is then estimated to be 65,755 VPD (34,489 + 31,266) which is below the design capacity of 72,000 VPD for an acceptable Level of Service "D."

2. AM Peak Hour

The existing traffic volume during the morning is 1,410 vehicles in the Honolulu direction. This will increase to 2,305, based on a 7 percent annual growth rate (1,410 x 1.70) and deletion of 5 percent of the peak hour volume destined for West Beach (1,834 x .05 = 92). The amount of traffic destined for West Beach in the peak hour, or 92 vehicles, will also be subsequently deducted from the analysis of the other highway segments.

Peak-hour employment trips destined for West Beach are also deducted from the Farrington Highway traffic volume. This reduces the volume by 1,140 vehicles, based on 40 percent of the 2,850 peak-hour employment trips originating in Waianae.

The a. m. peak-hour traffic from West Beach will add 2,317 vehicles. The peak-hour volume on Farrington Highway, therefore, is 3,482 vehicles (2,397 - 92 - 1,140 + 2,317 = 3,482), adjusting for the influence of West Beach as a destination for employee and other trips originating in Waianae.

The increase in traffic will exceed the 3,000 vehicle design capacity for Level of Service "D" and the highway will operate at Level of Service "E," based on a peak-hour capacity of 2,000 vehicles per lane or 4,000 vehicles for the two Honolulu-bound lanes.

Interstate Highway H-1 from Palailai Interchange to Makakilo Interchange

1. 24-Hour

   The existing traffic volume is 19,230 VPD along this existing four-lane highway segment. With a 7 percent annual increase over the next ten years, the future volume will be 31,227 VPD (19,230 VPD x 1.70 - 1,464 VPD). Reduction for employee trips to West Beach (1923) results in 29,304 VPD (31,227 - 1,923). The West Beach traffic will add 29,529 VPD to this segment, for a total volume of 58,833 VPD (29,304 VPD + 29,529 VPD). This volume is also below the design capacity of 86,400 VPD for Level of Service "C," based upon implementation of the planned widening of this highway segment to six lanes.

2. AM Peak Hour

   The existing traffic volume during the morning is 990 vehicles in the Honolulu direction. With an increase of 7 percent annually, future volume will be 1,591 vehicles (990 x 1.70 - 92). Adding the a. m. peak hour volume from West Beach of 2,188 vehicles and subtracting employment trips into West Beach (1,140), future traffic volume will total 2,639 vehicles (1,591 - 1,140 + 2,188). The total peak-hour volume along this highway segment is below the design capacity for Level of Service "C" of 3,600 vehicles for the planned three Honolulu-bound lanes.

Interstate Highway H-1: Makakilo Interchange to Kunia Interchange

1. 24-Hour

The existing traffic volume is 30,660 VPD for this segment of the existing four-lane highway. The future increase, at 7 percent annually, less 1,923 employee trips to West Beach, will result in a daily volume of 48,735 VPD (30,660 VPD x 1.70 - 1,464 VPD - 1,923). The additional traffic from West Beach, or 29,529 VPD, will bring the total volume to 78,264 VPD (48,735 VPD + 29,529 VPD). This volume is below the 86,400 VPD design capacity for Level of Service "C," based upon the planned widening of this highway segment to six lanes.

2. AM Peak Hour

The existing morning peak volume is 1,670 vehicles in the Honolulu direction. With an annual increase of 7 percent, the future volume will be 2,747 vehicles (1,670 x 1.70 - 92) in ten years. West Beach traffic will add 2,188 vehicles during the a. m. peak hour, less 1,140 employee trips to West Beach, bringing the future volume to 3,795 vehicles (2,747 - 1,140 + 2,188). With the planned addition of one lane in each direction to this segment of the highway, the a. m. peak hour design capacity for an acceptable Level of Service "D" will be 4,500 vehicles based on 1,500 vehicles per lane for three Honolulu-bound lanes. Therefore, the projected traffic volume falls below the design capacity with the planned State Highway improvements.

Interstate Highway H-1: Kunia Interchange to Waiawa Interchange

This highway segment consists of four lanes in each direction. Due to the increased carrying capacity, the traffic impacts from West Beach do not affect the future capacity of this highway segment. The existing traffic volume is 43,260 VPD. This will increase to 72,078 VPD (43,260 VPD x 1.70 - 1,464 VPD) in ten years. Employee trips to West Beach reduce this by 1,923 trips. West Beach will add 24,318 VPD for a future total of 94,473 VPD (72,078 VPD - 1,140 + 24,318 VPD). This is significantly below the design capacity of 115,200 VPD for Level of Service "C," based on 1,200 vehicles per lane for eight lanes per 12-hour day.

Based on the assumed distribution outlined above, it can be concluded that the existing highway system has sufficient capacity to accommodate the projected traffic volumes. The surface arterial effectively increases carrying capacity and acts to relieve the existing highway of a significant volume of future traffic.

Planning for the surface arterial beyond the project boundary will be coordinated with the City and County of Honolulu, since this route will be part of the City's road system. This route will also be a key part of the City's plans for the secondary urban center. Therefore, its route should be established to support City policies for expanded growth adjacent to West Beach.

Without the surface arterial, it can be concluded that Farrington Highway should be widened to three lanes in the Honolulu direction from the West Beach secondary interchange to Palailai Interchange, a distance of about 1.8 miles.

The scheduling of these alternative mitigating measures is dependent on the pace at which various uses at West Beach are developed. Table 4, Traffic Projection by Phase, indicates that additional capacity will be required after about 3,000 residential units are developed and occupied, which will take place during Phase IV of project development.

INTERCHANGE TURNING MOVEMENT ANALYSIS

The West Beach project master plan proposes two interchanges on Farrington Highway, the primary at the Waianae end of the project area and the secondary at the Honolulu end. Land areas for both interchanges are part of the project area and will not require additional acquisition.

The primary interchange provides free-flow movement in all directions, while the secondary interchange provides for right-turn in and out movements only. This design will minimize interruption to traffic flow on Farrington Highway.

Turning movement volumes during the morning peak hour were used to determine the required number of lanes. Traffic volumes are based on full development, distribution of trips between the two interchanges with and without the surface arterial, and peak-hour employment trips defined in Table 1. The resulting turning movements are shown on Exhibits B and C.

TABLE 4 - TRAFFIC PROJECTION BY PHASE, A. M. PEAK HOUR

PHASE	RESIDENTIAL UNITS	EXTERNAL TRIPS FROM WEST BEACH, HONOLULU-BOUND	TOTAL TRAFFIC VOLUME: FARRINGTON AT WEST BEACH	TOTAL TRAFFIC VOLUME: SURFACE ARTERIAL	DESIGN CAPACITY	RESULTING LEVEL OF SERVICE ON FARRINGTON
I	595	265	1,736	--	2,400	"C"
II	1,740	775	2,161	--	2,400	"C"
III	2,700	1,203	2,564	--	3,000	"D"
IV	4,230	1,885	2,427	660	3,000	"D"
V	5,200	2,317	2,676	806	3,000	"D"

EXHIBIT B **TURNING MOVEMENTS WITH SURFACE ARTERIAL**

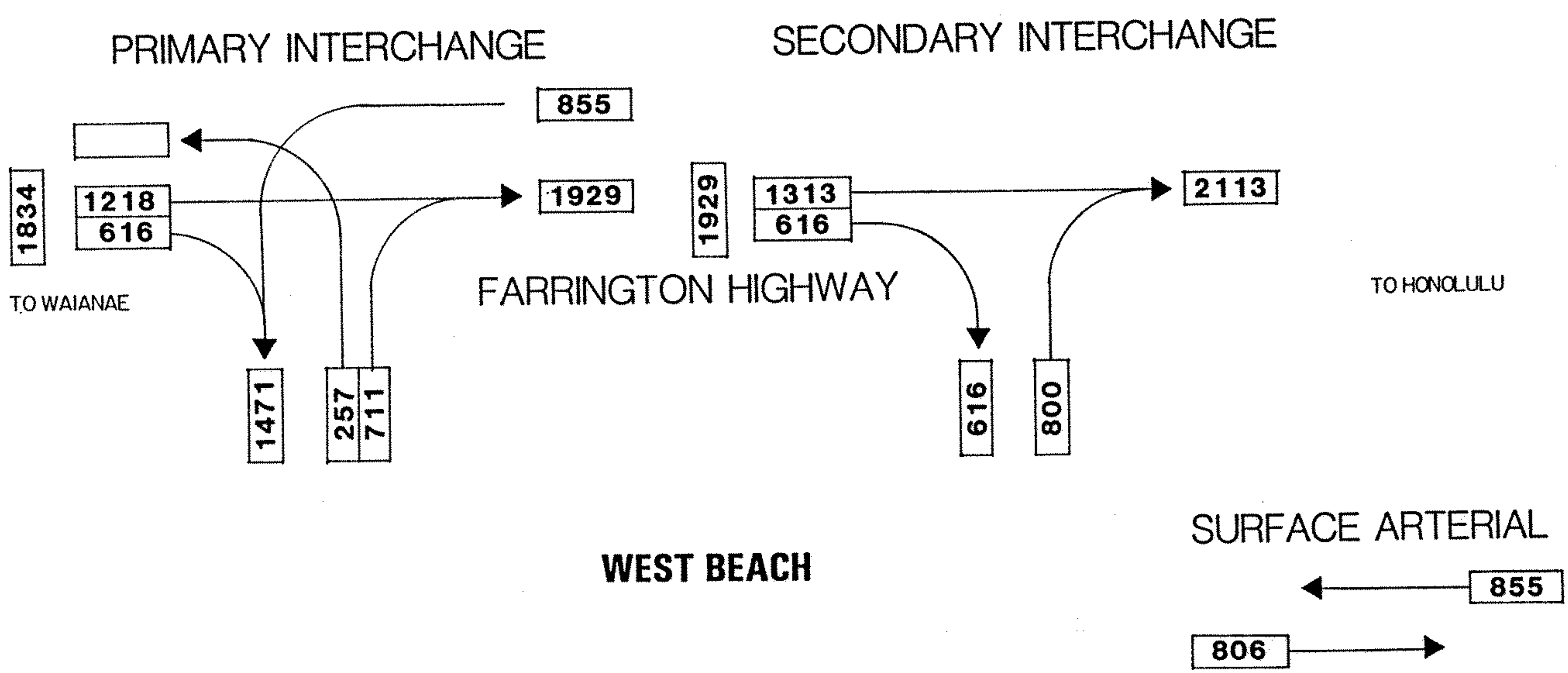
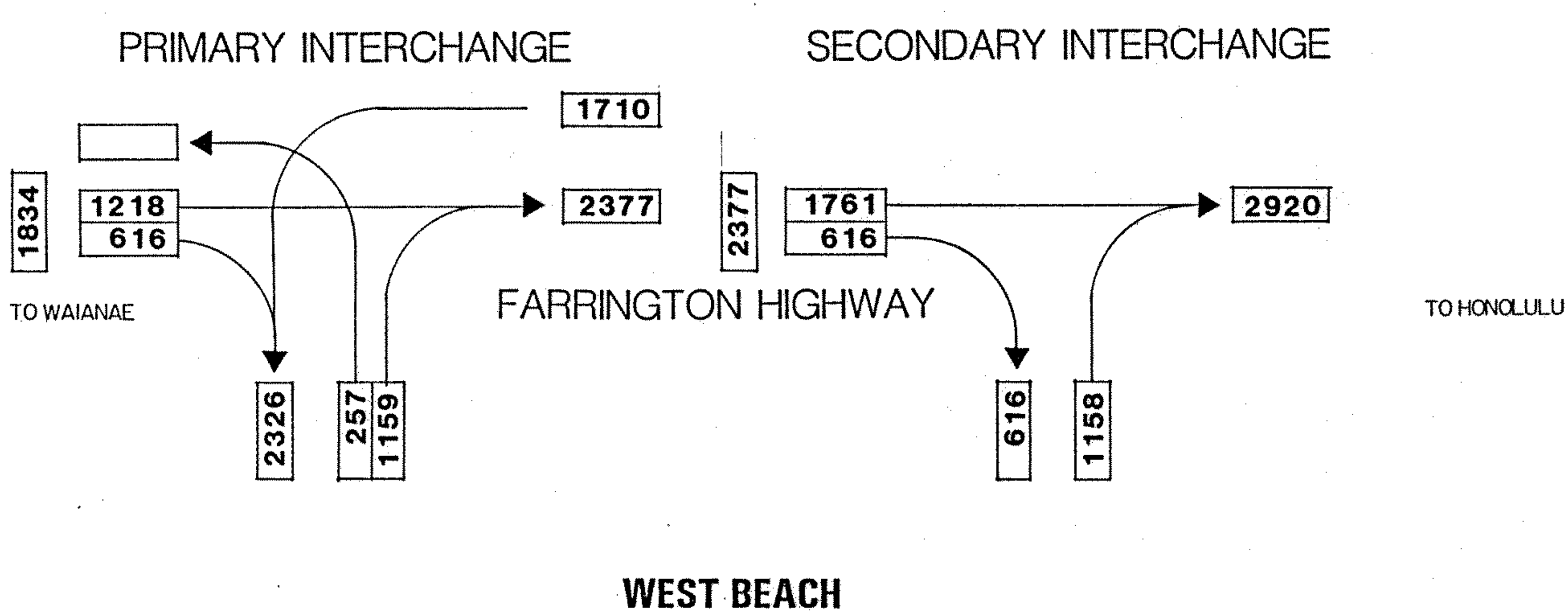


EXHIBIT C TURNING MOVEMENTS WITHOUT SURFACE ARTERIAL



For the primary interchange, the off-ramp overpass serving traffic from Honolulu should accommodate a volume of 1,710 vehicles, thus requiring two lanes. This assumes a design capacity of 1,000 VPH/L. All other on- and off-ramps can adequately serve projected peak-hour traffic volumes with one lane. The secondary interchange will provide on- and off-ramps for right-turn only movements, with deceleration and acceleration lanes designed to meet Department of Transportation standards for highway interchange construction.

With the surface arterial, the turning movement volumes are reduced so that all ramp sections can be one lane.

The primary interchange will be constructed during Phase I and the secondary interchange constructed during a later phase.

MASS TRANSIT

The traffic analysis has not included the effects of mass transportation on future traffic volumes. The increase in private automobile costs due to higher fuel prices, increased insurance rates, and vehicle sales prices have tended to modify travel patterns as people shift more of their trips to public transit and carpools. The City and County plans to improve express transit service to Ewa and Waianae communities in the near future and longer range plans for an improved mass transit system will also be pursued. These factors all tend to reduce the amount of travel by private vehicles. This should result in a decrease of the West Beach and future highway volumes by about 10 percent and subsequently improve the carrying capacity of the highway system.

FINDINGS

This analysis has compared the impacts of future traffic volumes on the existing highway system serving the West Beach project. Added to this is the expected traffic to be generated by the proposed West Beach development. The results of this analysis reveal the following:

- During the initial phases of West Beach development, Farrington Highway and Interstate Highway H-1 within the influence of the project area appear to have adequate capacity to accommodate projected increases in traffic volume.

- During the later phases of West Beach development, Phases III through V, expansion of the transportation system capacity serving the project will be required.

  Alternative measures to expand capacity include:

  1. Add an additional Honolulu-bound lane to Farrington Highway from the West Beach secondary interchange to the Palailai Interchange. This would provide a design capacity of 3,600 vehicles at Level of Service "C" compared to the projected peak-hour volume of 3,482 vehicles.

  2. Implementation of a new surface arterial from the eastern boundary of the West Beach project through the Ewa Plain, with a connection to Interstate Highway H-1 at the Palailai Interchange. This new roadway would be part of the City and County road system serving the Secondary Urban Center and would carry about 35 percent, or 806 vehicles, of the peak-hour trips generated by West Beach. Consequently, a reduction in the peak-hour volume on Farrington Highway would occur, resulting in 2,676 vehicles during the peak hour. This volume is below a design capacity of 3,000 vehicles at Level of Service "D," and the existing two Honolulu-bound lanes would be adequate.

- The timing of these alternative actions to expand capacity would be coordinated with the West Beach phasing schedule. The appropriate action would be selected and implemented by the project developer, in consultation with the State Department of Transportation and City and County Department of Transportation Services, when warranted by West Beach traffic volumes.

- Primary and secondary interchanges at Farrington Highway will provide ingress and egress to West Beach from the highway system. Peak-hour turning movement projections indicate that a grade separated design is warranted for the primary interchange, while the secondary interchange should provide only right turn in and out movements, with deceleration and acceleration lanes. The primary interchange will be constructed during Phase I by the West Beach developer. The secondary interchange will be constructed subsequently when warranted by traffic volumes. Land areas for both interchanges are part of the project area and will not require additional land acquisition. Both interchanges will be designed according to Department of Transportation standards. The design and construction process will also be coordinated with the Department of Transportation for review and approval.

- Should the surface arterial alternative be selected, it will be coordinated with the City and County of Honolulu as part of circulation plans for the Secondary Urban Center. This roadway will be a major arterial connecting West Beach with adjacent development envisioned in City plans for the Secondary Urban Center.

- Future improvements in mass transit service to the Ewa and Waianae districts will lessen the impact of future traffic volumes on highway capacity. Various transit alternatives are being considered by the State and City and County of Honolulu. The West Beach master plan has provided a transit right-of-way and set aside land for two transit stations to serve the West Beach project.

APPENDIX I

SECTION 8

WEST BEACH, OAHU: ARCHAEOLOGICAL STATUS REPORT

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July, 1984

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I. INTRODUCTION

This report presents the combined results of the first two phases of a three-phase archaeological investigation at the location of a proposed housing and resort development at West Beach, Oahu (Figure 1). The first phase, completed in 1979, was an intensive survey of the property to determine the presence or absence of archaeological and historical sites and to assess the possible impact of the development project on them (Figure 2).

The second phase, completed in July of 1984, was designed to gather additional information about certain particular sites (Figure 3). This work involved six specific tasks, as follows:

1. Reconnaissance surveys of Sites 2717 through 2720, which had been previously recorded by Bishop Museum and Archaeological Research Center Hawaii, to provide a basis for recommendations for future work. At the time of our original 1979 survey we were anticipating that a scope-of-work for these sites would be developed jointly by the U. S. Army Corps of Engineers and the State of Hawaii Department of Transportation, but we are not aware that this has been done and so the necessity for visiting these sites ourselves to make a determination of the amount of further work required.

2. Survey of an area on the south side of the property which had never been investigated during any of the previous archaeological projects. The purpose was to locate and map limestone sinkholes and to excavate a selected sample to determine the extent to which fossil bird remains and/or archaeological materials were present.

3. Consultation with Dr. Alan Ziegler, Zoologist, regarding the nature of the fossil bird remains, their importance and significance, and proper strategies for recovery of bird remains.

4. Test excavation at Site 1434A (stone wall) to make a determination of the nature and significance of the subsurface deposits, done in response to a review comment of the 1980 Environmental Impact Statement.

5. Historical research on Site 1436 (lime kiln) undertaken by Glen Mason of Spencer Mason Partnership to determine the age, history, and significance of this lime kiln.

