TRAFFIC IMPACT ANALYSIS REPORT

KAONOULU INDUSTRIAL PARK

Kihei, Maui, Hawaii

Prepared for:

Kaonoulu Ranch

Prepared by:

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Kaonoulu Ranch has proposed an 88-acre industrial park in Kihei, east of Piilani Highway across from the Kaonoulu Estates project (Figure 1). This report summarizes a traffic impact analysis conducted to determine the potential impact of the industrial park and the appropriate roadway improvements to provide adequate traffic capacity to serve the park.

The proposed project would construct infrastructure and subdivide the land for industrial use. While details of the project have not yet been finalized, vehicular access is proposed from Piilani Highway across from the Kaonoulu Estates project, changing the existing T-intersection of Piilani Highway and Kaonoulu Street to an X-intersection. The access road would bisect the site, and provisions would be made for the extension of this access road farther east should this corridor be selected for a roadway between Kihei and Kula. Two secondary roadways providing access to the individual lots would intersect the Kaonoulu Street extension.

Because the project is expected to provide industrial space in support of resort, residential, and other development in the South Maui area, regional traffic impacts would be positive in that travel into and out of the South Maui area would be lessened. Since occupancy of the proposed project would occur over a period of several years, the traffic impact would not be immediate, but would increase over a number of years. For the purposes of the traffic analysis, full occupancy of the project is assumed by the year 2010, and an interim condition for year 2000 was evaluated for peak hour traffic volumes equal to one-third of that expected at full occupancy.

For an industrial park, the greatest traffic impact would occur during weekday peak commuting periods. Since specific uses within the park have not yet been determined, per-acre trip rates from the informational report *Trip Generation*[1] were used to estimate the traffic generated by the project.

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1 - Institute of Transportation Engineers, *Trip Generation, 5th Edition,* 1991.

In the morning peak hour, when traffic entering the project is the greatest, the expected high volume of left turns off the southbound Piilani Highway would be made against the heavier northbound traffic on the highway; in the afternoon peak period, left turns out of the site would be made across and into the peak highway traffic. Conditions during these weekday peak hours were analyzed to determine the most critical conditions expected at the intersection of Piilani Highway and Kaonoulu Street; conditions at other times of the day, or on weekends, would be better.

Two future years and three highway conditions were evaluated. Full development and use of the proposed project by year 2010 was assumed and considered along with interim conditions in year 2000 with the proposed project generating one-third of the fully developed traffic. Future traffic conditions with the existing highway network and with two alternatives for a proposed Kula-Kihei Road, one with its west terminus at Kaonoulu Street and the other terminating south of Kaonoulu Street, were identified.

Analyses were done using methods described in the *Highway Capacity Manual*[2] from the Transportation Research Board. At unsignalized intersections, a Level of Service (LOS) was identified for each controlled movement, by comparing the traffic demand with the capacity available for the movement. Conditions at signalized intersections were evaluated using the Planning Analysis and are described as "under" capacity, "near" capacity, or "over" capacity. Levels of service are described in an attached appendix.

Existing Conditions

The proposed project would have access from Piilani Highway, via an access road built as the fourth leg of the existing T-intersection with Kaonoulu Street. Piilani Highway is a major arterial, two lanes wide, serving through traffic at a posted speed limit of 45 miles per hour. The typical section of the highway includes 12-foot lanes and 10-foot wide paved shoulders, which also serve as bikelanes. At major intersections, right turn deceleration and left turn deceleration/storage lanes are provided.

2 Transportation Research Board Special Report 209, *Highway Capacity Manual*, 1985.

Three intersections along Piilani Highway, at Mokulele Highway, Uwapo Road, and Ohukai Street, are presently signalized. Other side streets, including Kaonoulu Street, are stop-controlled at their intersections with Piilani Highway. Kaonoulu Street and Kulanihakoi Street to the south were both recently connected to Piilani Highway; while constructed as part of residential projects, neither street presently carries significant traffic volumes because residential units have not yet been constructed.

Field observations taken on the afternoon of Tuesday, January 25, 1994 in the area indicate that very long delays occur for drivers making left turns from the stop-controlled side streets onto Piilani Highway during the afternoon peak hour, from about 4:00 to 5:00 PM. Volumes of 274 vehicles southbound and 279 vehicles northbound were counted south of Ohukai Street between 4:15 and 4:30 PM.

A weekday count taken in June 1993 by the State Highways Division[3] shows a two-direction traffic volume of 22,000 vehicles in a 24-hour period on Piilani Highway north of Lipoa Street, located approximately 1½ miles south of Kaonoulu Street. The State Highways Division[4] has estimated that the Average Daily Traffic (ADT) on Piilani Highway in the vicinity of the project was 20,639 vehicles per day (vpd) in 1991. Table 1 shows the recent traffic counts on Piilani Highway near the project site.

Table 1
EXISTING TRAFFIC
Piilani Highway, North of Lipoa Street

	Southbound	Northbound
24-hour count		
June 1993	11,677	10,397
May 1991	10,574	10,025
AM Peak Hour		
June 1993	848	830
May 1991	968	702
PM Peak Hour		
June 1993	703	1,083
May 1991	1,005	793

3 - State Highways Division, *Traffic Survey Data (Individual Stations) - Island Of Maui, 1993*. Station 13-E.

4 - State Highways Division, *Traffic Summary - Island of Maui 1991*.

Future Conditions Without The Proposed Project

The State Department of Transportation and the County of Maui Departments of Public Works and Planning in 1988 initiated a long-range highway planning study, which included projections of traffic demands for years 2000 and 2010. The final report[5] for this study shows future traffic demand at a screenline across Waiakoa Gulch (between Uwapo Road and Ohukai Street); roadways carrying traffic across this screenline include Piilani Highway, Kihei Road, and other parallel roadways which may be constructed. These projections, based on the existing roadway network (no Kula-Kihei Road), were used to estimate future traffic on Piilani Highway.

Improvements to both Piilani Highway and Kihei Road were assumed in the long-range study; each would become four lanes wide. If one-third of the projected volume is carried on Kihei Road, Piilani Highway traffic would increase from the volume counted in 1993 by average rates of between 3 and 5 percent per year (with annual compounding). Table 2 shows the growth expected in Piilani Highway traffic.

Table 2
FUTURE TRAFFIC
Piilani Highway, Waiakoa Screenline

	Southbound	Northbound
Year 2000		
Projected volume *	21,991	21,992
On Kihei Road	7,330	7,331
On Piilani Highway	14,661	14,661
Increase over 1993:	25.6%	41.0%
Average/year:	3.30%	5.03%
Year 2010		
Projected volume *	34,960	34,955
On Kihei Road	11,653	11,652
On Piilani Highway	23,307	23,303
Increase over 1993:	99.6%	124.1%
Average/year:	4.15%	4.86%

* Source: *Maui Long-Range Highway Planning Study, Island-wide Plan, Final Report*

5 - State of Hawaii (Department of Transportation) and County of Maui (Department of Public Works, Department of Planning), *Maui Long-Range Highway Planning Study Island-Wide Plan.* (prepared by Austin, Tsutsumi & Associates, Inc., May 1991.)

The Kaonoulu Estates residential project (formerly known as Kaonoulu Village) is also expected to affect traffic at the intersection of Piilani Highway and Kaonoulu Street. The traffic due to occupancy of Kaonoulu Estates is taken from the project's traffic study[6] and full occupancy is assumed by year 2000.

Another project which will affect traffic volumes in the area is the new roadway between Kula and Kihei. Traffic projections for year 2000 made as part of a feasibility study for a Kula-Kihei Road[7] were used to account for additional traffic in the area if a direct Kula-Kihei roadway connection is made. In that study, three alternatives were considered. In Alternative A, the project roadway would be part of the Kula-Kihei Road. With Alternatives B and C, the western end of the Kula-Kihei Road would connect to Piilani Highway south of Kaonoulu, but increased traffic on Piilani Highway is expected.

Future (years 2000 and 2010) traffic estimates were made for the AM and PM peak hours, for three highway scenarios: the existing network, the Kula-Kihei Road terminating across of Kaonoulu Street, and a Kula-Kihei Road terminating south of Kaonoulu. These estimates are the basis of the traffic impact analysis and are shown in Figures 2 and 3.

