Village Park-Kupuna Loop Sub-Area Corridor Study

Village Park, Hawaii

Mitigative Measures Report

July 17, 2015

Prepared for

City and County of Honolulu

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I. INTRODUCTION

A sub-area traffic study is being prepared to evaluate safety and operations of existing roadway conditions in Village Park, along the entire Kupuna Loop. This includes Kupuohi Street between Anonui Street and lower Kupuna Loop which provides access to both the Kunia and Royal Kunia shopping centers. Kupuna Loop is a major collector, and like many other similar streets of this functional class in Honolulu, has direct driveway access to single family homes. Existing concerns include pedestrian crossing and walking safety, on-street parking, bicycle facilities, bypass traffic, sight distance, speeding and crashes.

The purpose of this study is to identify and develop location-specific traffic engineering plans for operations and safety improvements. This study may also serve to provide possible mitigative measures for other communities facing similar issues.

Task 1, Existing Traffic Operational Report, has been submitted to the City and County of Honolulu, Department of Transportation Services (DTS) for review and comment. As a product deliverable for Task 2, this Mitigative Measures Report will identify areas of concern in the project area and devise viable mitigative measures. Also included in Task 2 are conceptual plans and associated cost estimates representing these potential measures. Areas identified in the Existing Traffic Operational Report as well as information gained through the analysis of study area accident reports will be used to identify potential trends and resulting solutions.

The three major tasks of this project include:

TASK 1: Existing Traffic Operational Report

A. Conduct field visit of the study area to identify issues and problems.
B. Review adjacent land uses and traffic generators such as schools, shopping centers, and churches. Identify multi-modal use of the corridor including bus routes and stops, pedestrian facilities, and bicycle facilities.
C. Collect traffic counts including vehicles, bicycles, and pedestrians. This shall include volumes and time of day/week information where pertinent at intersections and along corridor segments.
D. Complete level of service capacity and operational analysis of study area.
E. Meet with area elected representatives including the Neighborhood Board Transportation Committee Chair, the City and County Councilmember, and State representatives.
F. Hold a kick-off meeting with interested community parties and elected officials to initiate study and solicit feedback. This will be conducted as a Field Walk-Through.
G. Prepare Existing Traffic Operational Report documenting traffic management and operational problems.

TASK 2: Mitigative Measures

A. Obtain available accident records and reports.
B. Tabulate and analyze accident data to identify trends and develop potential solutions.
C. Document traffic operations and safety issues and methodology/approach to resolving these.
D. Prepare conceptual designs of mitigative measures at locations identified in Existing Traffic Operational Report and through accident analysis.
E. Prepare cost estimates of improvements at a level suitable for use by the City and County for future budgeting.
F. Prepare Mitigative Measures Report that identifies areas of concern in the project area and identifies viable mitigative measures, accompanied by conceptual designs, cost estimates, and potential sources of funds.
G. Determine with the City and County whether results and recommendations should be presented at the Neighborhood Board or whether a separate public information meeting is preferable for disseminating information and receiving feedback. This will occur following analysis and alternative development but before completing the Final Traffic Report.

TASK 3: Final Traffic Study

A. Meet with the area Neighborhood Board.
B. Prepare Final Traffic Study that includes summation of Existing Traffic Operational Report and Mitigative Measures Report and deliverables.

II. EXISTING (2012) CONDITIONS

Existing conditions were established during field visits, traffic counts, and research completed between August and September 2012. This includes items noted during a study area walk-through on Thursday, September 13, 2012 by neighborhood leaders, administrators and key personnel from DTS, elected officials, health officials, and others. The project location is mauka (inland) of H-1 in Kunia District, 12 miles west of Honolulu International Airport (see Figure 1). As documented in the Existing Traffic Operational Report, the existing (2012) weekday and weekend peak hour volumes are referenced in Figure 2 and Figure 3.

A. Existing Traffic Operations

1. Intersection Operations

As documented in the Existing Traffic Operational Report, the following concerns were identified at the study intersections listed in Table 1.