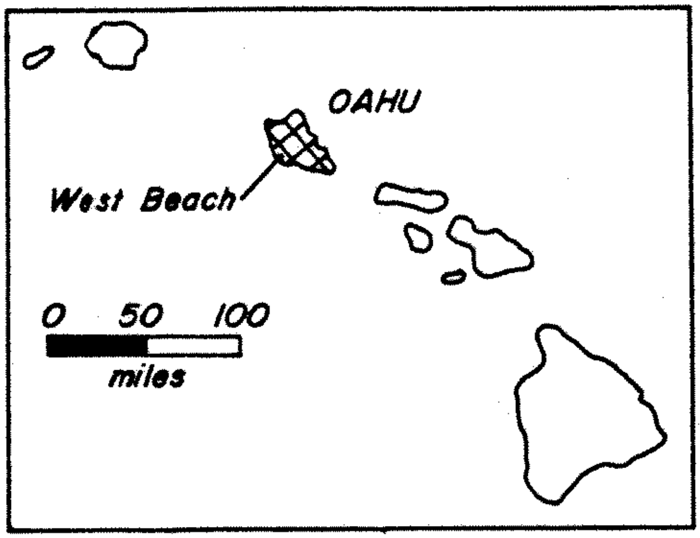

Figure 1. Map of Hawaii, Showing Location of the Project Area

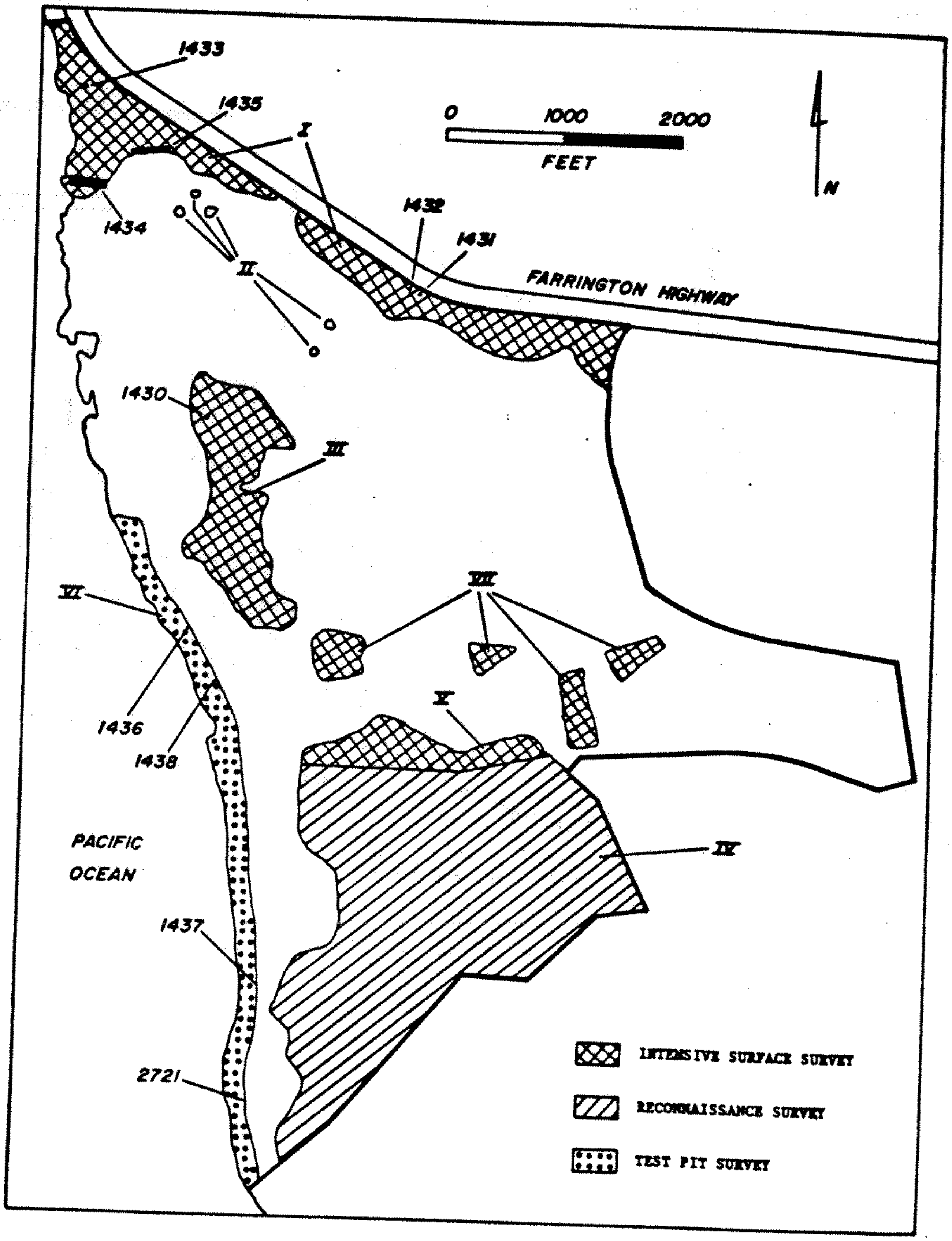

Figure 2. Map Showing 1979 Project Areas

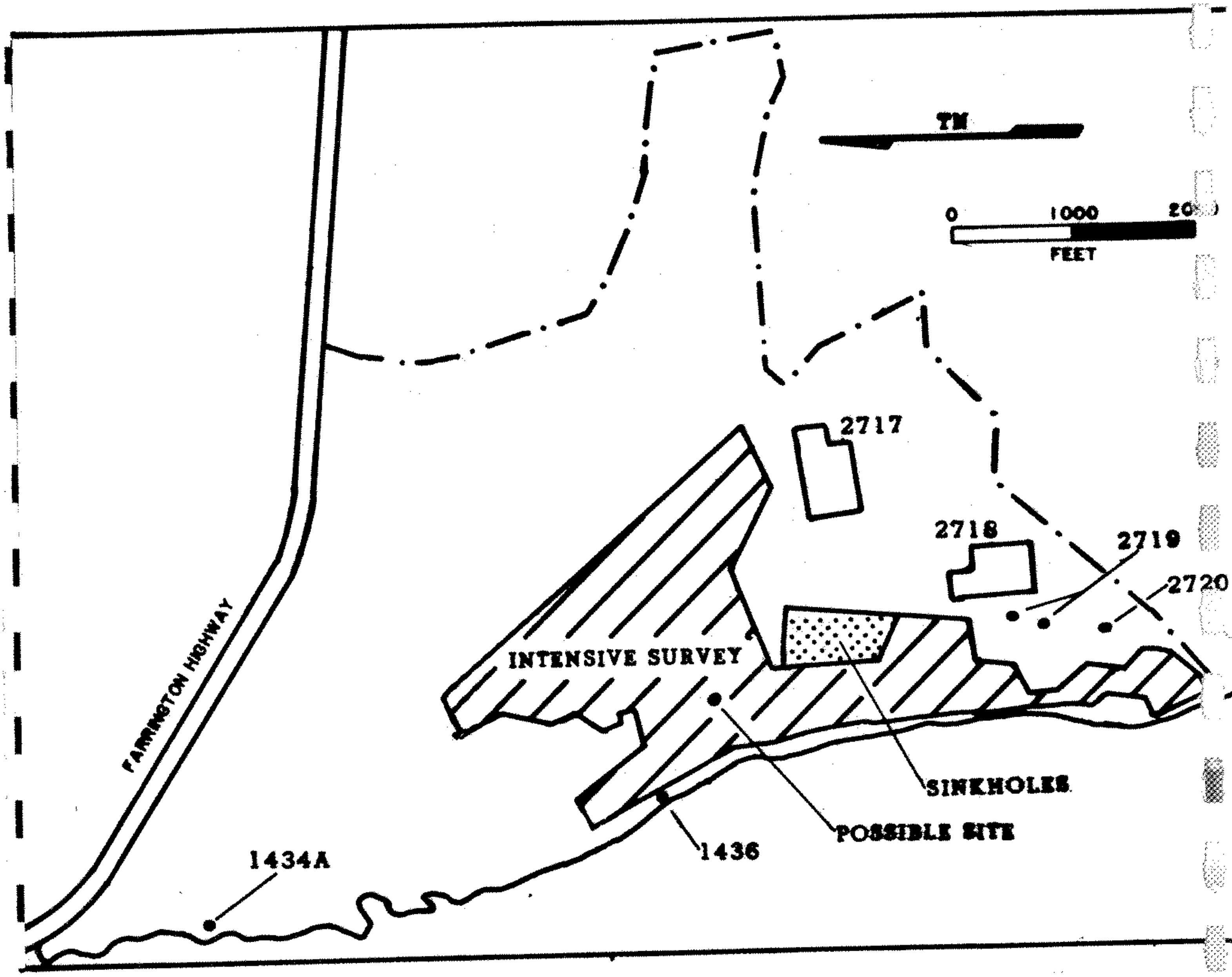

Figure 3. Map Showing 1984 Project Areas

6. Intensive survey of approximately 75 acres of former sugar land seaward of the railroad bed to determine the presence or absence of archaeological sites. This area could not be done at the time of the 1979 survey because access was prevented by the presence of sugarcane under cultivation.

The third phase of the project will involve the mitigation of any adverse effects posed by the development.

The major part of the 1979 report is presented here unchanged from the original version. Additions and modifications based on the 1984 Phase 2 investigations are clearly marked.

II. PHYSICAL BACKGROUND

The project area is relatively level and consists of an emerged calcareous coral-algae reef. Elevations range from sea level to approximately 80 feet. Sandy beaches are rare, as most the coastline consists of the exposed limestone reef [Figure 4]. Numerous sinkholes are scattered throughout the area of the former reef, having been formed by the leaching of carbonates and the subsequent collapse of the thus-formed subsurface cavities. Basalt and other igneous geologic features are rare.

The climate is arid, with annual rainfall averaging about 20 inches. Temperatures range between means of 64° F. and 93° F., with an annual mean teamperature of 73.5° F. Tradewinds from the northeast generally predominate, although southeasterly kona winds occasionally interrupt this pattern. Periods of still air are not uncommon. The porous limestone substrate absorbs most of the rain that falls, and surface runoff is generally confined to storm periods.

The vegetation is typical of dry coastal areas, and consists primarily of kiawe [*Prosopis* sp.] and haole koa [*Leucana* sp.]. Thick stands of *Panicum maximum* [Guinea grass] are also present at the north end of the project area.

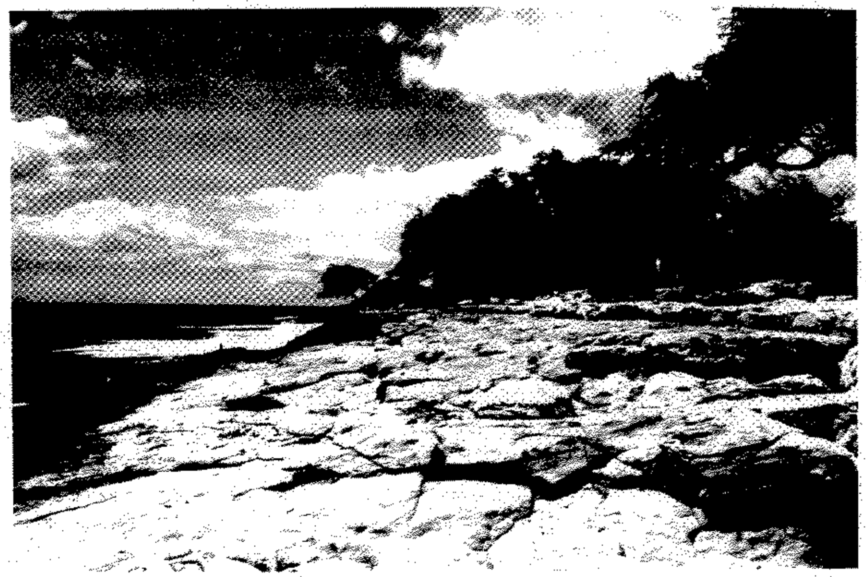

Figure 4. View of Shoreline,
Showing Emerged Limestone Reef

III. PREVIOUS ARCHAEOLOGICAL RESEARCH

Until relatively recently, the entire Barbers Point area had been virtually neglected in terms of archaeological or historical research. The term that most often appears in such research on the area is "marginal," which implies that the place would have been of little use to prehistoric Hawaiians. With the advent of large-scale archaeological surveys in the past few years, this ethnocentric attitude has had to undergo drastic modification. The first of these studies which has been restricted to the location of a proposed deep draft harbor immediately to the south of the West Beach project area, was carried out by Ernest Lewis who conducted a reconnaissance survey under the supervision of Bishop Museum [Lewis n.d.]. This was followed by another reconnaissance survey in 1975 [Barrera 1975), and then by an intensive surface in 1976 [Sinoto 1976]. On the basis of the results of these Bishop Museum efforts, the Museum returned to the area in 1977 for archaeological salvage excavations at selected sites [Sinoto 1978]. Additional research was conducted in 1977 and 1978 by Davis [Davis and Griffin 1978].

The nature of the materials located during these various projects has been summed up neatly in the abstract of Sinoto's 1976 report:

> "Sites range in form from simple stone mounds and modified limestone sinkholes to relatively large, well-constructed enclosures and dense clusters of small structures . . . The Barbers Point area, located on a karstic limestone plain, has been regarded as a marginal area, unfavorable for anything other than temporary forms of precontact cultural activity. The number, size and extent of archaeological sites, and the number of artifacts and samples recovered from the test excavations, cast new light on this limited idea of the prehistory of the area. . . Perhaps even more significant than the archaelogical remains, however, was the identification of some of the recovered skeletal materials as the remains of extinct native Hawaiian birds, including some species that have never been found before. The favorable potential for the recovery of more fossil avifauna, and the possible implications of such finds, accord great significance and value to the Barbers Point project area."

IV. METHODOLOGY

1979 Field Research

Three classes of effort were involved in the 1979 field research. The first, intensive surface survey, was conducted by walking sweeps through previously-unsurveyed portions of the project area. All sites located were described, photographed and mapped. The second, reconnaissance survey, was conducted in an area on the south side of the property that had been previously investigated as a part of the archaeological studies for the proposed deep draft harbor. The purpose of this work was to determine the accuracy of those surveys, as we would not have felt comfortable making recommendations that would have required total reliance on the work of others. The third class of survey effort, test pitting, was conducted along the sandy beach with the purpose of discovering sub-surface archaeological remains in that area where surface indications may not have properly reflected the archaeological situation.

All sites were assigned numbers according to the current practice of the State Historic Preservation Office, which consists of a four-part designation. The initial number, always a "50", indicates that the site is located in Hawaii [the fiftieth State]. The next number, in this case an "80", indicates that the site is located on the island of Oahu. The third number, a "12", indicates that the site is located on the Ewa Quadrangle map of the United State Coast and Geodetic Survey, and the final number designates the specific site that was recorded.

As a large part of the project area was under sugarcane production, only seven areas were investigated, as follows:

I. An undisturbed area fronting on Farrington Highway on the north side of the property,

II. A number of rocky knolls in the midst of the sugarcane fields,

III. A partially disturbed area located near the ocean on the northwest side of the property,

IV. An area at the south end of the property that had been previously surveyed,

V. A partially disturbed area on the north side of Area IV,

VI. The sand dunes along the beach on the west side of the property, and

VII. A number of small disturbed areas in the south-central portion of the property.

(See Figure 2 for location of areas I through VII.)

1984 Research

The 1984 research also involved a number of different approaches.

Information about Sites 2717 through 2720 was gathered by personal inspection in the field, using the ARCH report as a guide [Davis and Griffin 1978].

The previously unsurveyed area on the south side of the property was surveyed by two people walking sweeps back and forth across the parcel, locating and flagging sinkholes on the way. The latter were then revisited and, using forms designed for that purpose, their dimensions [length, width, depth] were recorded. Bearings and distances from one to another were then obtained using tape and compass, and an overall map was prepared.

A single one-meter-square test pit was excavated at Site 1434A (stone wall).

Historical research on Site 1436 (lime kiln) was conducted by Spencer Mason Partnership, under contract to Chiniago Inc.

Previously unsurveyed sugar land was surveyed by one person walking sweeps at intervals of approximately 100 feet back and forth across the area.

V. SURVEY RESULTS

Survey Area I

SITE # 50-80-12-1431 [Bedrock boulder wall, Figure 5]

Site 1431 consists of two crude walls constructed by filling in spaces between naturally-occurring bedrock boulders. The longer of the walls measures 18 meters in length, up to 80 centimeters in width, and stands to a height of 85 centimeters. The shorter wall measures 3.25 meters in length, up to 60 centimeters in width, and stands to a height of 35 centimeters. The only cultural materials found in association with the site consists of recent items that have undoubtedly been deposited by passerby on Farrington Highway, which is located approximately 17 meters to the north. The crudeness of construction of the walls would seem to rule out their use as animal barriers, such as would be expected if they were constructed by a ranch. The proximity of the site to an irrigation channel used in sugarcane production, and the fact that the site parallels this channel, suggests the possibility that the two are in some way functionally related. The absence of an evidence of aboriginal use [midden remains or artifacts] and the crudity of construction place its origins within recent times.

SITE # 50-80-12-1432 [Basalt rock wall, Figures 6 & 7]

This is a short wall section measuring 3.3 meters in length, up to 65 centimeters in width and to 85 centimeters in height. It is of multiple-stacked construction utilizing basalt rocks measuring between 20 by 30 and 40 by 50 centimeters. The only cultural remains present consist of recent items undoubtedly deposited from Farrington Highway, which is located 14 meters to the north.

SITE 50-80-12-1433 [Fishing Shrine, Figures 8 & 9]

This is a fishing shrine that consists of a nearly square platform measuring 4.5 by 5.0 meters, and standing between 30 and 60 centimeters in height. It is of multiple-stacked construction, utilizing fragments of coral and basalt. The basalt fragments used in the construction measure between 5 by 10 and 75 by 100 centimeters. The coral fragments measures between 5 by 10 and 15 by 20 centimeters. An upright rock is located at the west side of the structure. The only midden remains present consist of two shells of a cowrie [Cypraea reticulata].