Proposed Project

The proposed project is an industrial park intended to satisfy the needs of South Maui and the expected growth of the area. The 88-acre site presently does not generate any traffic and does not affect flows on Piilani Highway. Equations for best-fit lines provided in *Trip Generation* were used to estimate the traffic generated by development of the site as an industrial park. Table 3 shows the trip generation estimates.

Table 3
TRIP GENERATION

	Entering	Exiting
Average Weekday	2,410	2,410
AM Peak Hour	610	134
PM Peak Hour	152	574

6 - Parsons Brinckerhoff Quade & Douglas, Inc., *Traffic Impact Study, Kaonoulu Village*. August 1988 (Pre-Final report).

7 - Parsons Brinckerhoff Quade & Douglas, Inc., *Kula-Kihei Road Study, Travel Demand Forecast and Benefit Cost Analysis*, October 4, 1989.

The project traffic was distributed using the traffic projections (without project) at the intersection of Piilani Highway and Kaonoulu Street. For each case, the proportion of non-project traffic entering the intersection from each direction to the total entering the intersection was applied to the project attractions (traffic entering the project). Distribution of traffic exiting the project was done in the same manner using non-project traffic departing the intersection.

Since the project is expected to meet the needs of South Maui, traffic attracted to the site from the south or the west would be from traffic which would otherwise have to travel north to other parts of the island. In preparing traffic assignments for future conditions with the project, non-project traffic to or from the north were therefore decreased by the same amount of any project-related movements so that approach and departure volumes on the south and west legs of the intersection are maintained.

Turning movements at the two intersections of the Kaonoulu Street extension with the industrial park access roads were estimated from the trip generation and distribution calculations, assuming that all movements are allowed at each intersection. Figures 4, 5, and 6 show traffic assignments for year 2000, for the cases with the existing highway network, the Kula-Kihei Road terminating at Kaonoulu, and for a Kula-Kihei Road terminating south of Kaonoulu. Figures 7, 8, and 9 show similar traffic assignments for year 2010.

Traffic Analyses - Piilani Highway

Service volumes, the maximum volume a highway can accommodate at a given level of service, for the existing two-lane Piilani Highway were calculated using the procedure from the *Highway Capacity Manual*. In the AM Peak Hour, the maximum two-way volume is 1,490 vehicles per hour (vph) for LOS D and capacity (LOS E) is 2,610 vph. Because of different traffic characteristics, PM Peak Hour service volumes are slightly lower: 1,460 vph for LOS D and 2,550 vph for LOS E. Peak hour conditions on Piilani Highway south of the site would be LOS E in 2000 and LOS F in 2010. North of the site, year 2000 AM Peak Hour condition would be LOS E, and volumes in the PM Peak Hour in year 2000 and both peak hours in 2010 exceed the capacities of the two-lane highway (LOS F).

Table 4 summarizes the level of service findings for the existing highway; ratios of the volume to capacity (the service volume for LOS E) are also shown.

Table 4
HIGHWAY LEVELS OF SERVICE
Two-Lane Piilani Highway

LOS, v/c ratio:

NORTH OF KAONOULU STREET

	without project		with the project	
Existing Highway Network				
2000 AM	E	0.96	E	0.95
2000 PM	F	1.06	F	1.05
2010 AM	F	1.47	F	1.45
2010 PM	F	1.61	F	1.58
Kula-Kihei Road at or south of Kaonoulu				
2000 AM	E	0.93	E	0.91
2000 PM	F	1.06	F	1.05
2010 AM	F	1.41	F	1.38
2010 PM	F	1.62	F	1.60

SOUTH OF KAONOULU STREET

Kula-Kihei Road:	none, or @ Kaonoulu		south of Kaonoulu	
2000 AM	E	0.88	E	0.84
2000 PM	E	0.97	E	0.98
2010 AM	F	1.38	F	1.33
2010 PM	F	1.52	F	1.53

As indicated in Table 4, the project impact north of Kaonoulu Street would be to decrease traffic demand, as trips which may otherwise travel to other parts of Maui are contained within Kihei. The analysis also shows that the widening of Piilani Highway to four lanes, as described in the long-range plan, will be needed before year 2000.

Service volumes for a four-lane Piilani Highway were calculated using the *Highway Capacity Manual* procedure for multi-lane highways. As was the case with the two-lane highway, service volumes are higher of the morning peak hour than for the afternoon peak hour due to traffic characteristics. Calculated service volumes are:

	AM Peak Hour	PM Peak Hour
LOS B	1,570	1,350
LOS C	2,120	1,820
LOS D	2,670	2,290
LOS E (capacity)	3,500	3,010

Acceptable levels of service (LOS D or better) were found for the year 2010 peak hour traffic (year 2000 conditions were LOS C or better). Levels of service and the ratios of volume to service vo[1]· LOS D are shown in Table 5.

Table 5

HIGHWAY LEVELS OF SERVICE

Four-Lane Piilani Highway

LOS, v/svD ratio:

NORTH OF KAONOULU STREET

	without project		with the project	
direction:	south	north	south	north
Existing Highway Network				
2000 AM	B 0.42	B 0.52	B 0.45	B 0.48
2000 PM	C 0.64	B 0.54	B 0.56	B 0.57
2010 AM	C 0.66	C 0.77	C 0.74	C 0.68
2010 PM	D 0.96	D 0.83	D 0.83	D 0.93
Kula-Kihei Road at or south of Kaonoulu				
2000 AM	B 0.36	B 0.55	B 0.38	B 0.51
2000 PM	C 0.63	B 0.56	B 0.59	B 0.59
2010 AM	B 0.55	D 0.83	C 0.62	C 0.72
2010 PM	D 0.95	D 0.85	D 0.82	D 0.96

SOUTH OF KAONOULU STREET

Kula-Kihei Road:	none, or @ Kaonoulu		south of Kaonoulu	
direction:	south	north	south	north
2000 AM	B 0.41	B 0.45	B 0.34	B 0.48
2000 PM	B 0.57	B 0.51	B 0.56	B 0.53
2010 AM	C 0.65	C 0.70	B 0.54	C 0.76
2010 PM	D 0.89	D 0.80	D 0.88	D 0.83

Traffic conditions at the intersection of Piilani Highway and Kaonoulu Street were also considered. As reported in the traffic study for Kaonoulu Estates, traffic signals would be needed and warranted with occupancy of a portion of the residential project.

The signalized intersection would operate at "under" capacity conditions during both peak hours without the industrial park traffic in year 2000 (Piilani Highway assumed to be four lanes, with separate lanes for left turns). With the industrial park traffic and appropriate roadway improvements to allow all movements from separate lanes, year 2000 peak hour conditions would remain "under" capacity. Table 6 summarizes the results of the intersection analyses.

Table 6

INTERSECTION CONDITIONS (2000)

Piilani Highway and Kaonoulu Street

	without project	with the project
Existing Highway Network		
AM Peak Hour	791 under	816 under
PM Peak Hour	802 under	764 under
Kula-Kihei Road at Kaonoulu		
AM Peak Hour	844 under	893 under
PM Peak Hour	764 under	832 under
Kula-Kihei Road south of Kaonoulu		
AM Peak Hour	836 under	844 under
PM Peak Hour	792 under	755 under

Future year 2010 conditions would be "under" capacity conditions at the Piilani Highway and Kaonoulu Street intersection without the industrial park if there is no Kula-Kihei Road. The project traffic would cause "near" capacity conditions. Changing the phasing by splitting the Kaonoulu Street approaches and allowing left turns to Piilani Highway from the middle lane, which becomes an optional lane, improves conditions to "under" capacity in the AM Peak Hour; the critical movement sum in the PM Peak Hour is just into the "near" capacity range. A second southbound left turn lane from Piilani Highway into the site, along with the split phasing and option lane on the Kaonoulu Street approaches, would provide "under" capacity conditions in both peak hours.

Without the proposed industrial park, the additional traffic due to the Kula-Kihei Road cause conditions in the AM Peak Hour to be "near" capacity. For the Kula-Kihei Road located with its western terminus at Kaonoulu, a second westbound left turn lane (makaibound to Makena-bound) would improve the intersection to operate at "under" capacity conditions in both peak hours. The changes in traffic volumes due to the project will result in "over" capacity conditions without the mitigation noted above; with the second westbound left turn lane, conditions would be "near" capacity in both peak hours. A second southbound left turn lane from Piilani Highway into the site, along with the two westbound left turn lanes, would provide "under" capacity conditions in both peak hours.