Table 1: Study Intersections

Item	Intersection	Traffic Control
a)	Kupuohi Street at Walmart driveway (main entrance)	Unsignalized
b)	Kupuohi Street at Times Shopping driveway (main entrance)	Unsignalized
c)	Kupuohi Street at Kupuna Loop (upper)	Signalized
d)	Kupuohi Street at Kupuna Loop (lower)	Signalized
e)	Kupuna Loop at Aiki Street	Unsignalized
f)	Kupuna Loop at Kaaholo Street (southeast location)	Unsignalized

a) ***Kupuohi Street at Walmart driveway (main entrance)***

- The study intersection of Kupuohi Street at Walmart driveway had appropriate level of service (LOS) operations and did not pass traffic signal warrants.

b) ***Kupuohi Street at Times Shopping driveway (main entrance)***

- The study intersection of Kupuohi Street at Times Shopping driveway had appropriate LOS operations and did not pass traffic signal warrants.

c) ***Kupuohi Street at Kupuna Loop (upper)***

- Analysis of existing operations for Kupuohi Street at Kupuna Loop (upper) resulted in LOS E for the intersection during the weekend peak, LOS E and F for the eastbound left-turn movement during the PM and weekend peaks, respectively, and LOS E and F for the southbound right-turn movement during the PM and weekend peaks, respectively.
- Community concerns were noted with the intersection lane configuration. This included illegal traffic movements observed at the intersection which primarily involved vehicles traveling straight through in designated turn-only lanes.