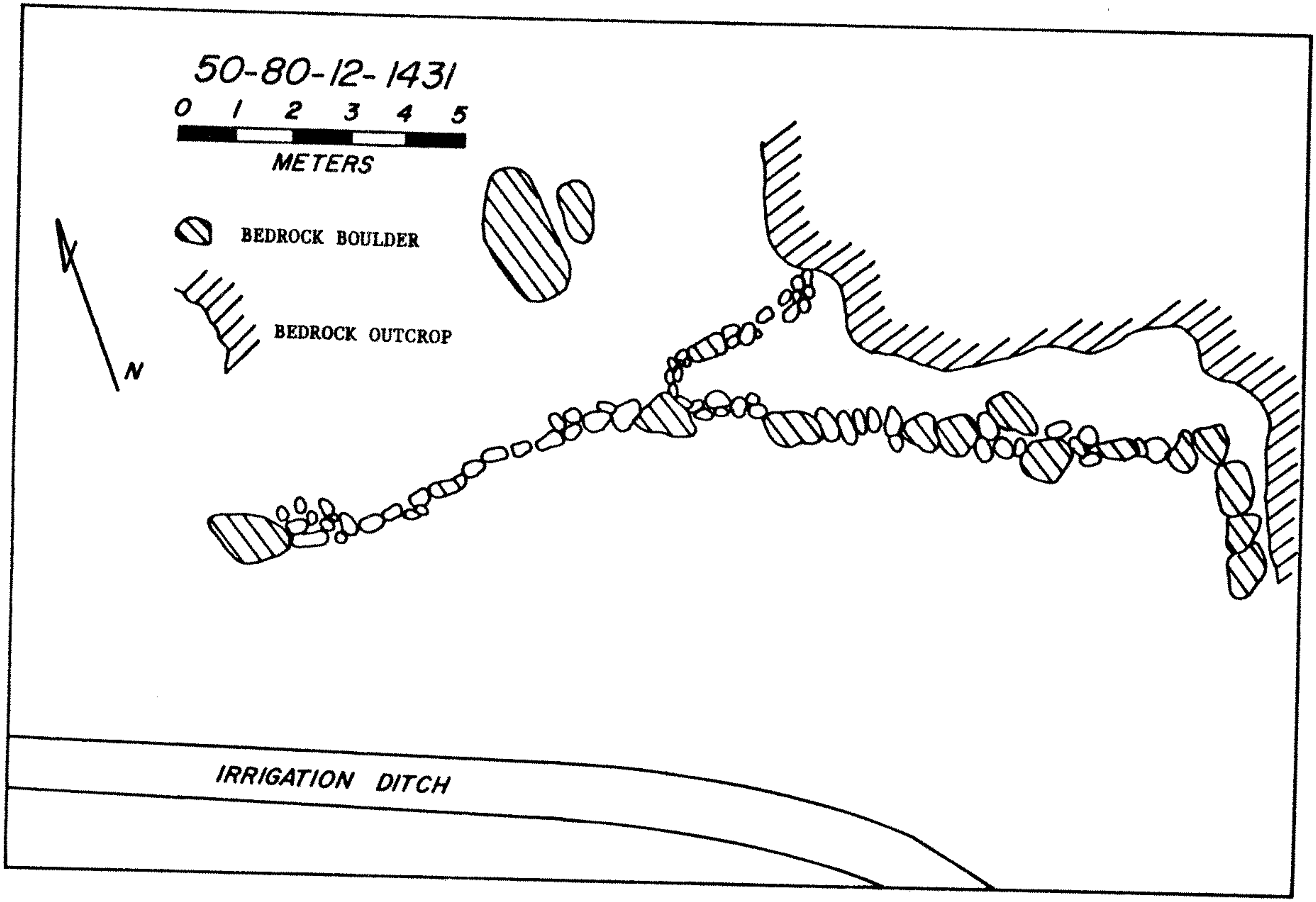

Figure 5 Plan of Site 1431

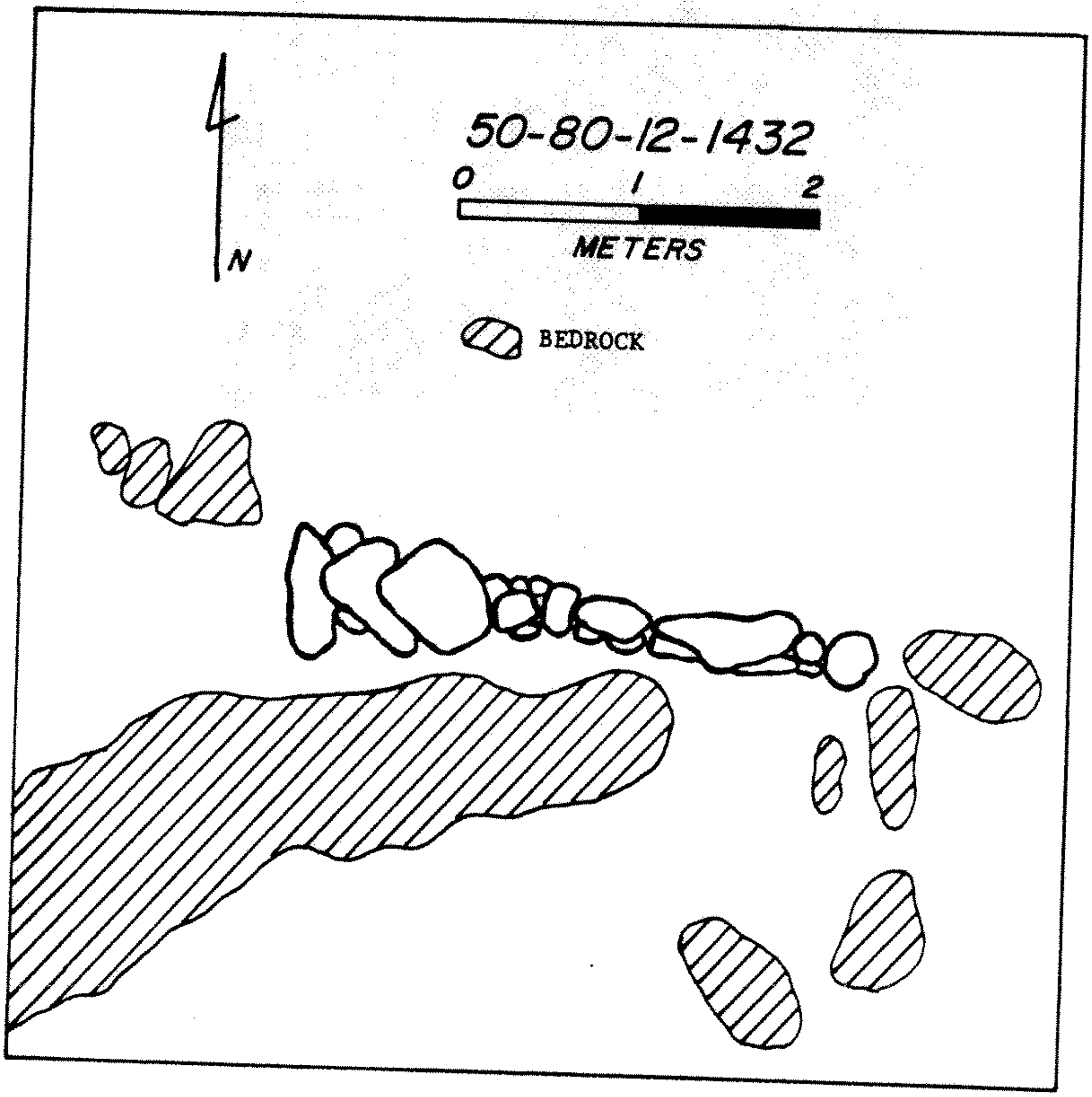

Figure 6. Plan of Site 1432

Figure 7. View of Site 1432, looking northwest

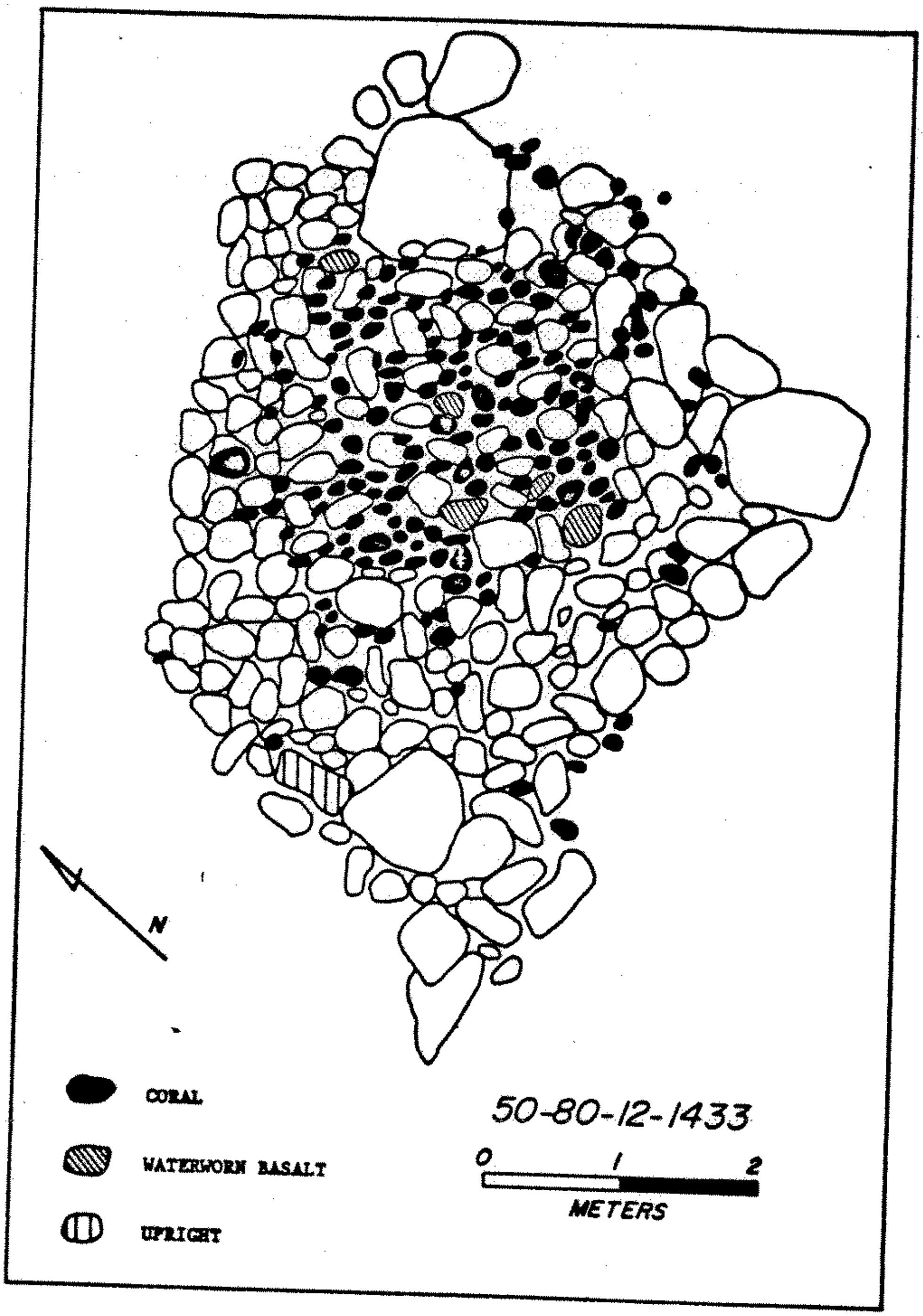

Figure 8. Plan of Site 1433

SITE # 50-80-12-1434 [Stone walls and enclosure]

This site consists of two features. Feature A consists of a 43-meter-long section of stone wall, abutted against which on the west end is a low collapsed enclosure. This enclosure measures 6 by 8 meters, is crudely constructed of multiple-stacked fragments of basalt and coral, and stands to a height of 45 centimeters. The presence of numerous historic artifacts suggests that the feature is of recent origin, and information provided by a local resident confirms this supposition.

Feature B is a stone wall measuring 64 meters in length, with a width of between 60 and 100 centimeters and a height of between 90 and 120 centimeters. It is of multiple-stacked construction utilizing basalt, coral and waterworn basalt pieces measuring between 25 and 75 centimeters in length.

A one-meter-square test pit was excavated in the enclosure at the west end of Feature A during the 1984 research phase. The pit reached a maximum depth of 20 centimeters, at which point the solid limestone bedrock common to the surrounding area was encountered. All materials were sifted through one-quarter-inch mesh, separated in the field and sorted in the laboratory.

Midden remains recovered from the excavation included six shells of Nerita picea, five shells of Cypraea caputserpentis, one shell of Conus sp., one fragment of Antigone reticulata, ten unidentified shell fragments, one incisor of Sus sp., five pieces of unidentified fish scale, five fragments of charcoal, twelve fragments of metal, and 59 fragments of bottle glass.

The complete absence of any evidence of prehistoric age for the deposit [bone fishhooks, coral and stone implements, for example], taken with the relatively large quantities of definitely recent historic artifacts [pieces of metal and bottle glass fragments], leads to the conclusion that no further investigations are necessary at this site, and that resort development does not represent an adverse impact to significant archaeological or historical materials.

Site # 50-80-12-1435 [Rock wall, Figure 10]

This is a 100-meter-long section of stone wall that roughly parallels a cane haulage road at a distance of 10 to 15 meters. It measures up to 1.85 meters in width and stands to a height of 1.45 meters. Construction is of multiple-stacked basalt rocks measuring between 5 by 15 and 40 by 60 centimeters. A local resident informed the field team that this feature had been constructed by the sugar company in recent times.

Figure 9. View of Site 1433, looking northeast

Figure 10. View of Site 1435, looking south

Survey Area II

A number of rocky knolls situated in the midst of the sugarcane fields were seen from the adjacent cane haulage roads. Although it was evident that much of the rock on these knolls had probably come from the clearing of the adjacent fields, it was felt necessary to conduct a closer inspection because of the possibility that the rocks had been deposited on already existing high points of hillocks. The clearing of the fields might have proceeded around these features, thereby leaving small "islands" of undisturbed ground. However, investigation of these knolls revealed them to be entirely of recent origin, and no archaeological or historical features were located on them.

Survey Area III

This area has been subjected to large-scale disturbance, apparently consisting of bulldozing the vegetation in long strips and depositing dead trees and brush to a height of 15 meters in places. Destruction of the original ground surface was not complete, however, and our 1979 survey revealed the presence of one site.

SITE # 50-80-12-1430 [L-shaped wall, Figures 11 & 12]

This is an L-shaped wall measuring 4 by 4 meters built on limestone bedrock. The crudeness of the structure and the lack of midden materials suggests that occupation was temporary or intermittent. No dateable material were recovered from the site. The structure, which stands to a height of 50 centimeters, is constructed by multiple-stacked pieces of coral ranging in size between 5 by 10 and 50 by 70 centimeters. At the southeast end of the feature is a small limestone sink measuring approximately 2.0 by 2.5 meters and approximately 30 centimeters in depth. This natural depression, is filled with small [5 by 10 to 10 by 15 centimeters] coral fragments, so its true depth cannot be ascertained at this time.

In addition to Site 1430, numerous remains of military structures [probably of World War II vintage] are scattered througout Survey Area III. Few of these appear to be of a residential nature, and consist of concrete blockhouses definitely designed wth defense in mind [Figure 13].

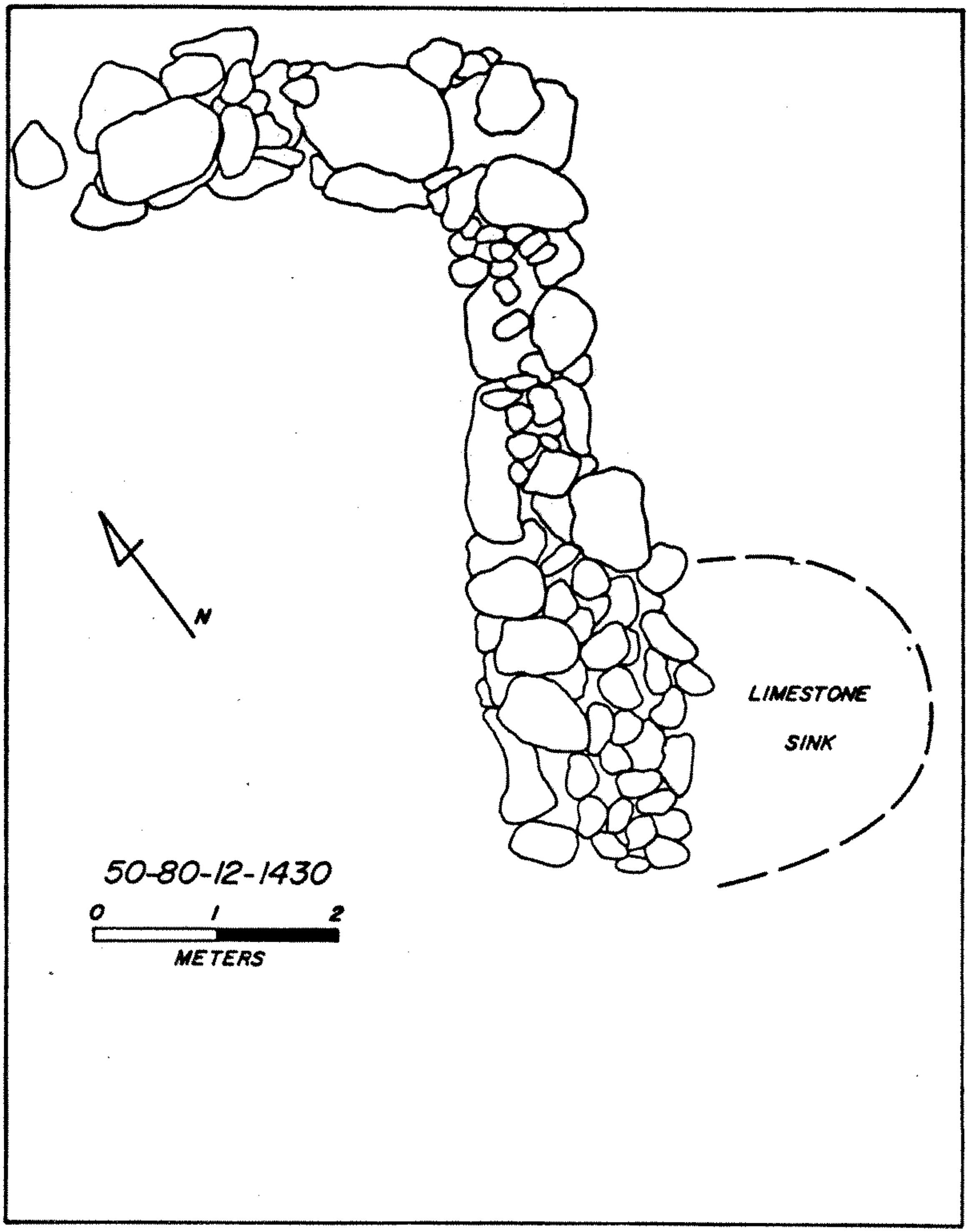

Figure 11. Plan of Site 1430

Figure 12. View of Site 1430,
looking north
(limestone sink in right foreground)

Figure 13. View of military structure
located in Survey Area III

Survey Area IV

In 1979, a reconnaisance survey of this area was conducted in order to satisfy ourselves of the accuracy and completeness of previous survey efforts. Originally surveyed by Bishop Museum [Sinoto 1976], a portion of this area was again investigated by Archaeological Research Center Hawaii [Davis and Griffin 1978] in order to record sites not located by the Museum's efforts and to more accurately map site locations. Our fieldwork demonstrated that only a few small archaeological features were missed by both of these projects, and we are reasonably confident that virtually 100 per cent of the sites in those project areas have been found and recorded.

A small section at the north end of Area IV, west of Malakole Road, was not re-surveyed by Archaeological Research Center Hawaii. Of primary interest in this area are numerous limestone sinkholes, some of which may contain the remains of fossil birdbones.

The 1984 project involved two distinct tasks in this area. The first was an inspection of Sites 2717 through 2720 to ascertain the level of effort required for the mitigation of any adverse impacts posed by the resort development, and the second involved the mapping, recording, and selective excavation of sinkholes that might contain the bones of fossil birds in one particular area that had been previously unsurveyed.

As for the first task, it was discovered that approximately one-third of the features at Site 2717 [wall and limestone sinkholes] have been destroyed since our 1979 survey, either by limestone quarrying or construction for the Deep Draft Harbor. Sites 2718 [enclosure and limestone sinkholes], 2719 [enclosure and mound] and 2720 [structure remnant and enclosure remnant] have not been disturbed since the original surveys. It is our recommendation that extensive salvage excavations should be carried out in all of these archaeological sites.

As for the second task, sixty-nine sinkholes, representing those most likely on the basis of size and configuration to contain bird bones, were recorded and mapped. Test pits were excavated in six in an effort designed solely to assess the level of effort which would be required in any future excavations that might be associated with a mitigation phase of the project. Three were found to contain fragments of bird bones, one of which also contained archaeological midden materials.

It was determined, after consultation with Dr. Alan Ziegler, our consulting zoologist who visited the sinkhole sites, that a proper approach regarding potential fossil bird bone localities would be to excavate a test pit in twenty per cent of the sinkholes, to be followed by complete excavation of a sinkhole only in the event of a discovery of bird bones of sufficient significance to warrant further collection. Dr. Ziegler has agreed to be the consulting authority on any future project who would analyze the bones and determine whether such further work is required.

Figure 14. Map of Sinkhole Locations in Unsurveyed Portion of Area IV.

Survey Area V

This area has been extensively disturbed, probably by sugarcane production activities. No sites were located.

Survey Area VI

In the 1979 survey, sand dunes along the beach were tested for the presence of subsurface deposits by utilizing a truck-mounted six-inch-diameter auger in those places where that vehicle could gain access, and by excavating 50-centimeter-diameter pits by shovel where such access was not possible. Any evidence of a cultural deposit produced by one of these tests was followed by the excavation of 50-centimeter-square test pits to determine the nature of those materials. All portions of the survey area were swept in order to locate any surface indications of archaeological or historical sites. The following sites are present:

SITE # 50-80-12-2721 [Midden]

This site is defined by Davis and Griffin [1978: 159] as "...a marginally defined beach midden. It was identified on the surface as charcoal-darkened sad, and its depth tested with a hand barrel-auger." The only other information available on the site is contained in their Table 11 [Ibid: 164], which indicates that it is about 25 meters in diameter and that cultural materials were found to a depth of 20 centimeters below the surface. These cultural materials consisted of shell midden, charcoal, and a single coral abrader that was found on the surface. We were unable to identify this site in the field, based on the map provided by Davis and Griffin [Ibid: Figure 22]. The thickness of the dune vegetation in this area, however, would easily obscure what they referred to as a faintly defined area of charcoal-darkened sand, and the possibility of shifting sands on the top of the dune may have covered up whatever surface evidence was present.