For a Kula-Kihei Road located to the south, split phasing of the Kaonoulu Street approaches and allowing left turns to Piilani Highway from the middle lane improves without-project conditions to "under" capacity in both peak hours. Conditions become "near" capacity with the project. The addition of a second southbound left turn lane on Piilani Highway would provide "under" capacity conditions in both peak hours.

In each case, the addition of a second lane for southbound left turn into the project site would maintain "under" capacity conditions. Even without the second turn lane, however, the sum of critical movements would be in the lower portion of the "near" capacity range. Table 7 summarizes the results of the intersection analyses, showing the sum of critical movements and capacity condition.

Table 7

INTERSECTION CONDITIONS (2010)

Piilani Highway and Kaonoulu Street

	without project	with the project
Existing Highway Network		
AM Peak Hour	1,136 under	1,229 near
PM Peak Hour	1,174 under	1,310 near
AM * (a)	-- --	1,193 under
PM * (a)	-- --	1,205 near
AM * (a)(c)	-- --	1,055 under
PM * (a)(c)	-- --	1,154 under
Kula-Kihei Road at Kaonoulu		
AM Peak Hour	1,343 near	1,468 over
PM Peak Hour	1,154 under	1,500 over
AM * (b)	1,193 under	1,273 near
PM * (b)	1,114 under	1,260 near
AM * (a)(c)	-- --	1,202 near
PM * (a)(c)	-- --	1,236 near
AM * (b)(c)	-- --	1,125 under
PM * (b)(c)	-- --	1,160 under
Kula-Kihei Road south of Kaonoulu		
AM Peak Hour	1,208 near	1,247 near
PM Peak Hour	1,158 under	1,331 near
AM * (a)	1,105 under	1,208 near
PM * (a)	1,102 under	1,230 near
AM * (a)(c)	-- --	1,088 under
PM * (a)(c)	-- --	1,180 under

* with mitigation measures:

(a) Split phasing for Kaonoulu Street approaches
(b) double westbound left turn lanes
(c) double southbound left turn lanes

Traffic Analyses - Kaonoulu Street Extension

The proposed site plan shows access to the site provided from secondary streets which intersect the east-west extension of Kaonoulu Street at two cross intersections. Each of these intersections was analyzed as an unsignalized intersection, with stop sign control of the northbound and southbound approaches; each approach was considered to consist of a single lane shared by left turns and through traffic, with an additional lane for right turns. Separate lanes were assumed for left turns from the Kaonoulu Street Extension.

Good conditions (Level of Service A, except LOS C in one instance in 2010) were found for the left turns off of the Kaonoulu Street Extension and for right turns from the stop-controlled cross streets. Level of Service B or better conditions were found for the shared lane at the stop sign for year 2000 peak hour traffic volumes. With year 2010 volumes and Kula-Kihei traffic on the Kaonoulu Street Extension, however, poor conditions (LOS F) would occur in the shared lane for northbound traffic due to high left turn volumes in the PM Peak Hour, as demand

exceeds the calculated capacity. Level of service findings from the analyses are shown in Table 8.

Table 8
INTERSECTION CONDITIONS
Kaonoulu Street unsignalized intersections

	2000		2010	
	AM	PM	AM	PM
Without Kula-Kihei traffic:				
Makai intersection				
left/through, north side	A	A	B	A
left/through, south side	A	A	C	E
all other movements	A	A	A	A
Mauka intersection				
left/through, south side	A	A	A	C
all other movements	A	A	A	A
With Kula-Kihei traffic:				
Makai intersection				
right turns, north side	A	A	A	C
left/through, north side	B	A	D	D
left/through, south side	B	B	E	F
all other movements	A	A	A	A
Mauka intersection				
maukabound left turns	A	A	B	A
left/through, north side	B	A	D	B
left/through, south side	B	B	E	F
all other movements	A	A	A	A

The projected volumes, however, would not satisfy the peak hour warrants[8] for signals at either intersection. However, in the case with Kula-Kihei traffic, drivers wishing to make left turns or through movements from the south will probably concentrate at a signalized intersection, and volumes would exceed the minimum volumes of the warrant. If all turns were served at only one signalized cross intersection, it would operate at "under" capacity condition in both peak hours.

Conclusions and Recommendations

The proposed project would change the existing T-intersection to a cross intersection and alter traffic demand in the vicinity of Kaonoulu Street. The proposed project's impact would be the worsening of intersection conditions unless additional mitigation measures are implemented; however, impacts to regional traffic are minimal and in some cases are positive (reduction in volume).

8 - U.S. Department of Transportation, Federal Highway Administration, *Manual on Uniform Traffic Control Devices for Streets and Highways*, 1989, as amended.

Without the proposed project, the growth of traffic on Piilani Highway indicates the highway would need widening to four lanes before the year 2000. The Piilani Highway and Kaonoulu Street intersection, which would need signalization even without the proposed industrial park, would have adequate capacity with or without the proposed project in year 2000.

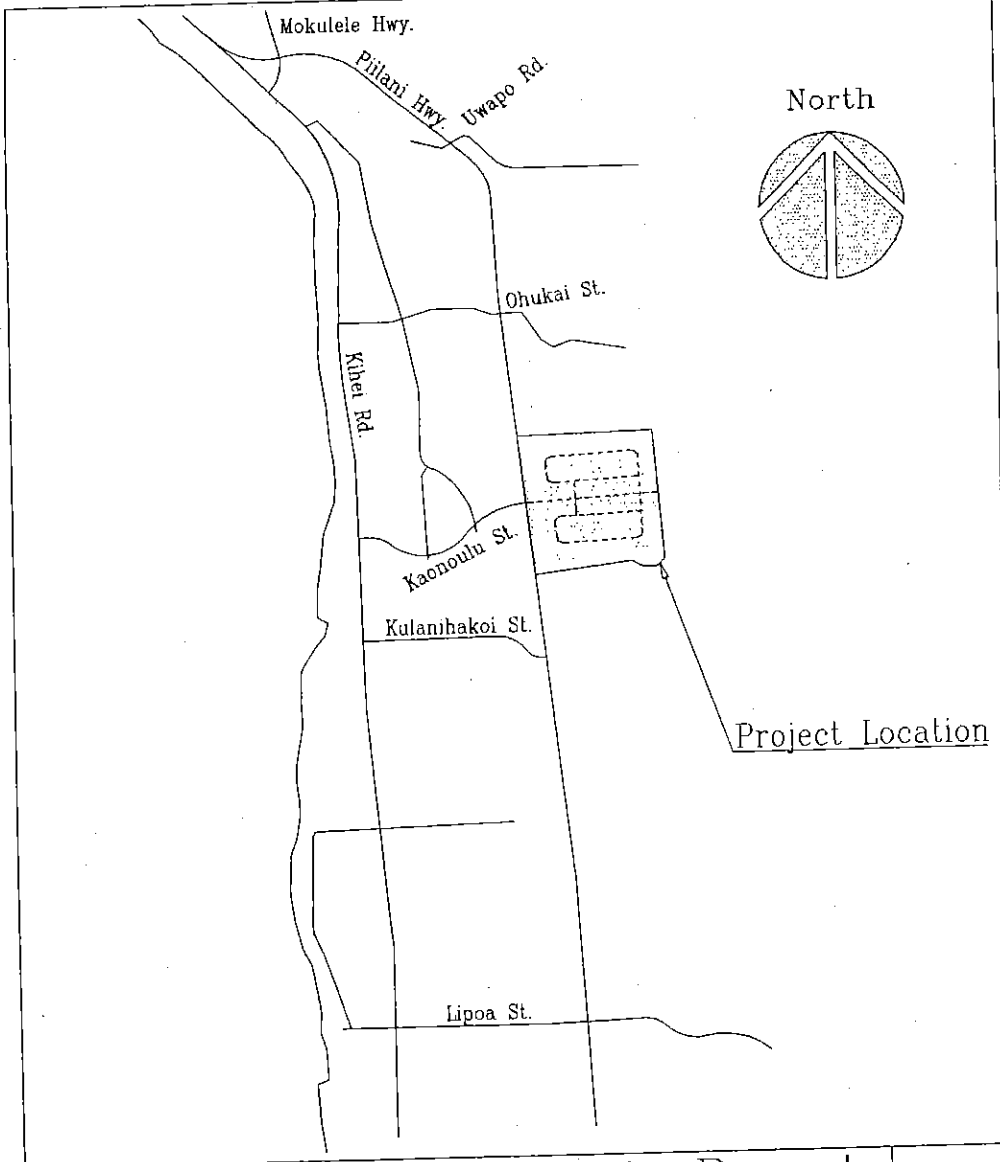
For the projected traffic in year 2010, the Piilani Highway and Kaonoulu Street intersection would have adequate capacity if no Kula-Kihei Road is built. The addition of the proposed project in this case would cause "near" capacity conditions and improvements may be needed.

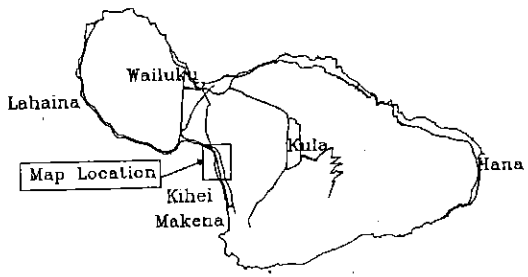
If the Kula-Kihei Road is built on a corridor terminating at Kaonoulu Street, two westbound left turn lanes would be needed to achieve "under" capacity conditions without the project; the project would increase turning movements to "near" capacity conditions. Provision of a second southbound left turn lane from Piilani Highway would improve with-project conditions to "under" capacity.

For a Kula-Kihei Road built south of Kaonoulu, split phasing for Kaonoulu Street would provide "under" capacity conditions without the project. With the project, peak hour conditions would be "near" capacity; provision of a second southbound left turn lane from Piilani Highway would improve with-project conditions to "under" capacity.

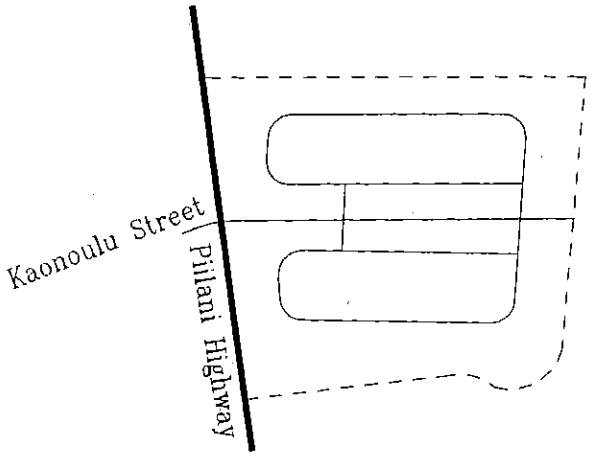
The following recommendations are based on the findings discussed herein:

- The design of the Kaonoulu Street intersection should allow for future conversion of the through lane to an option (left/through) lane, should split phasing be found to be more efficient.
- The widening of Piilani Highway should provide sufficient median width to accommodate a second southbound left turn lane in the future.
- The recommended laneage on the Kaonoulu Street Extension is shown in Figure 10.





Island of Maui



Proposed Site Plan

Source: Warren S. Unemori Engineering Co., Inc.

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Kaonoulu Industrial Park

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prepared by: Julian Ng, Incorporated

Not to Scale
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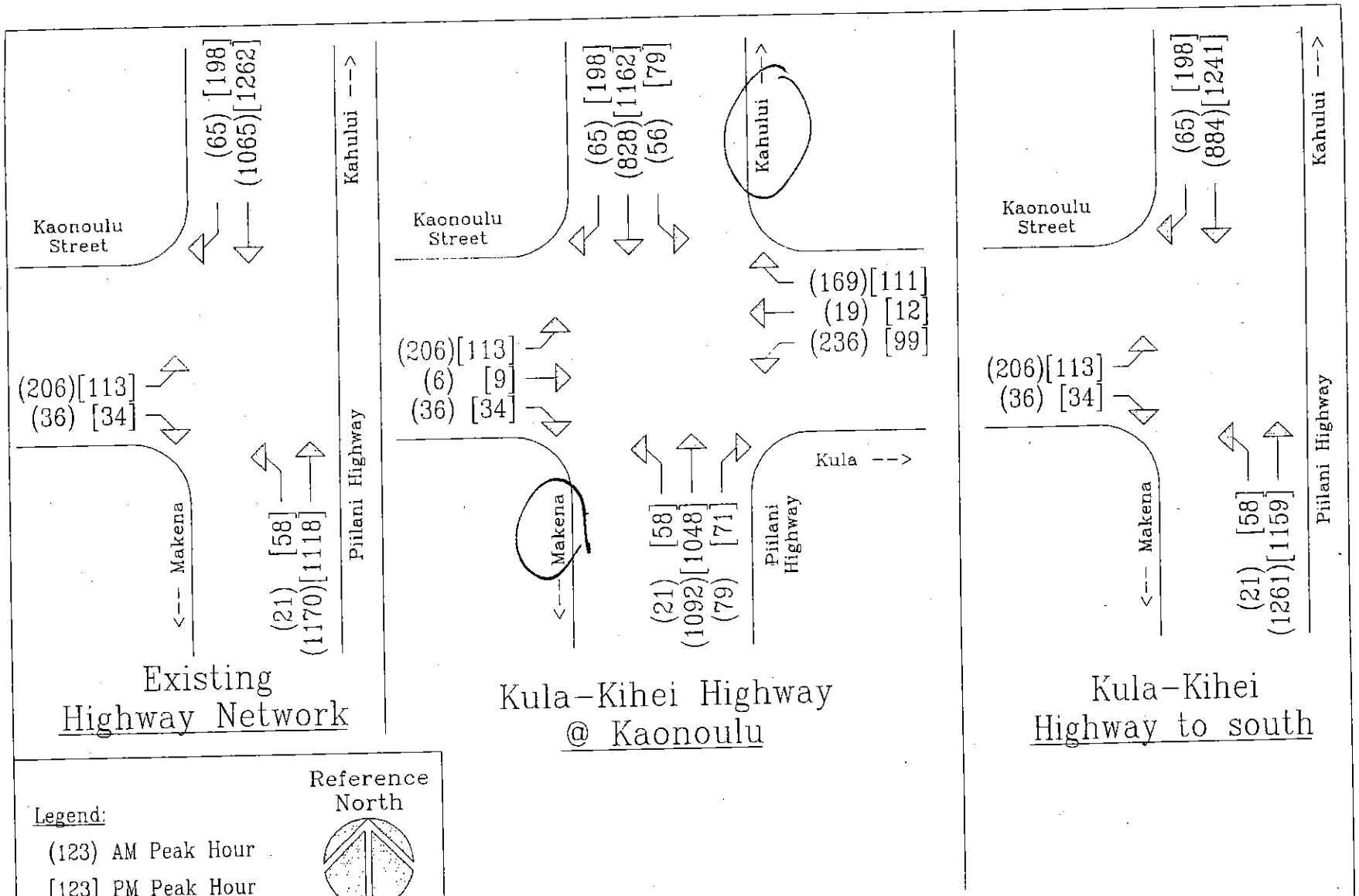
PROJECT LOCATION AND SITE PLAN