SITE # 50-80-12-1436 [Limestone kiln, Figure 15]

This a circular structure measuring 5.0 meters in diameter, to the exterior of which are attached two walls that form a rectangular enclosed area measuring 6 by 6.75 meters. The structure stands 3.9 meters in height and is constructed of shaped coral blocks, bonded by mortar, measuring between 5 by 10 and 50 by 85 centimeters. On the south side of the feature, at ground level, are three openings that extend into the interior of the structure for distances of 1.0, 3.1 and 1.5 meters. Each measures about 1.5 meters in height and 1.3 meters in width at its entrance. The inner section of the central opening is .75 meter wide and reduces in height from 1.1 to 0.5 meter. The inner sections of the other two openings measure about .25 meter in height and 0.5 meter in width, and terminate in walls constructed of bricks set on end. The interior of the central opening is arched, and constructed of both coral blocks and bricks.

Figure 15. View of Site 1436,
looking northwest

Figure 16. Site 1436, View of
Circular Depression on Top of
Structure, looking southwest

On top of the structure is a circular pit [Figure 16] measuring 2.5 meters in diameter and 1.6 meters in depth, with a 0.4-meter-high lip around the outside.

On either side of the structure is situated a short [2 meters] and high [2.6 meters] wall, each of which extends in front of the side openings of the main structure, and which appear to have functioned as windbreaks.

The wall enclosing the feature measures 1.2 meters in height and 0.65 meter in width.

The limestone blocks of which the site is constructed are similar in size and shape to those used in the construction of the railroad roadbed [constructed in 1889] that traverses the West Beach property, suggesting contemporaneity if not a functional association. The most likely interpretation for the feature is that it was an oven for the manufacture of mortar from limestone.

In 1984, historical research on this site by Glen Mason of Spencer Mason Partnership was unable to uncover any historical information about this particular structure, which definitely functioned as a lime kiln.[1] He determined that its primary significance is as a source of information about early lime-making process, and recommends two mitigative measures. One option is to relocate the kiln to a new location, making sure that the new site bears a similar relationship to the sea and agricultural fields as the old one, and that every stone in the structure is accurately marked and relocated during reconstruction. In the event that relocation is not feasible, an equally acceptable option is to thoroughly document the structure before it is destroyed. This would involve excavation, collection and analysis of construction materials, and the production of accurate drawings and photographs of the structure.

[1]Mr. Mason's complete report is included as an Appendix to this report, and includes a more accurate description as well as recent photographs of the structure.

SITE # 50-80-12-1437 [Midden]

This is a midden deposit located between a cane haulage road and the ocean. It covers an area of approximately 15 by 25 meters, and is siutated in a sandy knoll. Five test pits were excavated, two on top of the knoll, one at the base of the knoll between it and the ocean, and one on the storm berm on the west side of the site area. The only archaeological deposits encountered were found in the the two test pits on top of the knoll, suggesting that the surrounding area has been considerably eroded, or we would have expected to find similar deposits at the base of the knoll also. Figure 17 presents the section observed on the west side of the Test Pit 1.

The surface is covered with a thick mat of grass that is rooted in Layer I, which contains a high proportion of humic material in a matrix of carbonate sand. It is a dark brown to black, primarily as a result of the humus, and contains numerous shells of a nerite [Nerita picea], a limpet [Cellana sp.], a striate mussel [Brachidontes crebristriatus] and a sea urchin [Echinodermata], plus a few fragments of coral.

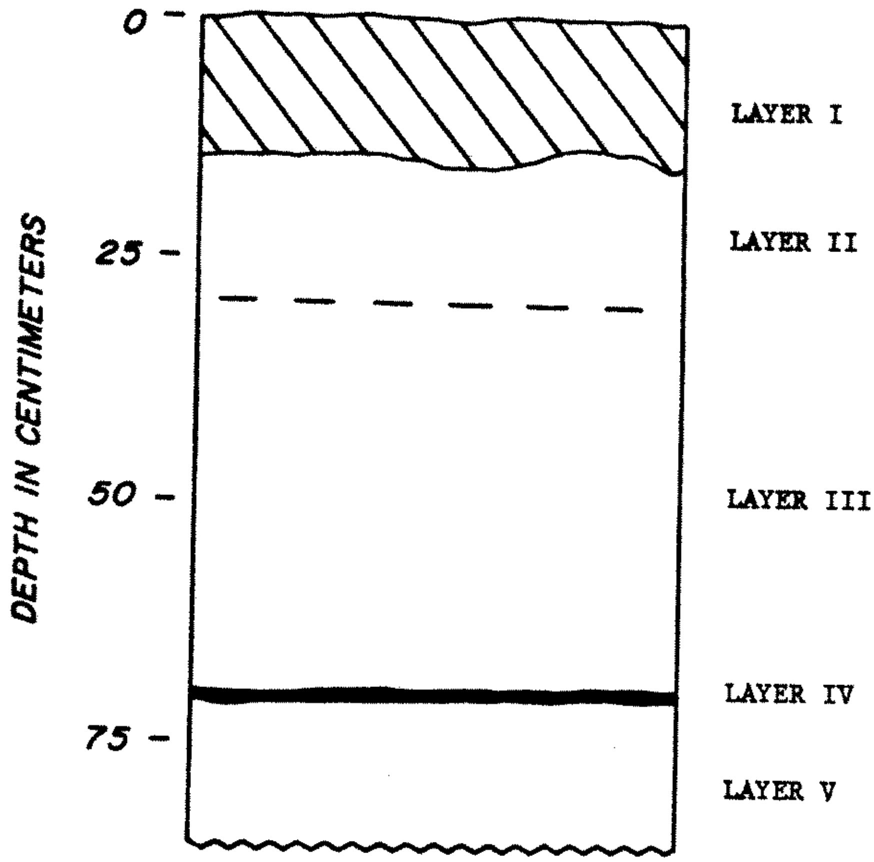

Figure 17. Site 1437,
Test Pit 1, West Face

Layer II is a light brown carbonate sand, primarily culturally sterile, but with occasional shells of a nerite [Nerita picea]. The contact between Layer II and Layer III, which is a sterile white carbonate sand, is uneven and mottled, and apparetly represents a zone of mixing.

Layer IV, which is only about 1 centimeter thick, is a grey sand containing numerous small charcoal flecks. Although no midden remains were noted in this layer, the presence of the charcoal suggests that it is cultural in origin.

Layer V is a white carbonate sand identical in every respect to Layer III.

SITE # 50-80-12-1438 [Midden]

This is a midden deposit measuring about 10 by 10 meters located on the inland slope of a sand dune, immediately adjacent to a cane haulage road. Figure 18 presents the section observed on the west side of a 50-centimeter-square test pit that was excavated into the site.

Layer I is a deposit of carbonate sand mixed with silt, overlying Layer II which is a deposit of mottled carbonate sand with occasional silty lenses.

Layer III is a dark brown silt with occasional grains of carbonate sand embedded in it.

Layer IV is a mottled grey carbonate sand with minor lenses of brown silt. Cultural materials were found at the contact between Layers III and IV. These consisted of the shells of a nerite [Nerita picea], a striate mussel [Brachidontes crebristriatus], a periwinkle [Littorina pintado], a thais [Thais aperta], a cowrie [Cypraea caputserpentis] and a sea urchin [Echinodermata], plus fragments of charcoal. A denser concentration of charcoal was present on the north side of the layer.

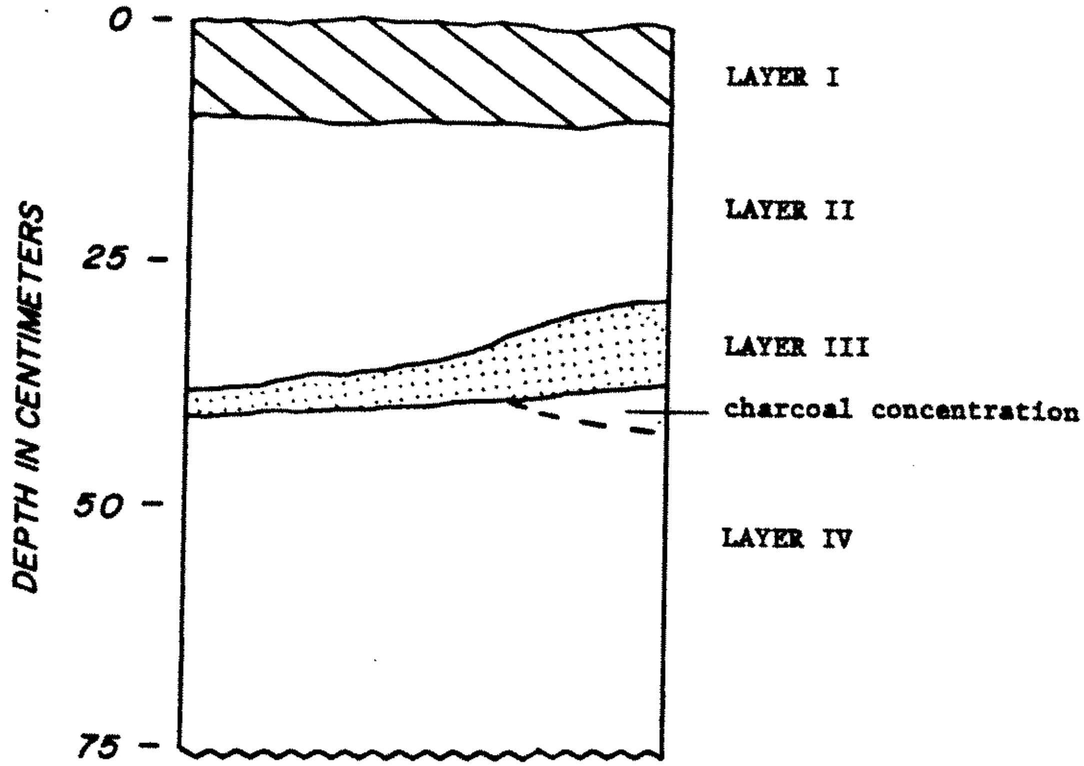

Figure 18. Site 1438,
Test Pit, West Face

Survey of Former Sugar Cane Land

An intensive survey of approximately 75 acres of former sugar land seaward of the railroad bed revealed the presence of only single possible site. It consists of a very thin scatter of perhaps a dozen mollusk shells covering an area about 40 meters in diameter. Only one artifact, a fragment of a stone adze, was found. We could not determine on the basis of surface indications whether any of the site still remains intact below the plow zone, and it is therefore our interim recommendation that test pits be excavated to make a determination of its significance.

Midden sites 1437, 1438 and 2721 are also of such significance that salvage excavations should be required in the event that they lie in the path of development. Sites such as these present archaeologists with the opportunity to study broader patterns of cultural activities than is usually the case with the sites of smaller areal extent [i.e. caves] or of sites associated with functionally specific activities, such as habitation, fishing, farming, etc.

In Site 1436, the historic lime kiln, is located in a construction area, there are two possibilities for mitigation. One is to move the structure to a new location that matches its physical surroundings, the other is to thoroughly document it prior to any construction on that site.

It is recommended that a twenty per cent sample of limestone sinkholes be tested to determine the presence or absence of fossil bird bones, with complete excavation to be done of those that produce positive results.

For Sites 2717 through through 2720, it is recommended that extensive archaeological salvage excavations be conducted before those areas can be developed.

And finally, test pits should be excavated at the possible site in the former sugar cane lands to determine its's significance.

VI. CONCLUSION AND RECOMMENDATIONS

When compared with the archaeological remains discovered during the various surveys of the deep draft harbor site on the south side of the project area, the West Beach remains are rather sparse and, to the untrained eye, unimpressive. This is not an indication of lack of interest on the part of the aboriginal population, but is more a function of the extensive clearing of large areas for sugarcane production. There can be no doubt that the pattern of site distribution observed in the deep draft harbor area once continued into the area now in sugarcane production. The presence of a fishing shrine [Site 1433] in virtual isolation at the north end of the property indicates that the adjacent area probably was the location of a number of residential features, for such religious sites are rarely found far from the houses of the people who used them. The remains reported in this volume, then, represent only a small fraction of what once existed at West Beach, and therefore assume added significance.

Table 1 presents a summary of what we consider to be viable approaches to the treatment of the cultural remains found. Sites 1431 [wall], 1432 [wall], 1434 [wall] and 1435 [wall] are of such recent vintage that no further research is deemed necessary.

Although there are no associated cultural materials at Site 1430 [an L-shaped structure], the possibility of the presence of fossil bird remains in the adjacent limestone sinkhold requires that it be archaeologically salvaged.

Site 1433 [a fishing shrine] is perhaps the only remnant of a larger site complex, and constitures the only evidence we have of settlement in that area. It is therefore of sufficient significance that we recommend salvage excavations.

TABLE 1

SUMMARY OF VIABLE APPROACHES

SITE	TYPE	RECOMMENDATION
1430	Shelter & limestone sink	Salvage - no preservation value
1431	Two walls	No further action
1432	Wall	No further action
1433	Fishing Shrine	Salvage
1434	Two walls	No further action
1435	Wall	No further action
1436	Kiln	Record in detail, possible relocation
1437	Midden Deposit	Salvage - no preservation value
1438	Midden Deposit	Salvage - no preservation value
2717	Various	Salvage - no preservation value
2718	Various	Salvage - no preservation value
2719	Enclosure and mound	Salvage - no preservation value
2720	Enclosure and shelter	Salvage - no preservation value
2721	Midden Deposit	Salvage - no preservation value

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APPENDIX I. SUMMARY OF PREVIOUS RESEARCH IN SURVEY AREA IV

This appendix presents a summary in both tabular [Table 2] and descriptive form of the results of previous research activities conducted on the West Beach property by Bernice P. Bishop Museum and Archaeological Research Center Hawaii [ARCH] [see pp. 8, 22 and Figure 19]. As the ARCH effort was the most recent and produced sites not located by the Bishop Museum study, the ARCH site numbers are used as the accepted designations for the archaeological remains. Those features that were subjected to test excavations are indicated by an asterist [*]; the results of these excavations are presented immediately following the descriptions of the sites.

SITE 2717

Feature 1 - This is a wall built of limestone fragments with an associated "floor area," covering a total area of 3.6 by 4.3 meters. The wall is 0.7 meter wide and stands to a height of 0.45 meter.

Feature 2 - This is a limestone sinkhole with a semi-circular wall of limestone boulders and cobbles constructed on its northeast side. The feature covers an area of 1.3 by 1.6 meters.

Feature 3 - This is a limestone sinkhole with a limestone boulder wall constructed on three sides. The feature covers an area of 1.3 by 1.6 meters.

Feature 4* - This is a shallow dirt-filled depression around the perimeter of which is located an alignment of limestone boulders and slabs. It covers an area of 4.2 by 6.0 meters.

Feature 5 - This is similar to Feature 4, but the wall construction also includes stacked limestone cobbles. It measures 3.4 by 8.7 meters.

Feature 6 - This is similar to Feature 5, and measures 3.0 by 6.0 meters.

Feature 7 - This is a limestone sinkhole with a wall consisting of boulders and vertical slabs, presumably limestone. The description states that it measures 2.1 meters in diameter, the illustration shows it to be 3.0 by 4.5 meters in extent.

Feature 8 - This is a limestone sinkhole with a 0.9 by 1.0 meter stacked limestone boulder wall on its north rim.

Feature 9 - This is a limestone sinkhole with a 3.8 meter long

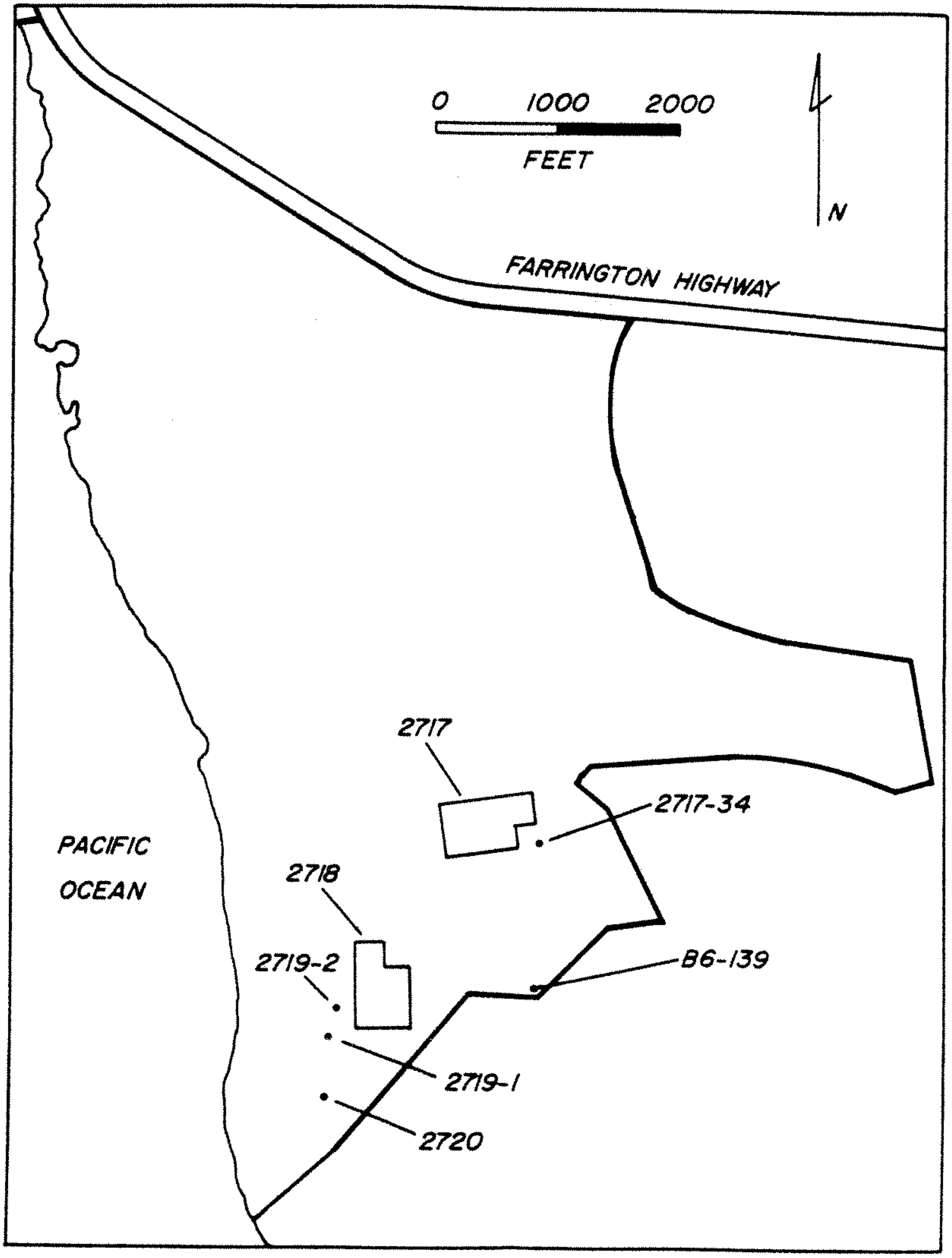

Figure 19 Previously Recorded Sites in West Beach Project Area

Source: Surveys by Bishop Museum (Sinoto 1976) and Archaeological Research Center Hawaii (Davis and Griffin 1978).