Figure 1



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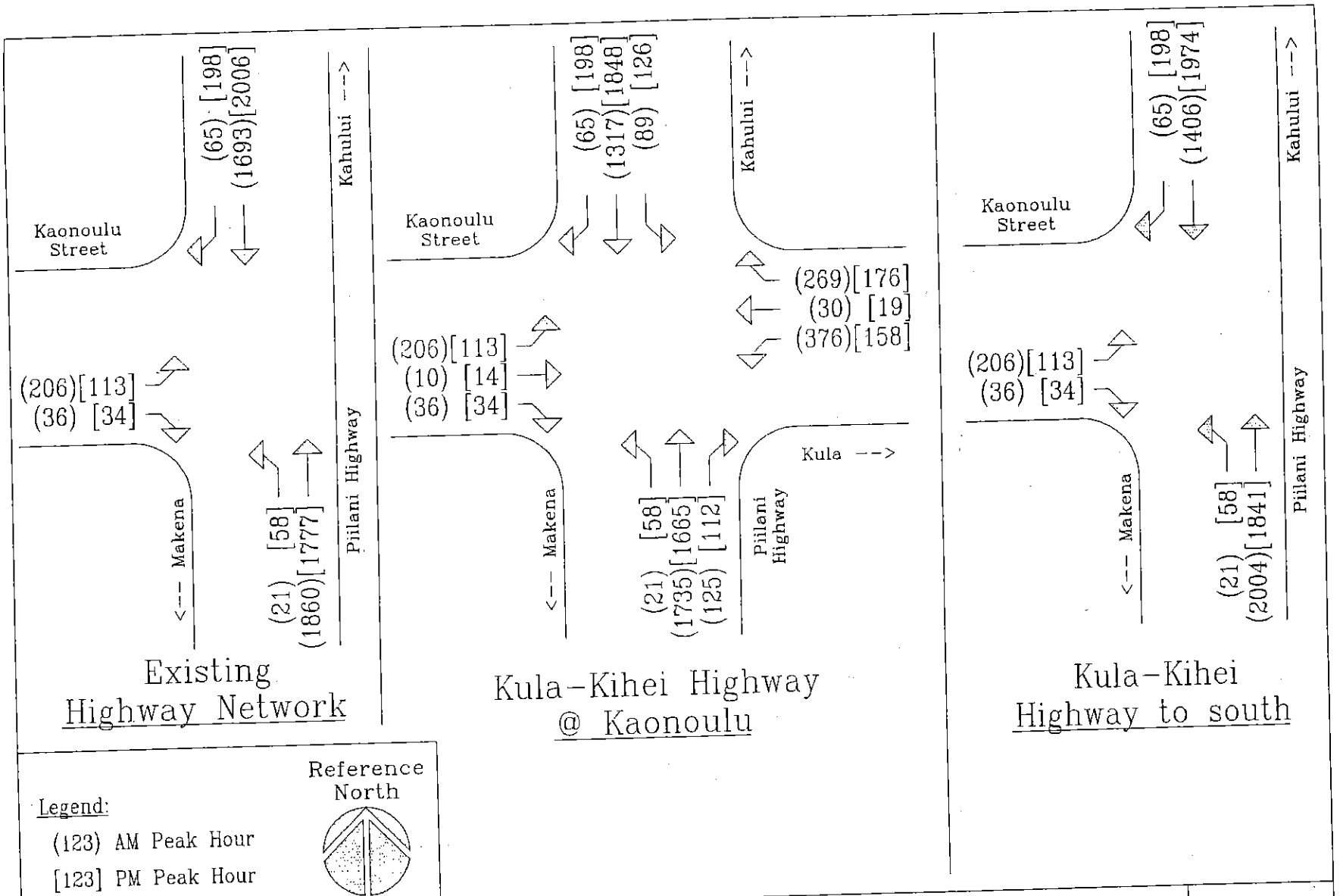
TRAFFIC ASSIGNMENTS 2000 WITHOUT PROJECT

Figure 2



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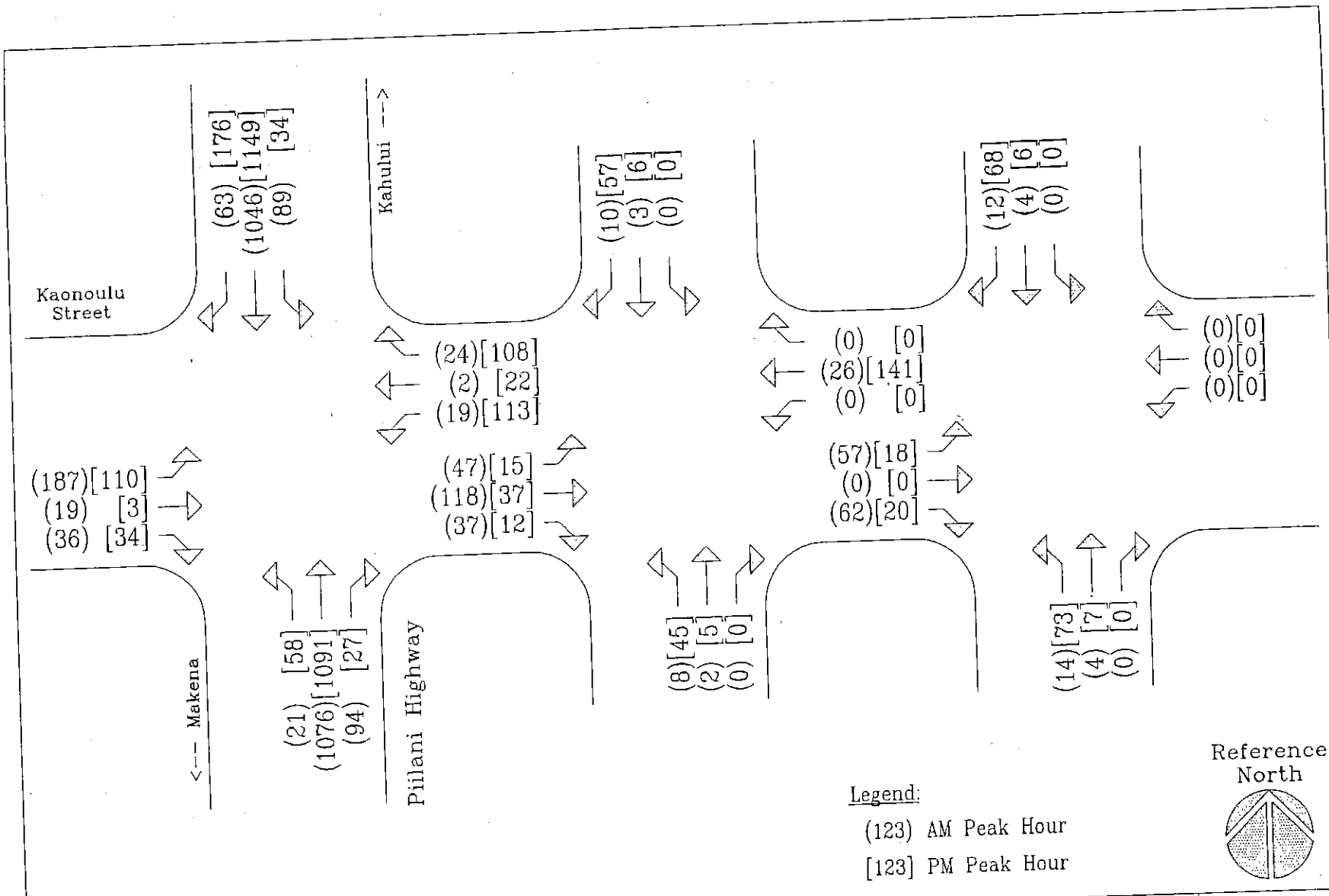
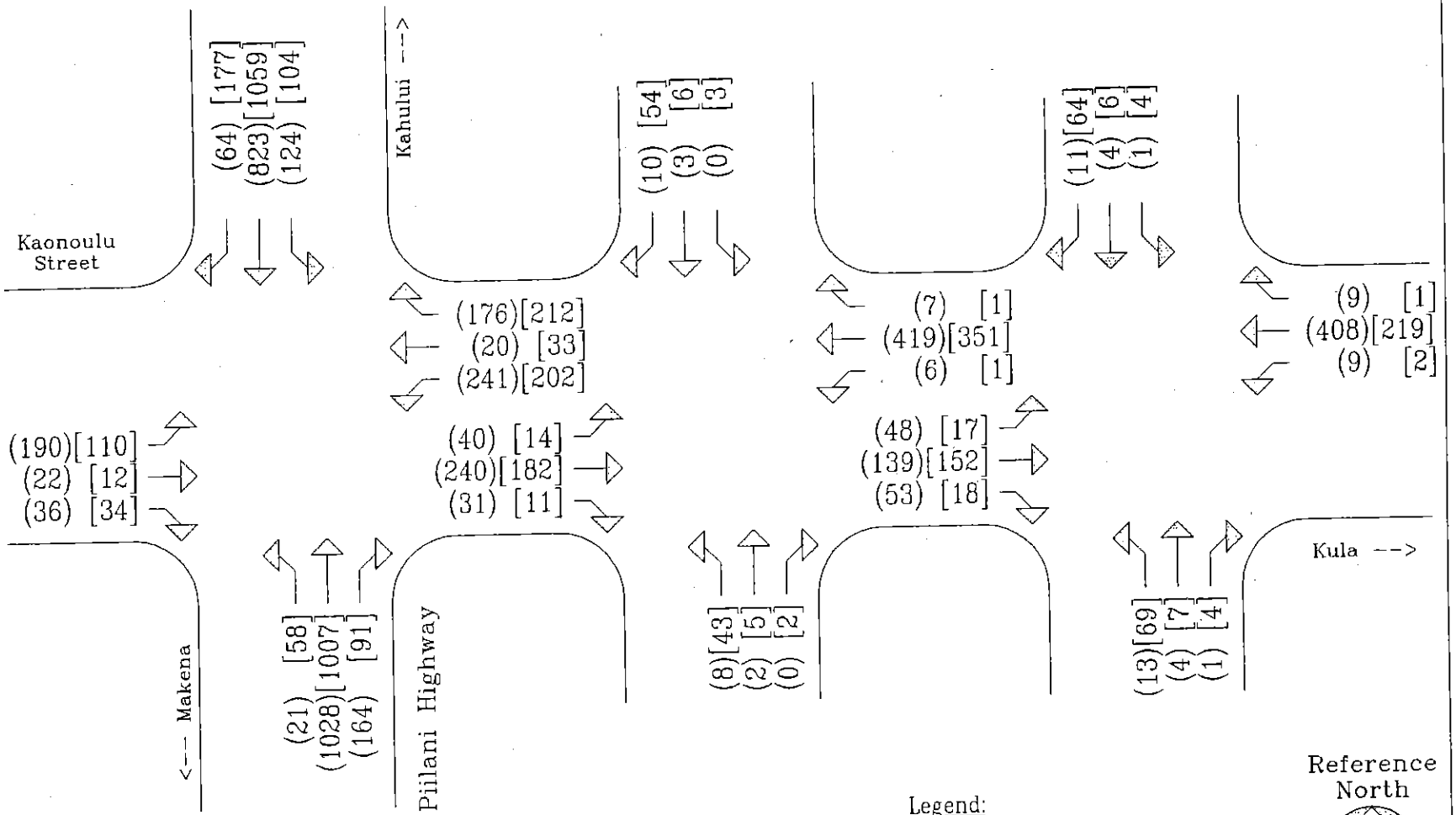
TRAFFIC ASSIGNMENTS 2010 WITHOUT PROJECT

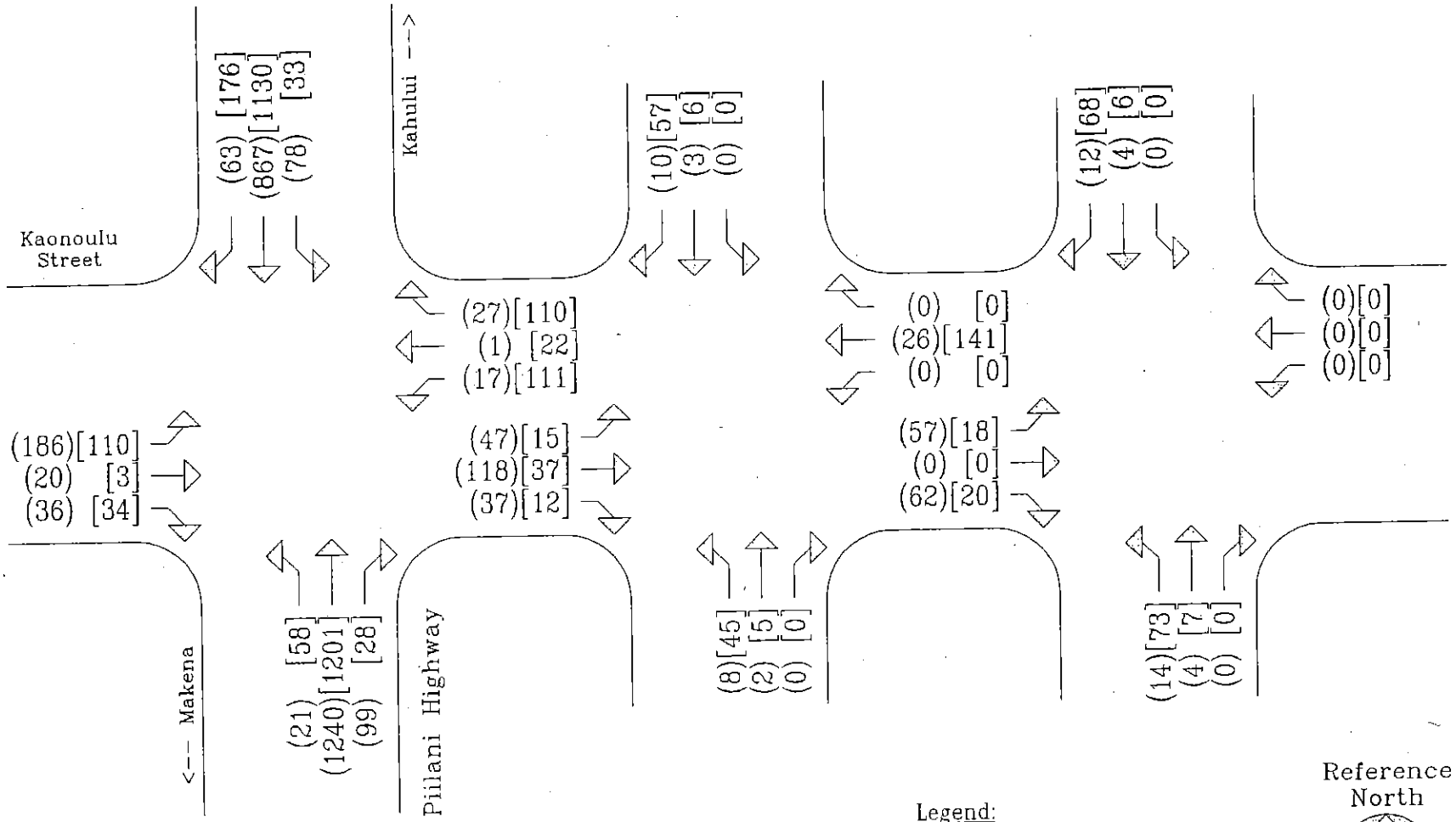
Figure 3



Traffic Impact Analysis Report Kaonoulu Industrial Park	TRAFFIC ASSIGNMENT 2000 WITH PROJECT (Existing Highway Network)	Figure 4
prepared for: Kaonoulu Ranch prepared by: Julian Ng, Incorporated	Not to Scale March 1994	



Traffic Impact Analysis Report Kaonoulu Industrial Park	TRAFFIC ASSIGNMENT 2000 WITH PROJECT (Kula-Kihei Road @ Kaonoulu)	Figure 5
prepared for: Kaonoulu Ranch prepared by: Julian Ng, Incorporated Not to Scale March 1994		



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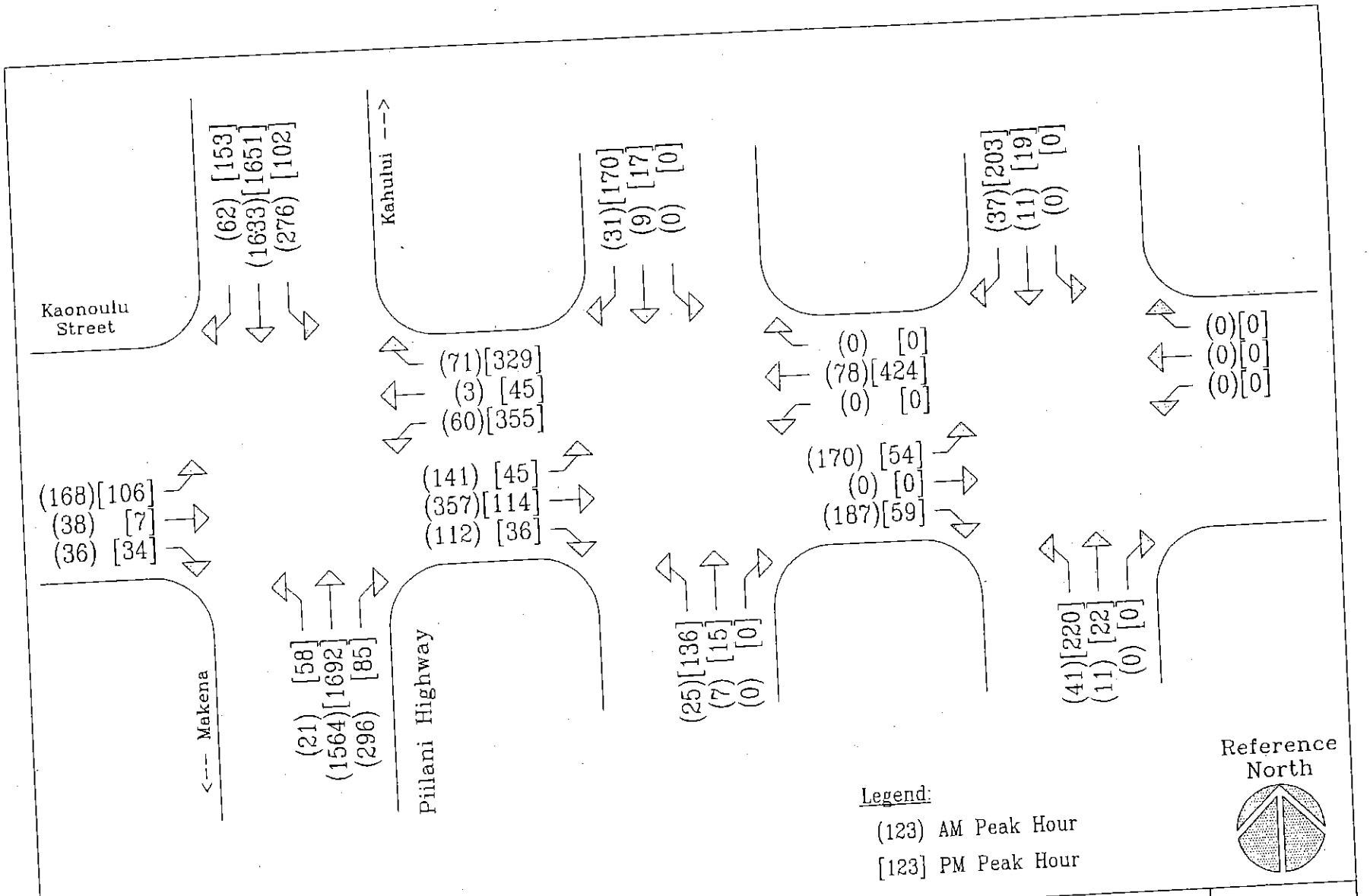
TRAFFIC ASSIGNMENT
2000 WITH PROJECT
(Kula-Kihei Road to south)