Table 2. Summary of Previously Recorded Sites in Survey Area IV

ARCH SITE #	Bishop Museum SITE #	Description
2717/1	B6-112	wall
/2	B6-112	limestone sinkhole and wall
/3	B6-112	limestone sinkhole and wall
/4*	B6-113	walled depression
/5	B6-114	walled depression
/6	B6-114	walled depression
/7	B6-115	limestone sinkhole and wall
/8	NONE	limestone sinkhole and wall
/9	NONE	limestone sinkhole and wall
/10	NONE	limestone sinkhole with boulder and cobble pile
/11	NONE	limestone sinkhole with boulder pile
/12	NONE	limestone sinkhole with wall
/13	NONE	limestone sinkhole with wall
/14	NONE	limestone sinkhole with cobble pile
/15	NONE	limestone sinkhole with wall
/16	NONE	limestone sinkhole with wall
/17	NONE	limestone sinkhole with wall
/18	B6-117	limestone sinkhole with wall
/19	NONE	limestone sinkhole with wall
/20	B6-110	limestone sinkhole with wall
/21	NONE	limestone sinkhole with wall
/22	NONE	limestone sinkhole with wall
/23	B6-108	limestone sinkhole with alignment
/24	B6-109	limestone sinkhole with wall
/25	NONE	limestone sinkhole with wall
/26*	B6-106	limestone sinkhole with alignment
/27*	B6-79	cairn
/28*	B6-80	cairn
/29	B6-101	cairn
/30	B6-102	cairn
/31	B6-102	cairn
/32*	B6-103	cairn
/33*	B6-105	enclosure
/34	NONE	surface midden scatter
2718/1a	B6-94	enclosure
/1b	B6-94	limestone sinkhole with midden inside
/2a*	B6-94	enclosure
/2b	NONE	limestone sinkhole with midden inside
/3	NONE	platform
/4	NONE	enclosure
/5	NONE	C-shaped structure

2718/6*	B6-93	enclosure
/7*	B6-92	C-shaped structure
/8*	B6-97	enclosure
/9	B6-95	cairn
/10	NONE	cairn
/11	NONE	cairn
/12	NONE	mound
/13a	B6-96	cairn
/13b*	B6-96	cairn
/14	B6-95	cairn
/15	NONE	walled depression
/16	NONE	limestone sinkhole with boulder and cobble pile
/17a	B6-91	limestone sinkhole with stacked slabs
/17b	B6-91	limestone sinkhole with stacked slabs
/18	NONE	walled depression
/19	NONE	limestone sinkhole cave with wall
/20	B6-94	wall
2719/1*	B6-125	enclosure and limestone sinkholes
/2	NONE	cairn
2720/1	NONE	bulldozed structure remnant
/2	NONE	disturbed enclosure remnant
NONE	B6-139	limestone sinkhole with fossil birdbone

wall of limestone slabs and boulders on the northeast side. The sinkhole is 1.0 meter in diameter and contains basalt rocks at the bottom.

Feature 10 - This is a limestone sinkhole measuring 1.0 meter in diameter, with a rough pile of boulders and cobbles on the southeast side

Feature 11 - This is a limestone sinkhole measuring 1.4 by 2.0 meters with limestone boulders piled on the east rim.

Feature 12 - This is a limestone sinkhole measuring 1.9 by 3.7 meter, apparently with an associated wall adjacent to which are fragments of fire-cracked basalt.

Feature 13 - This is a limestone sinkhole measuring 1.1 meter in diameter with a 2.0 meter long stacked limestone cobble wall on the east rim.

Feature 14 - This is a limestone sinkhold measuring 0.8 by 1.1 meter associated with which is a 1.1 meter long pile of limestone cobbles.

Feature 15 - This is a limestone sinkhole measuring 0.7 by 1.1 meter with a 2.0 meter long limestone slab wall on the northeast rim.

Feature 16 - This is a limestone sinkhole measuring 0.7 by 1.3 meter with a stacked limestone slab wall approximately 1.3 meter long on the north-east edge.

Feature 17 - This is a limestone sinkhole measuring 1.8 meter in diameter with a 3.0 meter long wall of limestone cobbles on the north side.

Feature 18 - This is a shallow limestone sinkhole measuring 3.0 meters in diameter with an encircling wall of slabs and cobbles.

Feature 19 - This is a limestone sinkhole measuring 1.5 meter in diameter with a semi-circular slab wall measuring 3.5 meters in length situated on the east rim.

Feature 20 - This is a limestone sinkhole measuring 1.1 by 1.2 meter with a 3.0 meter long wall of slabs and cobbles on the east rim.

Feature 21 - This is a limestone sinkhole measuring 1.9 by 3.4 meters on the north side of which is a 2.0 meter long section of limestone cobble wall, and the south and east sides of which are walled with rough boulder alignmens.

Feature 22 - This a shallow dirt-filled limestone sinkhole measuring 2.5 by 2.8 meters with a 4.0 meter length of slabs and cobbles on the south-east side.

Feature 23 - This is a shallow limestone sinkhole measuring 3.1 by 4.2 meters around the perimeter of which is an alignment of limestone boulders, some of which are stacked.

Feature 24 - This is a limestone sinkhole measuring 0.9 by 1.9 meters with a 2.30 meter long wall of slabs on the east rim.

Feature 25 - This is a limestone sinkhole measuring 2.0 by 2.3 meters with a 1.4 meter long wall of limestone cobbles on the west side.

Feature 26* - This is a limestone sinkhole measuring 1.5 by 2.0 meters with a 5.0 meter long semi-circular boulder and slab alignment on the south side.

Feature 27* - This is a cairn measuring 2.7 by 2.8 meters and standing to a height of 0.95 meter. It is constructed of limestone slabs and cobles.

Feature 28* - This is a cairn measuring 1.9 by 2.3 meters and standing to a height of 1.25 meter. It is constructed of boulders and cobles.

Feature 30 - This is a cairn measuring 1.8 by 2.4 meters and standing to a height of 0.55 meter. It consists of stacked limestone slabs with a small cavity in the interior, and was apparently built over a filled limestone sinkhole.

Feature 31 - This is a cairn measuring 1.5 by 1.6 meters and standing to a height of 1.1 meter, and is constructed of slabs built at the edge of a limestone sinkhole.

Feature 32* - This is an enclosure measuring 5.5 by 5.8 meters with walls standing to a height of 0.4 meter. It is constructed of limestone slabs and boulders.

Feature 33* - This is an enclosure measuring 17.7 by 18.5 meters with walls standing to a height of 0.7 meter. It is constructed of slabs, presumably limestone.

Feature 34 - This is a scatter of surface debris covering an area of approximately 30 by 30 meters, and is apparently the remains of a site disturbed during clearing operations for the adjacent limestone quarry. Remains present include charcoal, fircracked coral fragments and shell midden.

SITE 2718

Feature 1a - This is an enclosure measuring 3.0 by 4.8 meters and standing to a height of 1.0 meter. It has a doorway in the northeast side, and is constructed of limestone slabs. The southeast wall was constructed on top of a filled limestone sinkhole. Shell midden is present on the surface, and adjacent limestone sinkholes contain shell midden, basalt rocks and historic glass bottles.

Feature 1b - This is a limestone sinkhole measuring 3.5 by 6.0 meters with a small opening through the roof. Limestone cobbles are stacked on the northeast side. Midden materials present include shell and bone, organic materials, basalt cobbles, possible fragments of gourd and historic glass bottles.

Feature 2a* - This is an enclosure built of limestone slabs, and measures 5.2 by 5.7 meters and stands to a height of 0.5 meter. A possible doorway is located in the north wall.

Feature 2b - This is a limestone sinkhole measuring 1.2 by 2.0 meters, and contains shell midden.

Feature 3 - This is a platform measuring 6.5 by 7.6 meters and standing to a height of 0.2 meter. It is constructed of rock cobbles and earth, and includes shell midden, branch coral, charcoal and firecracked rock. Numerous limestone sinkholes are located near-by.

Feature 4 - This is an enclosure measuring 3.5 by 3.8 meters and standing to a height of 0.7 meter. It is constructed of slabs built against a limestone outcrop, and has a doorway in the southwest wall.

Feature 5 - This is a C-shaped structure measuring 3.2 by 3.4 meters.

Feature 6* - This is an enclosure measuring 5.7 by 6.0 meters and standing to a height of 0.75 meter, with a doorway in the south wall and a possible interior paving. Two limestone sinkholes are located adjacent to the north wall.

Feature 7* - This is a C-shaped structure measuring 3.8 meters in diameter constructed of limestone slabs. Limestone sinkholes are located near-by.

Feature 8* - This is an enclosure measuring 2.0 by 2.8 meters and standing to a height of 0.65 meter, with a doorway in the southwest wall.

Feature 9 - This is a cairn measuring 2.4 by 2.5 meters and standing to a height of 1.0 meter, constructed of limestone boulders and cobbles.

Feature 10 - This is a cairn measuring 2.2 by 2.8 meters and standing to a height of 0.7 meter, built of limestone fragments.

Feature 11 - This is a cairn measuring 2.5 meters in diameter and standing to a height of 0.4 meter, consisting of a circular alignment of limestone rock with a cobble fill.

Feature 12 - This is a mound measuring 1.5 by 2.5 meters and standing to a height of 0.5 meters, consisting of stacked limestone slabs.

Feature 13a - This is a cairn measuring 1.9 by 2.0 meters and standing to a height of 0.7 meter, constructed of slabs and cobbles.

Feature 13b* - This a cairn measuring 1.8 by 2.8 meters and standing to a height of 0.65 meter, constructed of slabs and cobbles. It is joined to Feature 13a by remnants of a stone alighment.

Feature 14 - This is a cairn measuring 1.8 by 2.6 meters and standing to a height of 0.65 meter, constructed of limestone slabs and cobbles.

Feature 15 - This a walled depression measuring 3 by 3 meters.

Feature 16 - This is a limestone sinkhole measuring 1.4 by 2.1 meters with limestone boulders and cobbles piled on its east rim.

Feature 17a - This is a limestone sinkhole measuring 1.7 by 2.0 meters with a 2.0 meter long rock alighment on the south side.

Feature 17b - This is a limestone sinkhole measuring 1.7 by 1.9 meters with stacked limestone slabs around the rim.

Feture 18 - This is a walled depression measuring 2.7 by 3.2 meters.

Feature 19 - This is a limestone sinkhole cave measuring 2.1 by 2.4 meters, with a restricted opening in the roof. A 2.0 meter long wall of limestone slabs and boulders is located on the south rim, the interior side of which is resting on the floor of the sinkhole.

Feature 20 - This is a wall measuring 25 meters in length.

SITE 2719

Feature 1* - This is an enclosure measuring .6 by 5.4 meters and standing to a height of 0.6 meter. A possible doorway is situated in the southwest wall, which is built of limestone slabs. Several limestone sinkholes are located near-by.

Feature 2 - This is a cairn measuring 1.5 by 2.2 meters and standing to a height of 0.65 meter, constructed of limestone boulders. It is located adjacent to a limestone sinkhole.

SITE 2720

Feature 1 - This is a remnant of a bulldozed structure. It is a limestone slab wall in the shape of the letter C, covering an area of 2.5 by 2.5 meters and standing to a height of 0.65 meter. The presence of a corner in the wall suggests that it was originally an enclosure.

Feature 2 - This is a disturbed remnant of an enclosure measuring 3.0 by 3.0 meters and standing to a height of 0.55 meter, constructed of limestone slabls. Limestone sinkholes are located near-by.

TEST EXCAVATIONS BY SINOTO, 1976

B6-79 [2717/27]I

The cairn was dismantled. Nothing was found.

B6-80 [2717/28]

The cairn was dismantled. Nothing was found.

B6-92 [2718/7]

A test pit revealed the presence of a cultural layer approximately 0.2 meter thick. Midden material, two basalt flakes and one calcite flake were found.

B6-93 [2718/6]

Two test pits were excavated, revealing the presence of a cultural layer approximately 0.15 meter thick. Cultural materials retrieved included midden remains, one bone fishhook blank, charcoal, possible cooking stones and an ash lense. Fossil bird bones were tentatively identified.

B6-94 [2718/2a]

Two test pits were excavated. A cultural layer approximately 0.2 meter thick was encountered, from which were recovered 24 artifacts, four of which were prehistoric and the remainder of which were historic in age. Two basaltic glass hydration-rind dates of A.D. 1666±41 and A.D. 1743±41 were obtained from samples from the site.

B6-95 [2718/14]

A cairn was dismantled. Nothing was found.

B6-96 [2718/13b]

One-half of a cairn was dismantled. Two artifacts [one coral file fragment and one basalt flake] were recovered, as well as midden materials, primarily fishbone.

B6-97 [2718/8]

One test pit was excavated, revealing the presence of a 0.05 meter thick ash deposit. One coral flake was found.

B6-103 [2717/32]

One test pit was excavated. Nothing was found.

By-105 [2717/33]

One test pit was excavated, revealing the presence of a cultural deposit 0.05 meter thick. The nature of the cultural deposit was not discussed.

B6-106 [2717/26]

One test pit was excavated. Nothing was found.

B6-113 [2717/4]

One test pit was excavated, revealing the presence of a cultural deposit approximately 0.15 meter thick, including part of an ash lense 0.05 meter thick. Midden was scarce, and no artifacts were found.

B6-125 [2719/1]

One test pit was excavated, revealing the presence of a cultural layer containing midden materials. No artifacts were found.

B6-139 [not discussed by ARCH]

This a paleontological site consisting of a large limestone sinkhole measuring 11 meters in diameter, and filled with water to a depth of 10 meters. Excavations revealed the presence of the bones of a number of crows [Corvus sp.] as well as other, as yet not identified birds.

Summary of Recommendations

Bernice P. Bishop Museum recommended salvage excavations in Sites B6-91 and B6-93 [State numbers 2718/17a and b, and 2718/6]. Archaeological Research Center Hawaii, with the benefit of more information as a result of their more complete survey and more excavation information, recommended the following sites for test excavations:

Site 2717, Features	1	13	20	28
	2	14	21	29
	4	15	23	30
	5	16	24	31
	6	18	25	32
	9	19	27	33
Site 2718, Features	3	10	13b	16
	5	11	14	18
	9	13a	15	
Site 2719, Feature	2			
Site 2720, Feature	1			

Archaeological Research Center Hawaii recommended archaeological salvage for the following sites:

Site 2718, Features	1a	2a	4	7	19
	1b	2b	6	8	
Site 2719, Feature	1				
Site 2720, Feature	2				

APPENDIX II

LIME KILN

Site No. 1436

Prepared by

Spencer Mason Partnership
1050 Smith Street
Honolulu, Hawaii

Prepared for

Chiniago Inc.
1040 B Smith Street #7
Honolulu, Hawaii

10 July 1984

Physical Description

The lime kiln structure (site no. 1436) is located on the Ewa coast of Oahu. The shore line in that area has small coral sand beaches with sand dunes and exposed outcroppings of sandstone. Underlying this strata is a basalt shelf which is exposed at the waterline.

The lime kiln is built about the normal high water mark. Immediately mauka of the site is an unimproved road which provides access to beach sites. The road also marks the edge of what were sugar cane fields until about 1981. Remains of the 1903 Oahu Railway and Land Company tracks lie about two hundred yards farther inland from the site.

The kiln and kiln site underwent significant damage due to the high surf accompanying Hurricane Iwa in November 1982. Photos 1 and 2 indicate the extent of that damage, which resulted in the collapse of its wing walls. The main portion of the lime kiln structure is a large cylinder aproximately 18 feet in diameter and 10'-6" high. The drawings and photos which accompany this report graphically describe its appearance. On the windward side at the base of the structure are three openings roughly 4'-6" high by 4' wide which funnel air to the interior of the kiln. (Figures 1 and 2) Remnants of two high side walls exist which curved out and down to meet a straight lower wall of approximately 30" in height. These apparently acted as wind scoops to increase air pressures at the vents.

The kiln basically consists of four concentric cylinders. The interior cylinder is the chamber itself which was approximately 7'-0" in diameter at mid-height and decreased gradually to about 6'-2" diameter at the top of the outer cylinder. It is presently filled to within four feet of the top of the cylinder with rubble.

Next is a nine inch thick cylinder of fire brick. The top layer of fire brick is presently about 4'-6" below the top of the kiln but there is one brick on top of this course which, in turn, has mortar on top of it. This indicates that the fire brick lining once was higher in that space. It is likely that the firebrick covered the entire inner surface of the kiln because, while sandstone is more tolerant of heat it nevertheless will break down at firing temperatures. The brick is laid in a running bond of double width thickness with a bond course every six courses. The brick is a yellow beige and the mortar is very soft and easily crumbled.

The next cylinder is about one foot thick and consists of small pieces of limestone rubble cemented together with a lime mortar.

This cylinder rises up to one foot above the outside cylinder and begins to curve inward. Since the rubble which partially fills the kiln is identical to that of this cylinder it is apparent that this cylinder originally formed a dome over the kiln.

The outer cylinder, approximately four feet thick, is constructed of large blocks of sandstone mortared together. The sandstone was probably quarried on the site. Many of the blocks are marked with wedge holes and some show small tool marks. The larger stones weight in excess of one thousand pounds.

SIGNIFICANCE STATEMENT

Lime is used for many things in a variety of industries. In Hawaii the two major industries to which lime is important are in agriculture, expecially the sugar industry, and in the construction industry. The earliest uses of lime in Hawaii were in masonry construction. A somewhat impure lime was obtained by the open pit burning of coral. This lime was used, with sand and water, to make the earliest mortars. It is likely that until about 1850, much of the lime used in construction was locally produced.

Lime was, and is, extensively used in the agriculture industry. It is used as a soil conditioner and, in the sugar industry, hydrated lime is added to cane juice to clarify it. This kiln may have been constructed to provide lime to Ewa Plantation mill, which was started in 1890, since it is located only about 200 yards from the Oahu Railway & Land Company line and about a mile from the mill.

Lime was being imported to Hawaii in large quantities at least as early as 1873.[1] The importance of lime to Hawaii's industry led to early efforts to produce lime locally. One of the earlier efforts to commercially produce lime was made by the Waianae Lime Company.

"The Waianae Lime Company Ltd. was originally established for the purpose of manufacturing lime for plantation field use in the treatment of soils.[2] The Hawaiian Stone Company, predecessor of the Waianae Lime Company, applied for permission "to erect a Lime Kiln and....the assistance of [The Interior Department] in placing a Mooring Buoy at the landing near the Quarry of the Company at Waianae, Oahu"[3] in May of 1885. It is uncertain where this referenced kiln was to be.

1 Letter from Department of the Interior to C. Brewer & Co., Archives Bk. 12, p. 131, ordering lime for Aliiolani Hale.
2 Advertiser; 10/27/1935; Sec. 3; c.3.
3 Document #164; Dept. of Interior letter dated May 20, 1885.

By 1907 Hawaii imported $125,000.00 worth of lime per year for its various industries. In that year the Waianae Lime Company opened a new double lime kiln in Iwilei. Limestone was transported from their Waianae quarries via the Oahu Railway to the continuously operating kilns. In 1925 two Island companies began manufacturing a high quality quicklime, one from coral sand and the other coral rock. This lime was used in its hydrated form in the sugar industry.[4]

This lime kiln predates the modern efforts of manufacturing lime in continuously operating kilns such as the 1907 Waianae Lime Co. kilns. In the older kilns beach sand or crushed limestone or coral were burned using wood as the fuel. In this type of older kiln the process of burning required as much as two or three weeks and almost as long as that to cool the kiln down sufficiently to extract the lime.[5] This is obviously a slow and inefficient method of obtaining lime.

No State or U.S. Geologic survey maps have been located which show this lime kiln. Sources checked included the original Oahu Railway and Land Company right of way maps at the Bishop Museum and survey maps of the Honouliuli District from 1885 to 1939 stored at the State of Hawaii Surveyors office.

This lime kiln is significant as an early and relatively primitive example of a kiln built to burn coral sand or sandstone to obtain lime. It is the only known existing example anywhere in the Islands. It is a valuable source of information about how early lime making was done.

Further research may reveal with more certainty the place, if any, this site has in the history of Ewa Plantation or the Oahu Railway and Land Company. Its value as a source of information about earlier industrial processes is unquestionable. It is apparent from the development master plan that the site and structure are to be significantly affected by development actions. Two options are recommended to mitigate these changes:

Option A - Destruction of the kiln following a thorough documentation effort. This effort should involve the following elements:

1. Excavation of the base of the kiln and the kiln interior.
2. Analysis of the mortar for lime and cement content.
3. Drawings of the structure which accurately depict, to the extent possible, the original configuration of the kiln structure.