Figure
6



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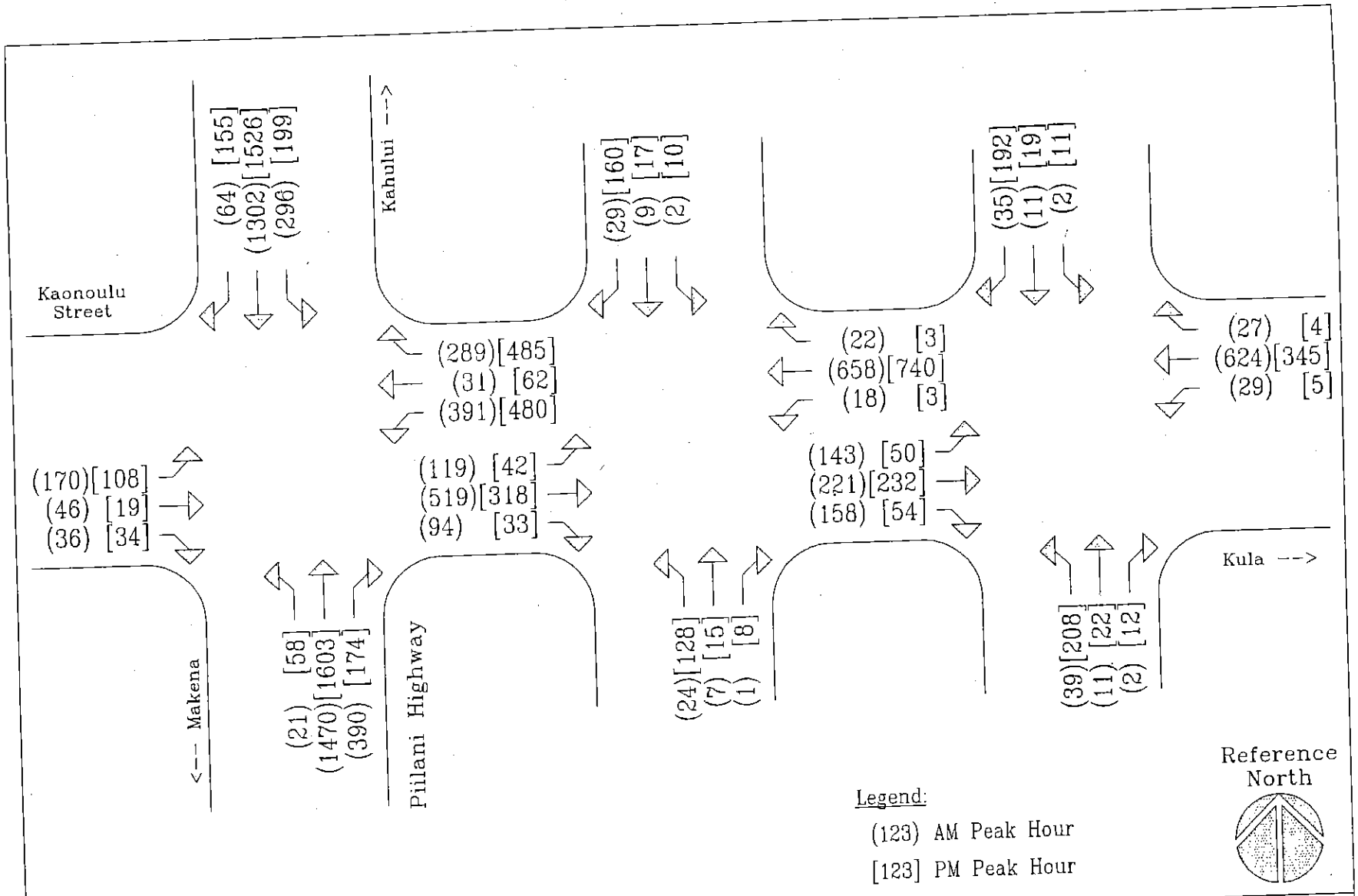
TRAFFIC ASSIGNMENT
2010 WITH PROJECT
(Existing Highway Network)

Figure 7



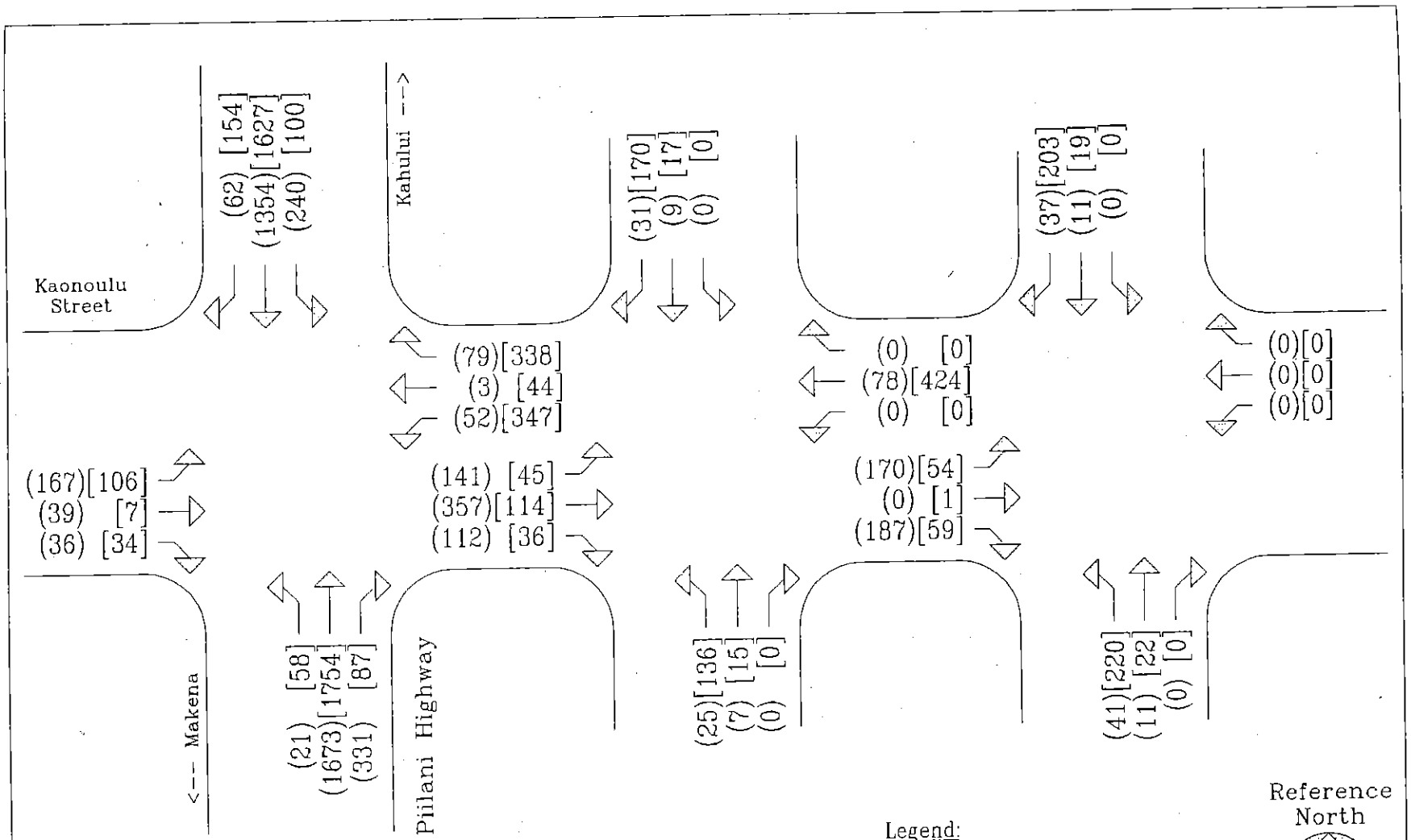
Traffic Impact Analysis Report
Kaonoulu Industrial Park