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[4] Letter from H.P. Agee at Hawaiian Sugar Planters Association to M.J. Proffit, 10/27/78.

[5] Pacific Commercial Advertiser; 11/30/1907; p.6 c.2.

4. Supplementary photographs to those already taken.

5. Collection and preservation of stone, mortar and brick samples.

Option B - Moving the kiln to a new location. This is only recommended after following steps 1 through 4 of Option A above and then only with the following additional provisions:

1. The new site must bear a similar relationship to the sea and agricultural fields as the present site. It also should be geographically related to Ewa Plantation.

2. Every stone must be accurately marked and relocated.

Simply leaving the structure in its present location is not deemed desireable for the following reasons:

1. The valuable information that the lime kiln can provide can be adequately satisfied by thorough documentation.

2. The site has undergone significant damage in its present location due to Hurricane Iwa. The hurricane-spawned waves also cleared the site and exposed the kiln to campers who use the site for camping and are damaging the kiln. This use is likely to continue, which will further damage the kiln.

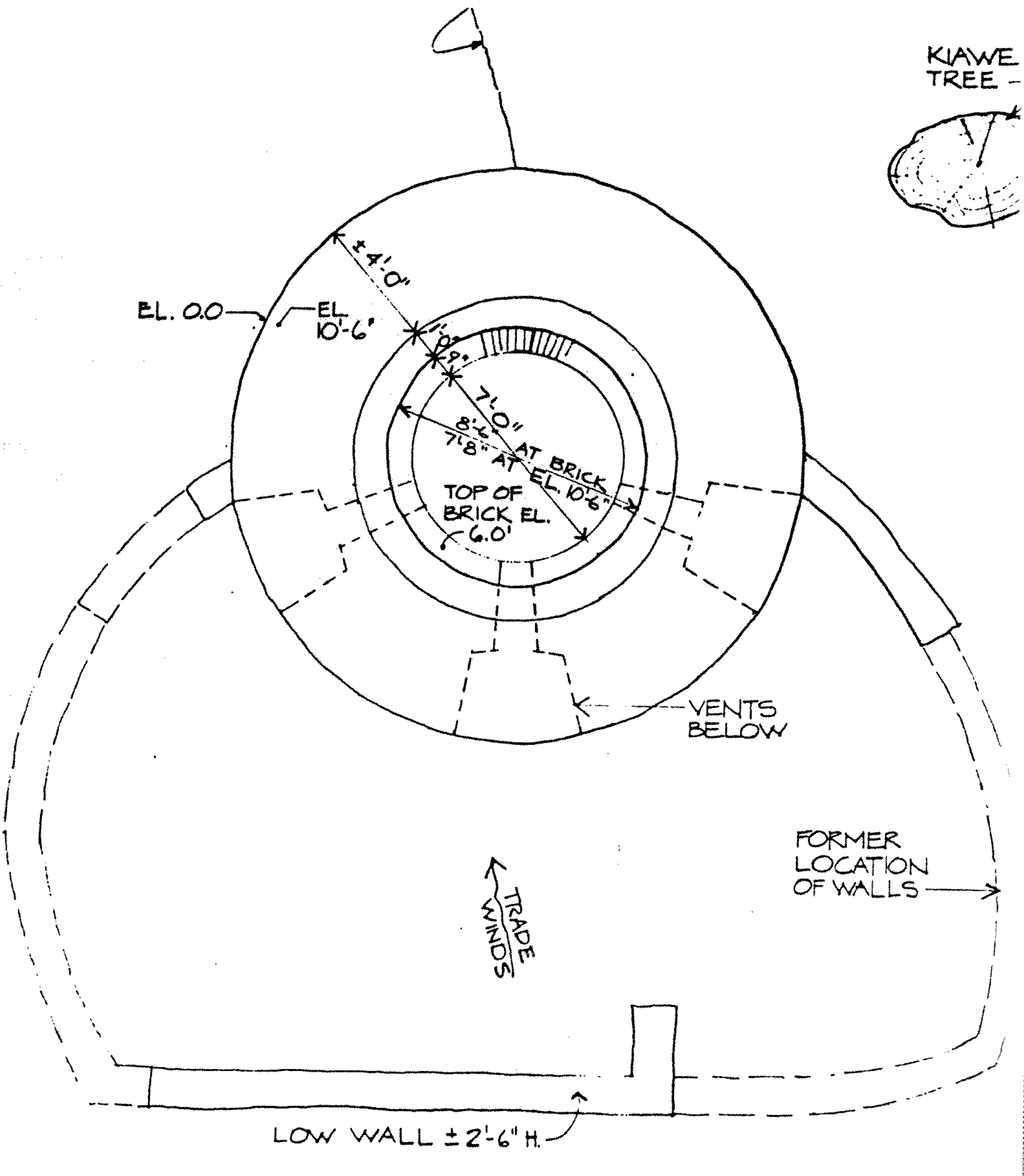


FIG. 1 - PLAN OF LIME KILN
1/4" = 1'-0"

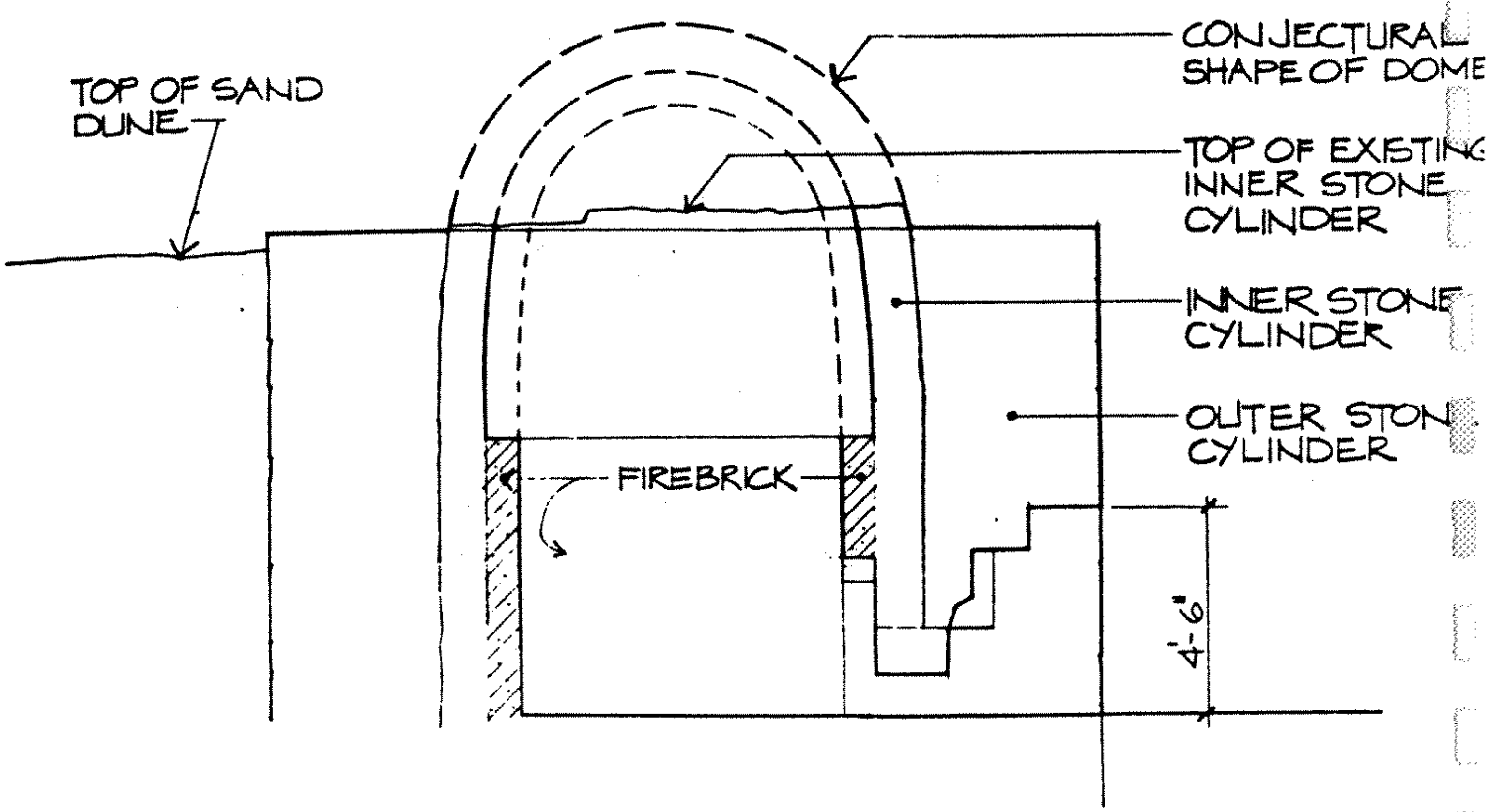


FIG. 2 - SECTION THRU THE KILN
1/4" = 1'-0"

1. Taken before the Nov., 1982 Hurricane Iwa, this photo shows the relatively intact front and side walls which acted to funnel air into the kiln.

2. This photo, taken in June, 1984 shows the damage done to the site by the hurricane. The side and walls are partially collapsed and surrounding vegetation has been torn away. The site is presently being used by campers who use the kiln vents for fire places, resulting in the blackening of those recesses and the sandstone above.

3. Photo showing the south side of the kiln. In the left foreground are the collapsed remains of the southwest wing wall. Note the projecting stones on the left side near the top and at the base where that wall tied into the main part of the kiln.

4. Photo from the southeast. The wing wall on this side also acts as a retaining wall.

5. Photo from the westside. At least six stones on this side show drill holes from their quarrying process. See photos 13 and 14.

6. This photo is show from the north side looking down the Ewa coast and shows the remains of the kiln dome.

7. This photo was taken standing atop the kiln looking south along the Ewa coast. In the foreground is a large quantity of sandstone boulders. To the right midground of the photo are exposed sandstone outcroppings. The lime kiln itself and the boulders in the foreground are all of the same material.

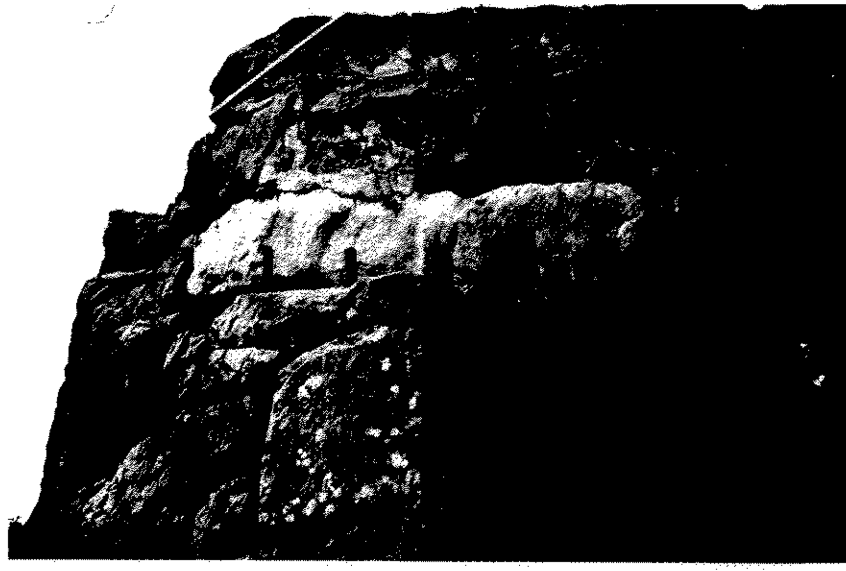
8. Top of kiln. Rubble infill is material pieces similar to the material used to create the inner stone lining.

9. The straight joint line shown is the only straight joint in the inner stone lining and occurs at the same level as the massive outer stone cylinder. This indicates that the inner lining was completed and leveled before the domed top was constructed.

10. Closeup of the southwest kiln opening. The lintel block, which is 5'1" long by 10" to 14" thick by 1'-7" deep is marked on its lower edge by holes drilled in the stone during the quarrying process. The main side walls of the opening slant back and the stones to the rear of the opening slant back and the stones to the rear of the opening are set and shaped to create a wind funnel.

11. Interior of the kiln, partially excavated, showing remains of the fire brick lining.

12. Closeup of the fire brick coursing. The top of one of the vent openings is visible at the center of the photo.



13. Fine grained sandstone block on the southeast side showing five drilled holes.

14. A coarser grained block on the southwest side showing seven drilled holes.

15. A sandstone block at the center vent opening which exhibits some tooling marks.

APPENDIX III

MEMORANDUM:

DATE: 10 August 1984

TO: Environmental Communications, Inc., Frederick J. Rodriguez, Pres.

FROM: Alan C. Ziegler, Consultant

SUBJECT: Occurrence and significance of palaeontological and archaeological remains in the West Beach Resorts development area, O'ahu, with recommendations for their location, recovery, and treatment.

DEFINITIONS

Certain terms used in this memorandum sometimes cause confusion, so a short explanation may be helpful. As you already know, the terms Botany and Zoology are usually used to mean only the study of living species of plants and animals, while Anthropology is understood to be the study of relatively modern or living man and his activities. If, however, we are studying extinct or prehistoric wild species of plants and animals (especially those of relatively great age) the discipline is called Palaeontology; and if early or prehistoric man, along with his artifacts and domestic plants and animals is the subject, the field is termed Archaeology.

Thus, it is easy to explain the difference between the two sciences of Palaeontology and Archaeology, and even to study them separately in many places around the world. But, in the general Barbers Point area, remains representing both of these two scientific fields are often found intermingled or overlapping in soil deposits, and thus have to be considered together. Previous environmental studies related to the deep-draft harbor project immediately to the south of the proposed West Beach Resorts development area have shown that evidence of prehistoric (or "fossil") animals--bones of such extinct birds as a flightless goose and a Hawaiian eagle (see examples in Fig. 1), shells of extinct land snails, etc.; i.e., palaeontological items--may be found in the lower levels of the deposits unaccompanied by any evidence of man; and signs of only a prehistoric Hawaiian culture--bone fish

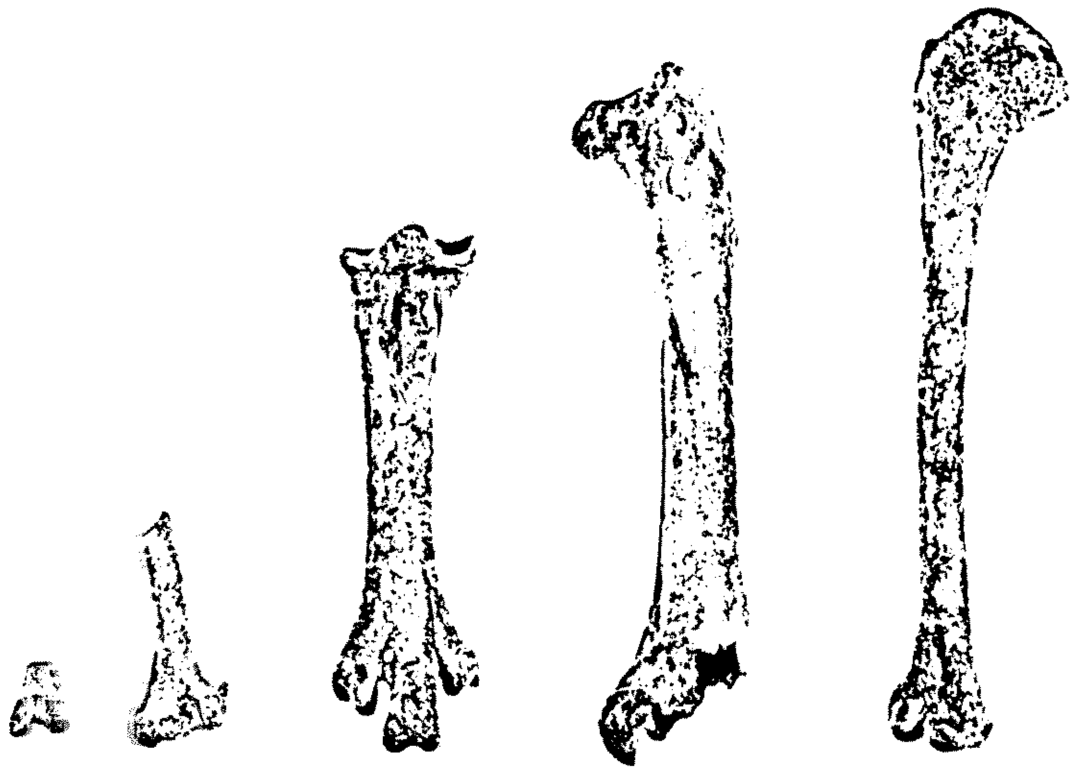


Fig. 1. Bird bones from sinks in deep-draft harbor project area, Barbers Point region, Oahu, Hawaii. Left to right: extinct long-legged owl; extinct Oahu crow; extinct flightless goose; extinct Hawaiian eagle; flighted goose, possible nene (length of this bone = 12.5 cm or approximately 5 inches). (Reproduced, with permission, from unnumbered figure immediately preceding page 67 in: Sinoto, A., 1976, A Report on Cultural Resources Survey at Barbers Point, Island of Oahu, MS 122476 of Bishop Museum Anthropology Department, prepared for Department of the Army, Corps of Engineers, Pacific Ocean Division, Honolulu, Hawaii.)

hooks, volcanic glass flakes, old stone walls, etc.; i.e., archaeological items may be found in upper levels as well as on the surface around the area; while at intermediate levels may be found the remains of prehistoric birds and snails in apparent association with artifacts, bones of Polynesian-introduced animals, and similar culturally related items. (One such association in the proposed harbor area has been radiocarbon dated at approximately 800 years before the present time.

OCCURRENCE OF PALAEONTOLOGICAL AND ARCHAEOLOGICAL REMAINS

In the general Barbers Point area, these remnants of the past are usually found in sinks or solution pits formed by the dissolving action of rain or ground water on numerous spots in an ancient coral reef now situated some 10 to 80 feet above sea level. (This emergent reef formation once extended from the Waianae Coast to Waikiki but the Barbers Point area now contains essentially the only part not already destroyed by construction and other modern activities.) Through thousands of years, long before the discovery of Hawaii by Polynesians, dust and mud gradually settled in these sinks, covering the bones and shells of prehistoric birds and land snails that occaisionally died in them. Upon arrival of Hawaiians in this area perhaps a thousand years ago, additional remains of at least some of these animals, as well as those of other possible food items along with Hawaiian artifacts, were added to the deposits of certain sinks.

FINDINGS OF RECENT SURVEYS

Such sinks undoubtedly once occurred over the entire West Beach Resorts planned development area but most have been irretrievably lost as a result of massive land-altering operations such as topsoil-filling of sugar cane fields and bulldozing for construction of former military facilities. William M. Barrera, Jr., in a 1979 study of the entire 640-acre project area (West Beach, Oahu: An Archaeological Survey, Chiniago, Inc.), found only one region where any significant number of sinks was still locatable: his Area IV, shown here in Fig. 2. And, as of July, 1984, he estimated that even about 50% of this area's surface was too disturbed to permit detection of sinks.