prepared for: Kaonoulu Ranch
prepared by: Julian Ng, Incorporated

Not to Scale
March 1994

TRAFFIC ASSIGNMENT
2010 WITH PROJECT
(Kula-Kihei Road @ Kaonoulu)

Figure
8



Traffic Impact Analysis Report Kaonoulu Industrial Park	TRAFFIC ASSIGNMENT 2010 WITH PROJECT (Kula-Kihei Road to south)	Figure 9
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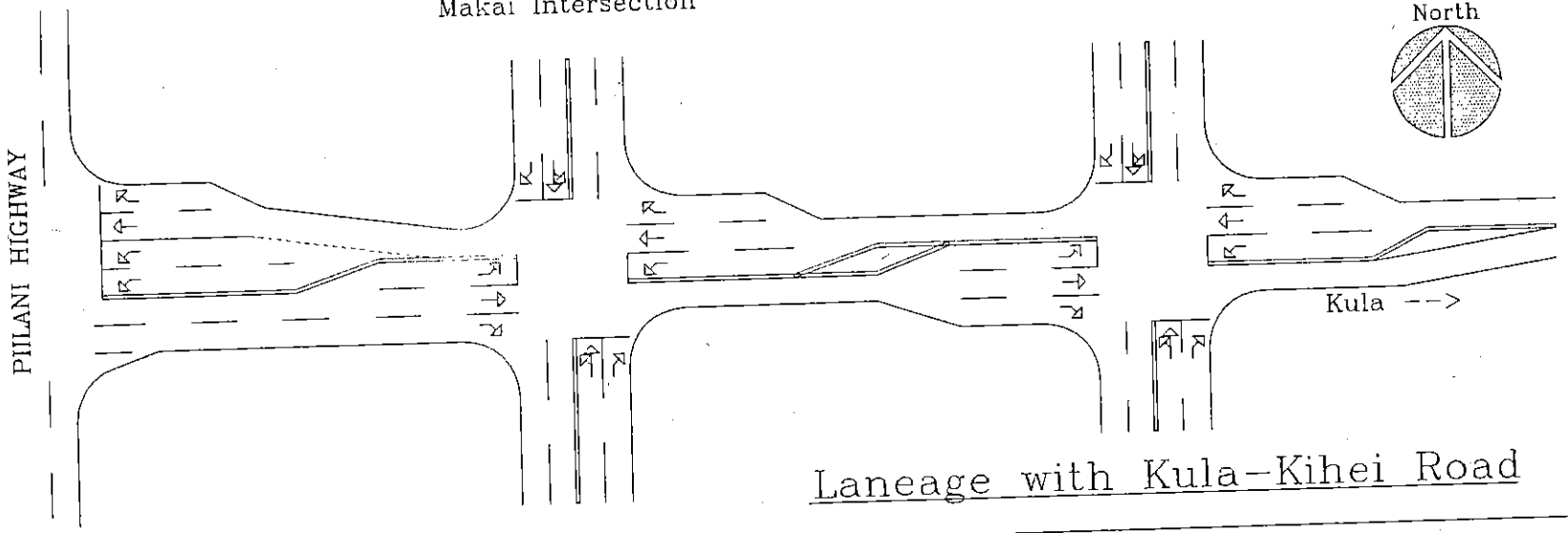
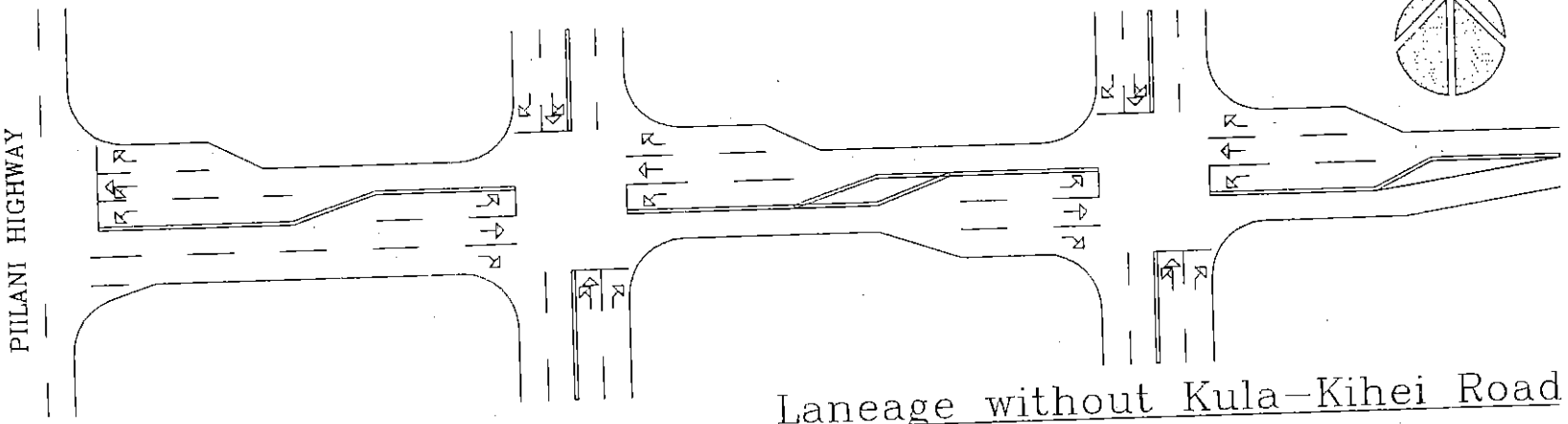


Laneage with Kula–Kihei Road



Laneage without Kula–Kihei Road

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RECOMMENDED LANEAGE

Figure 10

APPENDIX - LEVELS OF SERVICE

A qualitative measure used by traffic engineers to describe traffic operational conditions is the **level of service** (LOS). Six levels have been defined, from **LOS A** (best operating condition) to **LOS F** (worst). The *Highway Capacity Manual* describes analysis procedures for different types of facilities.

Levels of service are identified for the controlled movements at unsignalized intersections. The analysis procedure determines the reserve capacity (total capacity less volume) of a controlled movement such as a left turn against oncoming traffic, or traffic entering a roadway from a side street controlled by a stop sign:

Reserve Capacity	Level of Service	Expected Delay to Controlled Movement
≥400	A	Little or no delay
300 - 399	B	Short traffic delays
200 - 299	C	Average traffic delays
100 - 199	D	Long traffic delays
0 - 99	E	Very long traffic delays

At signalized intersections, an operational analysis and a planning analysis are available. The operational analysis estimates vehicular delays based on detailed traffic count data and information about intersection geometry, and is used for evaluating design or operational alternatives. The planning analysis determines the number of lanes needed at an intersection by totaling the conflicting movements, expressed on a per-lane basis, and compares it with the following criteria to determine conditions relative to capacity:

Sum of Conflicting Movements	Condition
less than 1,200	under capacity
1,201 to 1,400	near capacity
more than 1,400	over capacity

Reference: Transportation Research Board, National Research Council, *Highway Capacity Manual,* Special Report 209, Washington, D.C., 1985