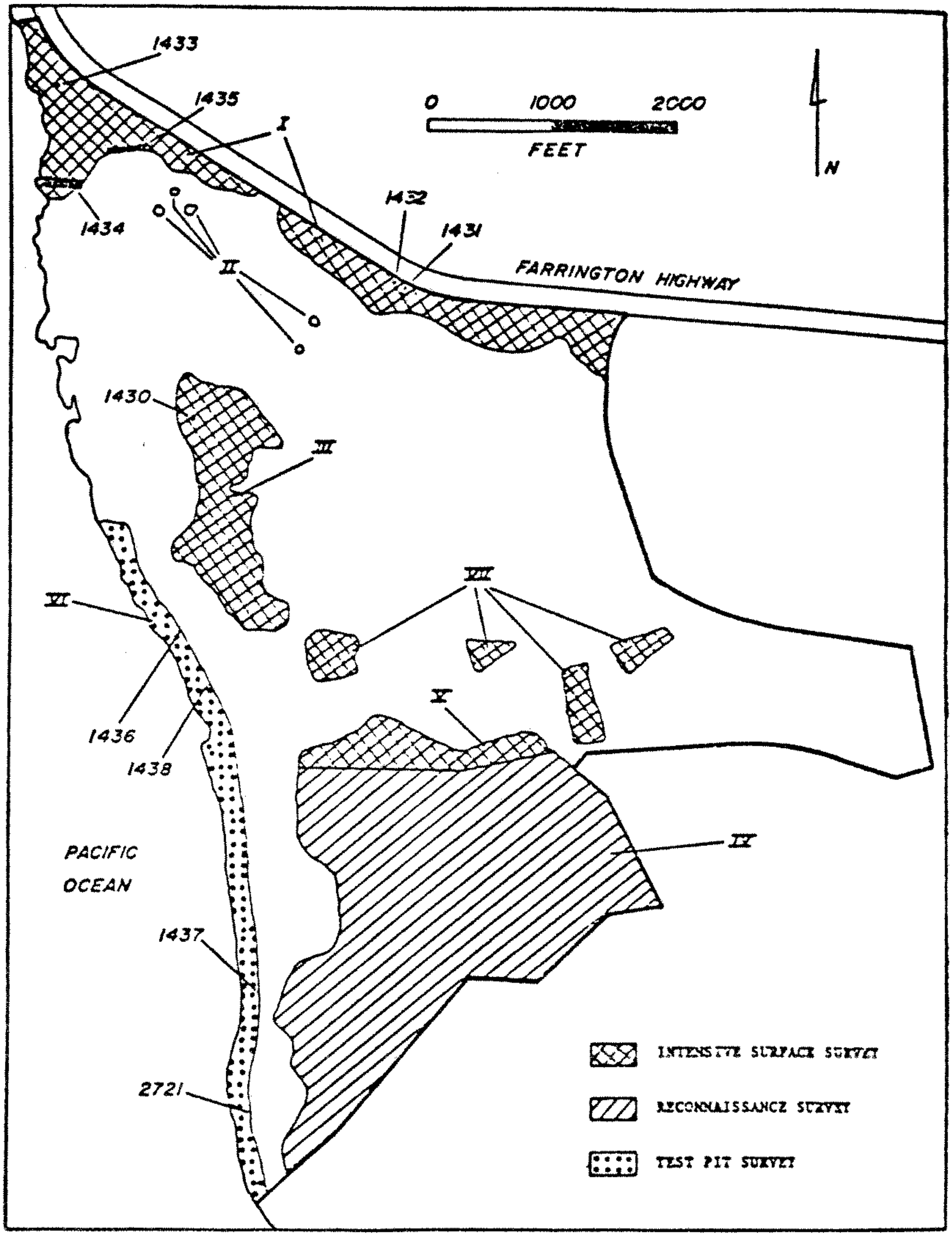


Fig. 2. <u>Map of West Beach Resorts proposed development area, Barbers Point region, Oahu, Hawaii</u>. The portion labeled IV is the primary sink area. A single sink occurs in Area III, and three Hawaiian sand-dune habitation sites are located in VI. (Reproduced, with permission, from Fig. 2: Barrera, W., Jr., 1979, <u>West Beach: An Archaeological Survey</u>, Chiniago, Inc.

I visited the Area IV site in the same month and was shown representative examples of the remaining sinks as well as the general site area by Barrera and an assistant. The area appears to have almost exactly the same characteristics as that in the deep-draft harbor project area immediately to the south, in which were located many sinks containing either or both prehistoric bird bones and Hawaiian cultural remains. Later, using rough graph-grid planimetry applied to an aerial photograph, I calculated that Barrera's Area IV represents about 18% of the entire 640-acre West Beach Resorts project area, or about 115 acres--and, as noted earlier, only about half of this, or approximately 60 acres, contains locatable sites.

Barrera recently made a rough count of accessible sinks (i.e., those with a surface opening greater than about half a meter) on approximately 10% of this 60-acre area, and found about 75 such sinks. This means a density of accessible sinks in this region of approximately 12.5 per acre, and an estimated total of 750 accessible sinks within the boundaries of the entire West Beach Resorts proposed development, essentially all restricted to the northern and western parts of Barrera's Area IV along the south-central border of the project.

Additionally, by the end of last July, Barrera had sampled six of the accessible sinks by means of half-meter-square test pits dug to bedrock in order to obtain some idea of how many of the estimated total of 750 might be expected to contain palaeontological and/or archaeological remains. This sample, unfortunately statistically rather small, indicated that about 50% of accessible sinks may contain significant amounts of palaeontological/archaeological material. Three of his six sinks proved sterile as regards such remains; but two other contained (only) bird and rodent remains; while the final one showed remains of rodents and one bird bone along with relatively abundant fish bones and other evidence of marine animals, almost surely indicating a Hawaiian cultural deposit. I performed a preliminary analysis of the vertebrate material from these latter three sinks, and tentatively identified bird species from the first two as including a totally extinct flightless goose, as well as a petrel now found only on the islands of Maui and Hawaii. The rodent found in all three sinks is the Polynesian-introduced Hawaiian Rat. The fish represented in the last sink is still unidentified but the bird bone fragment accompanying it could prove to belong to an extinct species of crow when an opportunity arises to directly compare the fragment with identified skeletal material in the Bishop Museum. The type and general frequency of these animal remains in this limited sample seem similar to those characteristic of sinks previously excavated in the deep-draft harbor project area.

At least one additional accessible sink outside of Area IV, as well as three presumed Hawaiian habitation sites in sand dune areas along the ocean shore, were found or noted by Barrera in his 1979 survey (see general locations of these sites in Fig. 2).

DISCUSSIONS

I sought figures on the density of similar sinks as well as on percentages of sinks yielding palaeontological/archaeological remains in various reports concerning the deep-draft harbor area to compare with those found by Barrera in the West Beach Resorts area. The only pertinent figures encountered were those for a proposed dredged-material disposal site in the far southeastern portion of the harbor project (near the junction of Malakole Road and Kalaeloa Boulevard) presented by Aki Sinoto (Cultural Resources Survey of New Dredged Material Disposal Sites at Barbers Point, Oahu, Hawaii, MS 050179 of the Bishop Museum Anthropology Department, prepared for the U.S. Army Engineer Division, Pacific Ocean, November, 1979). The southern portion of this site was systematically surveyed for accessible, archaeologically unmodified, sinks, and Sinoto found a mean of 104 such sinks per 10,000 m^2, or approximately 40 per acre. (However, the range to either side of this mean figure was great: 0 to 276 sinks per 10,000 m^2, indicating the density of sinks may vary widely over this entire Barbers Point limestone reef area, including, presumably, also the West Beach Resorts development portion.)

Sinoto's average of 40 sinks per acre is noticeably higher than the figure of 12.5 sinks calculated from Barrera's West Beach Resorts data. But note that Sinoto's figure was simply an average and that certain parts of his area had no appropriate sinks. Also, as he himself states, the density of sinks in the surveyed portion of his site was "extremely high" and the number of sinks "decreased markedly" in the remaining portion of the area. I was unable to similarly circulate densities of sinks in surrounding parts of the deep-draft harbor project, primarily because of lack of reported dimensions of other harbor project areas found to contain stated numbers of sinks. However, after studying mapped site areas and related environmental-report data, my subjective impression is that the usual density of bone-containing sinks in the overall harbor area is, as intimated by Sinoto, normally much less than about 40 per acre, and that it may well be even less than the 12.5 per acre obtained from Barrera's data. So, there presently seems no compelling reason to think that this proposed figure of 12.5 sinks per acre for the West Beach Resorts property is inaccurate and, thus, it will tentatively be accepted for use in further calculations.

As to determining the fraction of the estimted total number of 750 accessible West Beach Resorts sinks that might contain palaeontological and/ or archaeological remains, it may be recalled that Barrera's recent investigations indicated that 50% of the total could be expected to contain such material. However, because this sample was so small and thus susceptible to so great a potential sampling error, I compared this 50% figure with that found by Sinoto in his previously mentioned work involving part of the harbor dredged-material disposal area.

There, 24 archaeologically unmodified sinks systematically chosen (one from each of 24 ten-thousand-meter-square grids) and sampled revealed that 19, or almost 80%, contained bird bones. I do not know how to account for this relatively great discrepancy in percentage of bone-bearing sinks in different areas, unless it is simply chance; that is, due to the probable sampling error suggested above in the case of the West Beach Resorts site. (In this regard, it should be realized that the occurrence of bone in only one more of Barrera's sinks would have increased his percentage to 67%, and in only two more to 83%.) alternatively, it could be that there is a real difference in percentage of sinks containing bone in various parts of the overall Barbers Point region and/or even within the West Beach Resorts portion of it. Thus, until and unless further sampling is undertaken, and such work indicates a necessary change, I would suggest considering Barrera's figure of 50% as representative of the approximate frequency of bone-containing sinks among the total number of such formations. This would mean that about 375 West Beach Resorts area sinks can be expected to contain palaeontological and/or archaeological remains.

The problem now remaining is twofold: how to locate the possible 375 sinks that contain the bone or cultural remains among the estimated total of 750; and, once identified, what to do with these particular sinks as regards possible excavation and preservation.

It seems the bone-containing sinks can most efficiently and economically be located by means of a program of test-pitting. In this procedure, to accommodate at least part of any possible geographic variation in both density and bone-bearing potential of sinks at the site, broad transects should be laid out traversing the entire sink area--perhaps running from the seaward to the inland side of the area. Every second sink along each of these transects should then be sampled by, say, excavation of a quadrant in smaller sinks or a half-meter-square test pit in larger ones, until either the first bird bone is recovered or the bottom of the sink is reached. Thus, in the West Beach Resorts project area, every other one of about 750 accessible sinks would be so test-pitted, and approximately half of these 375 tested sinks--or 188--might be found to contain palaeontological and/or archaeological items. These 188 sinks, once so identified, should be marked both on the ground and on a map, and considered eligible for complete excavation.

With regard to what should be done with such identified sites--more specifically, what percentage of them should be completely excavated and/or preserved--the sort of salvage palaeontology/archaeology indicated proves to be, for once, a relatively satisfactory procedure. This is, in contrast to the case of a just-discovered or recently excavated heiau or Hawaiian house site facing imminent destruction from development activities, the bone-containing sinks themselves are expendable (or at least most of them are) once the contents of an adequate number of them are properly recorded and removed for educational and scientific purposes. To restate this, it is primarily the sink contents and recorded associations that are important, not the sinks themselves. If all of the 188 sinks under consideration were completely excavated, this would represent an approximate 25% excavation of the total available sinks occurring on the West Beach Resorts project area.

The relation of this percentage to other somewhat similar excavation figures should be briefly examined. An excavation figure of 10% is often mentioned as a minimally acceptable one for examination of many archaeological sites. For example, in the study of an open and relatively extensive site such as one thought to represent a former small village, the total areal extent of which is judged to be about 1000 m^2, it would be desirable to excavate at least 100 one-meter-square pits scattered over the entire site surface. But this amount of excavation (i.e., 10%) would be aimed primarily only at discovering if the site did, in fact, represent a former village and, if so, what activities might have taken place in different parts of this habitation area. The major objective would not be to recover a maximum--or even a necessarily significant--number of artifacts or other items from the site for subsequent scientific study or display purposes. If, however, total destruction of the site was imminent, a great effort would undoubtedly be made to gather as much more site material as could feasibly be excavated in the remaining time available.

Thus, in the case of the West Beach Resorts area sinks, most or all of which will be lost as development proceeds, a suggested excavation figure of about 25% does not, in my opinion, seem at all unreasonable. This would mean the total excavation of an estimated 188 sinks. However, because various improved dating methods and other palaeontological/archaeological techniques will undoubtedly be developed in the future, a few of these bone-containing sinks--say, 10 or 15--should be preserved intact for use in future investigations. These few sinks could also serve as a minor visitor attraction in the eventual resort area if suitably marked and interpreted; and might conveniently be located out of the way of development among those sinks that still appear to be locatable along the old railroad right-of-way passing through the West Beach Resorts area.

In addition, the sink discovered by Barrera outside of the primary sink area, as well as the few sand-dune habitation sites, may yield bones of extinct and still-extant bird species. These remains would serve as sources of information complementary to data derived from sink excavations. Finally, it seems the scientific and educational value of recovered West Beach Resorts development area palaeontological and archaeological specimens could best be realized by deposition of most or all of such material, along with appropriate documentation, in the Bishop Museum rather than in some out-of-state institution.

SUMMARY

Soil-filled limestone sinks containing apparently significant amounts of palaeontological and archaeological material are now locatable on only about a fifth of the proposed 640-acre West Beach Resorts project area. This sink-bearing portion of the land is situated almost entirely in the south-central portion of the planned development. The density of sinks, as well as their contents, may prove to differ geographically over the site region. An estimated 750 sinks are accessible for purposes of excavation (i.e., have surface openings greater than 0.5 meters). Possibly half of these can be expected to contain palaeontological and/or archaeological remains such as bones of prehistoric birds and shells of extinct land snails, as well as items indicating early Hawaiian culture. Thus, if about half of the total number of 750 sinks were test-pitted to determine presence or absence of such remains, and the resultant 50% found positive in this respect were subsequently completely excavated, about 188 sinks--or approximately 25% of the total sink number--would have been examined about as thoroughly as presently appears possible and feasible. After completion of this suggested amount of excavation, in almost all cases, the sinks themselves (both excavated and unexcavated) would seem expendable, and any planned development of the sink area could then proceed. A few sinks, shown by test-pitting to contain prehistoric bird bones, should be preserved intact in a limited geographic area for their educational and future scientific value.

RECOMMENDATIONS

(1) Locate and appropriately mark--on both ground and map--all accessible (diameter greater than 0.5 meters) sinks in the pertinent south-central portion of the proposed West Beach Resorts development area. (Estimated total sink number = 750.)

(2) Establish several broad transects, oriented mauka-makai, through the entire sink-bearing area, and test-pit every second accessible sink encountered along each of the transects. (Estimated test-pitted sink number = 375.)

(3) Completely excavate essentially all of the 50% of test-pitted sinks that will probably be found to contain bones of extinct birds and/or Hawaiian cultural remains. (Estimated excavated sink number = 188.)

(4) After completion of this excavation procedure, consider essentially all of the primary sink area, including both excavated and unexcavated sinks, available for any desired construction or other development purpose.

(5) Preserve a few--perhaps a dozen or so--intact sinks in a convenient non-development location to serve as a minor visitor attraction as well as for possible future scientific study.

(6) Excavate the single presently accessible sink known to be situated outside of the primary sink area, as well as the few sand-dune habitation sites along the shore.

(7) Deposit most or all palaeontological and archaeological material recovered in the Bishop Museum, Honolulu.

WEST BEACH RESORT PROJECT WATER POLLUTION IMPLICATIONS OF PROJECT SITE STORM RUNOFF
-1984 UPDATE-

June, 1984

by
Gordon L. Dugan, Ph.D.
Environmental Consultant

INTRODUCTION

This updated report follows the same procedures that were used for the July 1979 report, by M.J. Chun and G.L. Dugan, by the same name except for alterations of land use within the 642 acre project boundaries and the inclusion of the project drainage into two distinct areas, the west and the east.

The east drainage comprises approximately 1705 acres, which includes approximately 1080 acres above and about 625 acres below Farrington Highway. The area below Farrington Highway includes the community of Honokai Hale, an intermediate area approximately between Honokai Hale and the project boundaries, and all but 150 acres of the actual project. The east drainage terminates at multiple locations into the project's 36 acre marina.

The west drainage includes approximately 800 acres above Farrington Highway and another 150 acres of the west portion of the project. The discharge point for the west drainage discharges into the ocean opposite the 150 acre western project portion.

For purposes of evaluation, only the area included within the project's 642 acres were considered in the presented results.

PURPOSE AND SCOPE

The purpose of this study is to evaluate the environmental impact of the proposed updated West Beach Project as it relates to storm water runoff. From an assemblage of available baseline hydrologic and water quality data, an estimate of the existing and projected volume and quality characteristics of storm water runoff from the project site will be made.

METHODOLOGY

Methods necessary to obtain an estimate of a particular storm induced surface water runoff requires a determination of reasonable rainfall-runoff coefficients for various magnitude and duration storms, land management, vegetation, soil, soil moisture, etc., conditions. In most practical situations it is not considered feasible, due to the numerous factors involved that influence rainfall-runoff coefficients, to attempt to determine varying coefficients, therefore, for most design and evaluation considerations a constant coefficient for a particular land-use and rainfall intensity range is generally assumed. Ranges of rainfall-runoff coefficients that are considered typical for Oahu are presented in the City and County of Honolulu "Storm Drainage Standards" (1969).

There are several soil series within the project site area, each of which has significant different percolation rates. In an attempt to circumvent a major portion of the unavoidable error created by an assumed constant rainfall-runoff coefficient, it was decided to use a method presented by the University of Hawaii Environmental Simulation Laboratory (HESL) for determination of representative storm water volumes under varying conditions (Lopez and Dugan, 1978).

The method presented by HESL is primarily based on an incorporation of U.S. Soil Conservation Service (SCS) data and the U.S. Weather Bureau (1962). The SCS data involves the use of curve numbers that were obtained from emperical data including precipitation, soil and changing soil moisture, and vegetative cover information from the classification of thousands of soils throughout the nation. These soils were segregated into four groups, labeled A, B, C, and D, with Class A having the highest water intake rates and Class D soils the lowest. The numerous soil series within the project's two separate drainage areas includes class groups A through D. The curve numbers, which have been modified for Hawaiian conditions, and are presently considered preliminary, only pertain to non-urban conditions. The SCS published a manual entitled "Urban Hydrology for Small Watersheds" (SCS, 1975), which is similar in concept and application to the method presented by HESL; however, the SCS manual is not, as yet, applicable to portions of the mainland Pacific Coast and Hawaii. For developed conditions, including the community of Honokai Hale, the HESL method utilized information published by Miller and Viessman (1973).

RESULTS

Proceeding with the method published by HESL (Lopez and Dugan 1978), the calculated weighted mean surface water runoff for 1-hr, 6-hr, and 24-hr storms at recurrence intervals of 1, 5, 10, 25, 50, and 100-yr, developed for both the east and the west drainage area, are presented in Tables 1 and 2, respectively. The developed project's open water surfaces, 44 acres of Marina and lagoons for the east drainage area and a 5 acre lagoon for the west drainage area, were not included in the developed project results, because they did not transmit runoff.

The quantity of rainfall produced by the given storms, which varied from 1.3 to 13.0 in., and the corresponding surface runoff, in acre-feet/event, for present (1984) conditions and full developed conditions, and the incremental difference that is predicted to result if the proposed project is completed are also included in the tables. The values presented in Tables 1 and 2, it must be emphasized, are for compartive purposes only and are not intended to be representative of the accuracy implied by the practice of not rounding-off the recorded values, which was primarily for convenience of calculations and balancing.

As would be generally expected, the greatest calculated incremental storm runoff volumes for the two drainage acres resulted from the 100-yr storm with a 24-hr duration, as shown in Tables 1 and 2. These values (acre-ft/event) represent a volume of water and should not be confused with the peak discharge values for design purposes which represent the maximum volume of storm water runoff discharged per unit of time (e.g. cfs). Peak discharge values, required for the engineering design of the proposed drainage facilities and ascertaining the capacity of existing facilities can be obtained by following the procedures outlined in the City and County of Honolulu's "Storm Drainage Standards" (Dept. of Public Works, 1969).

Besides the changes in the volume of storm water runoff, the quality of the various constituents being transported is of equal if not of more importance.

However, estimates of water quality constituents resulting from significant storm water runoff that occur, at the most, only a few times a year is very perplexing, especially since only very limited information on this subject is available at both the local and national level.

Inasmuch as there is not water quality information for storm water runoff from the project site, nitrogen and phosphorus values of 1.10 mg/L and 0.11 mg/L, respectively, were used for the present (1984) conditions. These values, which were based on information published by R.C. Loehr (1972), that involved a study of reported information from rural and agricultural land under different land management conditions, were derived from nitrogen outputs of 2 lb/acre-yr and phosphorus outputs of one order of magnitude less; an annual rainfall of 20 in.; and a rainfall-runoff coefficient of 0.40. The nitrogen and phosphorus output values reported by Loehr (1972), that represent the nearest situation to the one under review, ranged from 1 to 3 lb/acre-yr for nitrogen and a magnitude less for phosphorus.

Representative suspended solids values in storm water runoff from the proposed project site are again difficult to determine, inasmuch as it is commonly presumed, by mainly indirect methods, that the majority of the annual suspended solid load is carried by the heavy storm water runoff events which tend to occur on an infrequent basis. For estimation purposes, and considering the results from the analysis of sporatic storm water runoff samples during heavy storms, a value of 1500 mg/L was used for the present (1984) situation.

The concentration of water quality constituents of storm water runoff from urban areas is very sparse both locally and nationally; however, R.C. Loehr (1974) published a compilation of urban storm water runoff quality data collected throughout the United States with a few from international locations. As would be expected the results are at times somewhat diverse. There is, however, a study of urban storm water runoff quality collected from storm drains in different drainage areas of Honolulu; the results of which were presented in a University of Hawaii graduate Civil Engineering student Master of Science Thesis (Fujiwara, 1973). For comparative purposes the results of average storm water runoff values for residential areas of Honolulu, rounded-off to 0.60 mg/L, 0.57 mg/L, and 250 mg/L for nitrogen, phosphorus, and suspended solids, respectively, were used to simulate complete project development conditions.

The summation of nitrogen, phosphorus, and suspended solids loads from both present (1984) and full development conditions for storms of 1 and 24-hr duration at recurrence intervals of 1, 5, 10, 25, 50, and 100-yr are shown in Tables 1 and 2. As can be observed from the Tables, the incremental changes per storm event for the present (1984) and full project development conditions for the various duration and recurrence interval storms indicate that from the least to the greatest amount of rainfall: nitrogen increases for the lower level storms and decreases for the higher level storms; phosphorus increases for all given storm conditions; and suspended solids, except for the lowest level storm, decreases.

It must again be emphasized, as was the case for the hydraulic aspects, that the constituent values are only for comparative purposes, thus the indicated decrease in nitrogen output for higher level storms as a result of development should be construed as essentially having no apparent changes; the phosphorus output would be an increase while the total suspended solids load should generally decrease as the level of the storms increase.

The apparent reason for the phosphorus increase is that organic soils readily absorb phosphorus, thus, water that has percolated through the soil or has been in intimate contact with the soil usually has a low phosphorus concentration, whereas, storm water runoff from the developed areas with usually only small areas of exposed soil tend to transport a higher concentration of phosphorus. Conversly, the decreased amount of exposed soil in residential areas tend to decrease the quantity of the suspended solids load even though the total quantity of storm water runoff increases.

The hydrologic and water quality aspects of the surface water runoff were only considered for the present (1984) and completed, developed project conditions;

however, increased constituent loads will undoubtably result from construction activities, especially if a significant storm occurs during the interim period between earth moving operations and soil stablization completion. The impact of construction activities can be minimized by adhering to strict erosion control measures, particularly those specified in the City and County of Honolulu's (1972) Grading Ordinance.

For comparison and information purposes Tables A-1 and A-2 are included in Appendix A to indicate the hydraulic and constituent loads that are estimated to originate outside of and flow into the proposed project's east and west drainage areas, respectively, under given storm duration and recurrence intervals.

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TABLE 1

Estimated Storm Water Runoff and Constituent Changes due to the (1984) Proposed 642 acre West Beach Project, Leeward Oahu, Hawaii

East Drainage Area to Marina (Only Within Project Boundaries)

Storm a)			Storm Water Runoff											
Duration	Recurrence Intvl	Quantity	Hydraulic			Nitrogen b)			Phosphorus c)			Suspended Solids d)		
			Development		△	Development		△	Development		△	Development		△
			1984	Full		1984	Full		1984	Full		1984	Full	
hr	yr	in.	AF/evnt	AF/evnt	AF/evnt	lb/evnt	lb/evnt	lb/event	lb/evnt	lb/evnt	lb/evnt	tons/evnt	tons/evnt	tons/evnt
1	1	1.3	2.2	17.8	+ 15.6	6.4	29.0	+ 22.6	0.6	27.6	+ 27.0	4.4	6.0	+ 1.6
1	5	2.0	7.4	32.4	+ 25.4	22.2	52.9	+ 30.7	2.2	50.2	+ 48.0	15.2	11.0	- 4.2
1	10	2.3	10.4	39.3	+ 28.9	31.2	64.1	+ 32.9	3.1	60.9	+ 57.8	21.3	13.4	- 7.9
1	25	2.5	12.7	44.1	+ 31.4	37.8	72.0	+ 34.2	3.8	68.4	+ 64.6	25.8	15.0	- 10.8
1	50	2.8	16.2	51.7	+ 35.5	48.4	84.3	+ 35.9	4.8	80.0	+ 75.2	33.0	17.6	- 15.4
1	100	3.1	20.2	59.3	+ 39.1	60.5	96.8	+ 36.3	6.1	91.9	+ 85.8	41.3	20.2	- 21.1
6	1	2.2	9.3	36.9	+ 27.6	27.9	60.2	+ 32.3	2.8	57.2	+ 54.4	19.0	12.6	- 6.4
6	5	4.2	37.1	89.3	+ 52.2	111.0	145.7	+ 34.7	11.1	138.4	+127.3	75.7	30.4	- 45.3
6	10	5.2	55.3	118.6	+ 63.3	165.3	193.5	+ 28.2	16.5	183.8	+167.3	112.7	40.3	- 72.4
6	25	6.3	78.5	152.9	+ 74.4	234.8	249.3	+ 14.5	23.5	236.9	+213.4	160.1	51.9	-108.2
6	50	7.0	94.4	174.5	+ 80.1	282.2	284.5	+ 2.3	28.2	270.3	+242.1	192.4	59.3	-133.1
6	100	8.1	121.5	209.9	+ 88.4	363.2	342.3	- 20.9	36.3	325.2	+288.9	247.6	71.3	-176.3
24	1	3.2	21.7	61.5	+ 39.8	65.0	100.4	+ 35.4	6.5	95.3	+ 88.8	44.3	20.9	- 23.4
24	5	6.5	84.0	158.5	+ 74.5	251.0	258.5	+ 7.5	25.1	245.6	+220.5	171.2	53.9	-117.3
24	10	8.2	123.9	213.2	+ 89.3	370.4	347.6	- 22.8	37.0	330.3	+293.3	252.6	72.4	-180.2
24	25	10.0	172.3	273.0	+100.7	515.0	445.3	- 69.7	51.5	423.0	+371.5	351.2	92.8	-258.4
24	50	11.0	200.8	307.0	+106.2	600.3	500.7	- 99.6	60.0	475.7	+415.7	409.3	104.3	-305.0
24	100	13.0	260.6	375.9	+115.3	779.2	613.0	-166.2	77.9	582.4	+504.5	531.3	127.7	-403.6

a) From U.S. Weather Bureau Rainfall-Frequency Atlas of the Hawaiian Islands (1962).
b) Based on a nitrogen value of 1.10 mg/l for undeveloped (1984) conditions and 0.60 mg/l for full development.
c) Based on a phosphorus value of 0.11 mg/l for undeveloped (1984) conditions and 0.57 mg/l for full development.
d) Based on a suspended solids value of 1500 mg/l for undeveloped (1984) conditions and 250 mg/l for full development (suspended solids are know refered to as non-filterable solids).

TABLE 2

Estimated Storm Water Runoff and Constituent Changes due to the (1984) Proposed 642 acre West Beach Project, Leeward Oahu, Hawaii

West Drainage Area (Only Within Project Boundaries)

Storm a)			Storm Water Runoff											
Duration	Recurrence Intvl	Quantity	Hydraulic			Nitrogen b)			Phosphorus c)			Suspended Solids d)		
			Development		Δ	Development		Δ	Development		Δ	Development		Δ
			1984	Full		1984	Full		1984	Full		1984	Full	
hr	yr	in.	AF/evnt	AF/evnt	AF/evnt	lb/evnt	lb/evnt	lb/evnt	lb/evnt	lb/evnt	lb/evnt	tons/evnt	tons/evnt	tons/evnt
1	1	1.3	1.5	6.9	+ 5.4	4.4	11.3	+ 6.9	0.4	10.8	+ 10.4	3.0	2.4	- 0.6
1	5	2.0	4.5	12.7	+ 8.2	13.4	20.7	+ 7.3	1.3	19.6	+ 18.3	9.1	4.3	- 4.8
1	10	2.3	6.1	15.3	+ 9.2	18.2	24.9	+ 6.7	1.8	23.6	+ 21.8	12.4	5.2	- 7.2
1	25	2.5	7.2	17.1	+ 9.9	21.6	27.8	+ 6.2	2.2	26.5	+ 24.3	14.7	5.8	- 8.9
1	50	2.8	9.0	19.8	+10.8	26.8	32.4	+ 5.6	2.7	30.7	+ 28.0	18.3	6.7	- 11.6
1	100	3.1	10.9	22.7	+11.8	35.5	37.0	+ 1.5	3.6	35.1	+ 31.5	22.2	7.7	- 14.5
6	1	2.2	5.5	14.4	+ 8.9	16.4	23.4	+ 7.0	1.6	22.2	+ 20.6	11.2	4.9	- 6.3
6	5	4.2	18.6	33.4	+14.8	55.6	54.5	- 1.1	5.6	51.8	+ 46.2	37.9	11.4	- 26.5
6	10	5.2	26.2	43.7	+17.5	78.3	71.8	- 6.5	7.8	67.7	+ 59.9	53.4	14.9	- 38.5
6	25	6.3	35.4	55.4	+20.0	105.8	90.4	-15.4	10.6	85.9	+ 75.3	72.1	18.8	- 53.3
6	50	7.0	41.4	62.9	+21.5	123.8	102.5	-21.3	12.4	97.4	+ 85.0	84.4	21.4	- 63.0
6	100	8.1	51.5	74.9	+23.4	153.8	122.1	-31.7	15.4	116.0	+100.6	104.9	25.4	- 79.5
24	1	3.2	11.6	23.5	+11.9	34.7	38.3	+ 3.6	3.5	36.4	+ 32.9	23.6	8.0	- 15.6
24	5	6.5	37.1	57.4	+20.3	110.9	93.7	-17.2	11.1	89.0	+ 77.9	75.6	19.5	- 56.1
24	10	8.2	52.3	76.0	+23.7	156.5	123.9	-32.6	15.7	117.7	+102.0	106.7	25.8	- 80.9
24	25	10.0	69.6	96.1	+26.5	208.2	156.7	-51.5	20.8	148.9	+128.1	141.9	32.7	-109.2
24	50	11.0	79.6	107.5	+27.9	237.9	175.2	-62.7	23.8	166.5	+142.7	162.2	36.5	-125.7
24	100	13.0	100.0	130.3	+30.3	299.1	212.5	-86.6	29.9	201.9	+172.0	203.9	44.3	-159.6

a) From U.S. Weather Bureau Rainfall-Frequency Atlas of the Hawaiian Islands (1962).
b) Based on a nitrogen value of 1.10 mg/l for undeveloped (1984) conditions and 0.60 mg/l for full development.
c) Based on a phosphorus value of oil mg/l for undeveloped (1984) conditions and 0.57 mg/l for full development.
d) Based on a suspended solids value of 1500 mg/l for undeveloped (1984) conditions and 250 mg/l for full development (suspended solids are now refered to as nonfilterable solids).

APPENDIX TABLE A-1

Estimated Storm Water Runoff and Constituent Loads for Full-Development of the (1984) Proposed 642 acre West Beach Project, Leeward Oahu, Hawaii

East Drainage Area a)b)

Storm c)			Storm Water Runoff Loads											
Dur-ation	Recur-rence	Quan-tity	Hydraulic			Nitrogen d)			Phosphorus e)			Suspended Solids f)		
			Only a) Within Proj.	Only b) Outside Proj.	Total Drain to Ocean	Only a) Within Proj.	Only b) Outside Proj.	Total Drain to Ocean	Only a) Within Proj.	Only b) Outside Proj.	Total Drain to Ocean	Only a) Within Proj.	Only b) Outside Proj.	Total Drain to Ocean
hr	yr	in.	AF/evnt	AF/evnt	AF/evnt	lb/evnt	lb/evnt	lb/evnt	lb/evnt	lb/evnt	lb/evnt	ton/evnt	ton/evnt	ton/evnt
1	1	1.3	17.8	5.4	23.2	29.0	12.1	41.1	27.6	5.2	32.8	6.0	6.0	12.0
1	5	2.0	32.4	33.9	66.3	52.9	93.6	146.5	50.2	17.4	67.6	11.0	59.3	70.3
1	10	2.3	39.3	47.8	87.1	64.1	133.3	197.4	60.9	23.2	84.1	13.4	85.4	98.8
1	25	2.5	44.1	58.4	102.5	72.0	163.7	235.7	68.4	27.5	95.9	15.0	105.4	120.4
1	50	2.8	51.7	75.0	126.7	84.3	211.4	295.7	80.0	34.2	114.2	17.6	136.9	154.5
1	100	3.1	59.3	92.8	152.1	96.8	262.9	359.7	91.9	41.3	133.2	20.2	170.9	191.1
6	1	2.2	36.9	42.9	79.8	60.2	119.2	179.4	57.2	21.2	78.4	12.6	76.1	88.7
6	5	4.2	89.3	166.7	256.0	145.7	476.6	622.3	138.4	69.9	208.3	30.4	312.5	342.9
6	10	5.2	118.6	242.5	361.1	193.5	696.5	890.0	183.8	98.6	282.4	40.3	453.8	499.1
6	25	6.3	152.9	331.5	484.4	249.3	955.5	1204.8	236.9	131.9	368.8	51.9	631.2	683.1
6	50	7.0	174.5	390.8	565.3	284.5	1127.9	1412.4	270.3	154.0	424.3	59.3	746.1	805.4
6	100	8.1	209.9	486.3	696.2	342.3	1406.3	1748.6	325.2	189.3	514.5	71.3	931.7	1003.0
24	1	3.2	61.5	98.9	160.4	100.4	280.4	380.8	95.3	43.7	139.0	20.9	182.5	203.4
24	5	6.5	158.5	347.7	506.2	258.5	1002.6	1261.1	245.6	138.0	383.6	53.9	662.6	716.5
24	10	8.2	213.2	495.1	708.3	347.6	1431.9	1779.5	330.3	192.5	522.8	72.4	948.8	1021.2
24	25	10.0	273.0	657.6	930.6	445.3	1905.5	2350.8	423.0	252.2	675.2	92.8	1264.8	1357.6
24	50	11.0	307.0	749.6	1056.6	500.7	2173.7	2674.5	475.7	286.0	761.7	104.3	1443.9	1548.2
24	100	13.0	375.9	937.4	1313.3	613.0	2721.8	3334.8	582.4	354.5	936.9	127.7	1809.9	1937.6

a) Drainage area within project site (not including 44 acres of lagoons and marina) = 448 acres
b) Drainage area to project site (outside project boundaries) = 1213 acres.
c) From U.S. Weather Bureau Rainfall-Frequency Atlas of the Hawaiian Islands (1962), Tech. Paper No. 43.
d) Based on a nitrogen value of 1.10 mg/l for undeveloped land and 0.60 mg/l for full-project development.
e) Based on a phosphorus value of 0.11 mg/l for undeveloped land and 0.57 mg/l for full-project development.
f) Based on a suspended solids value of 1500 mg/l for undeveloped land and 250 mg/l for full-project development.

APPENDIX TABLE A-2

Estimated Storm Water Runoff and Constituent Loads for Full-Development of the (1984) Proposed 642 Acre West Beach Project, Leeward Oahu, Hawaii

West Drainage Area a)b)

Storm c)			Storm Water Runoff Loads											
Dur-ation	Recur-rence	Quan-ity	Hydraulic			Nitrogen d)			Phosphorus e)			Suspended Solids f)		
			Only a) Within Proj.	Only b) Outside Proj.	Total Drain to Ocean	Only a) Within Proj.	Only b) Outside Proj.	Total Drain to Ocean	Only a) Within Proj.	Only b) Outside Proj.	Total Drain to Ocean	Only a) Within Proj.	Only b) Outside Proj.	Total Drain to Ocean
hr	yr	in.	AF/evnt	AF/evnt	AF/evnt	lb/evnt	lb/evnt	lb/evnt	lb/evnt	lb/evnt	lb/evnt	ton/evnt	ton/evnt	ton/evnt
1	1	1.3	6.9	1.2	8.1	11.3	3.6	14.9	10.8	0.4	11.2	2.4	2.4	4.8
1	5	2.0	12.7	19.0	31.7	20.7	56.9	77.6	19.6	5.7	25.3	4.3	38.8	43.1
1	10	2.3	15.3	27.6	42.9	24.9	82.6	107.5	23.6	8.3	31.9	5.2	56.3	61.5
1	25	2.5	17.1	34.3	51.4	27.8	102.6	130.4	26.5	10.3	36.8	5.8	70.0	75.8
1	50	2.8	19.8	44.8	64.6	32.4	133.9	166.3	30.7	13.4	44.1	6.7	91.3	98.0
1	100	3.1	22.7	56.1	78.8	37.0	167.8	204.8	35.1	16.8	51.9	7.7	114.4	122.1
6	1	2.2	14.4	24.6	39.0	23.4	73.5	96.9	22.2	7.4	29.6	4.9	50.1	55.0
6	5	4.2	33.4	103.4	136.8	54.5	309.2	363.7	51.8	30.9	82.7	11.4	210.8	222.2
6	10	5.2	43.7	152.4	196.1	71.8	455.7	527.5	67.7	45.6	113.3	14.9	310.7	325.6
6	25	6.3	55.4	210.3	265.7	90.4	628.7	719.1	85.9	62.9	148.8	18.8	428.6	447.4
6	50	7.0	62.9	248.9	311.8	102.5	744.1	846.6	97.4	74.4	171.8	21.4	507.3	528.7
6	100	8.1	74.9	311.2	386.1	122.1	930.4	1052.5	116.0	93.0	209.0	25.4	634.4	659.8
24	1	3.2	23.5	59.9	83.4	38.3	179.2	217.5	36.4	17.9	54.3	8.0	122.2	130.2
24	5	6.5	57.4	220.8	278.2	93.7	660.0	753.7	89.0	66.0	155.0	19.5	450.0	469.5
24	10	8.2	76.0	317.0	393.0	123.9	947.6	1071.5	117.7	94.8	212.5	25.8	646.1	671.9
24	25	10.0	96.1	423.2	519.3	156.7	1265.2	1421.9	148.9	126.5	275.4	32.7	862.6	895.3
24	50	11.0	107.5	483.3	590.8	175.2	1455.1	1630.3	166.5	145.5	312.0	36.5	985.3	1021.8
24	100	13.0	130.3	606.4	736.7	212.5	813.1	2025.6	201.9	181.3	383.2	44.3	1236.2	1280.5

a) Drainage area within project site (not including 5-acre lagoon) = 145 acres.
b) Drainage area to project site (outside project boundaries) = 798 acres.
c) From U.S. Weather Bureau Rainfall-Frequency Atlas of the Hawaiian Islands (1962), Tech. Paper No. 43.
d) Based on a nitrogen value of 1.10 mg/l for undeveloped land and 0.60 mg/l for full-project development.
e) Based on a phosphorus value of 0.11 mg/l for undeveloped land and 0.57 mg/l for full-project development.
f) Based on a suspended solids value of 1500 mg/l for undeveloped land and 250 mg/l for full-project development.