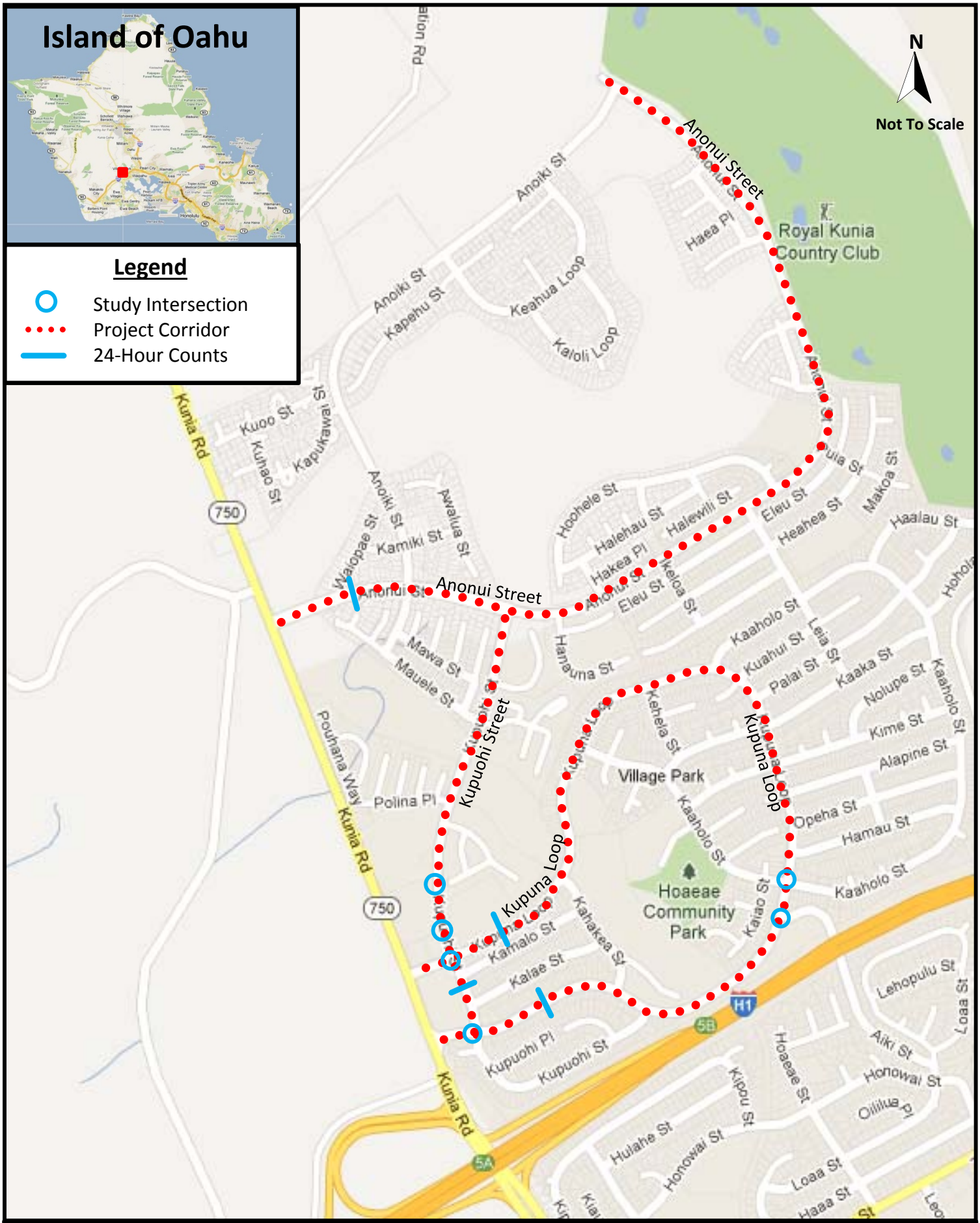

Figure 1: Project Location Map

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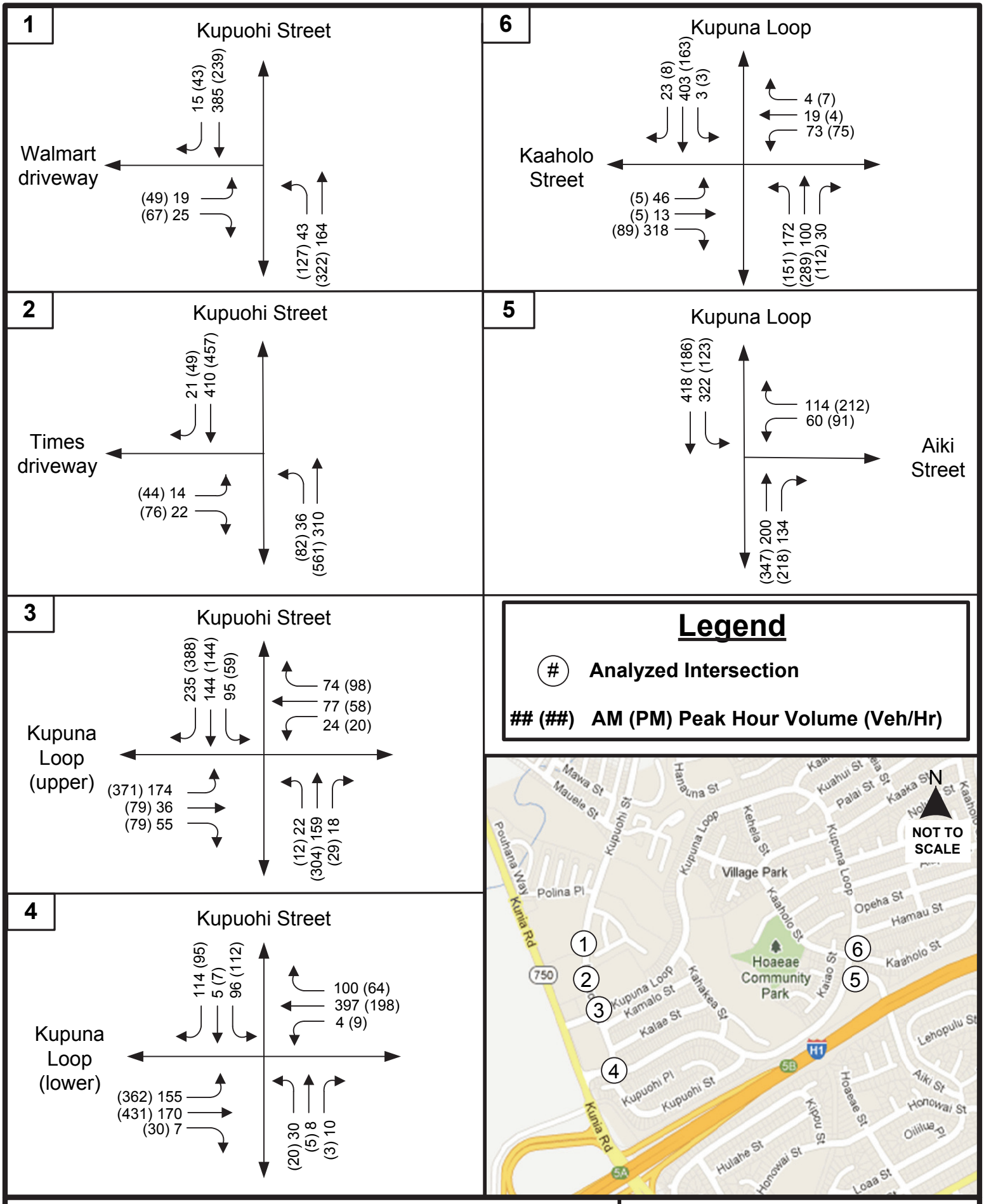

Figure 2: Existing (2012) Peak Hour Volume - Weekday

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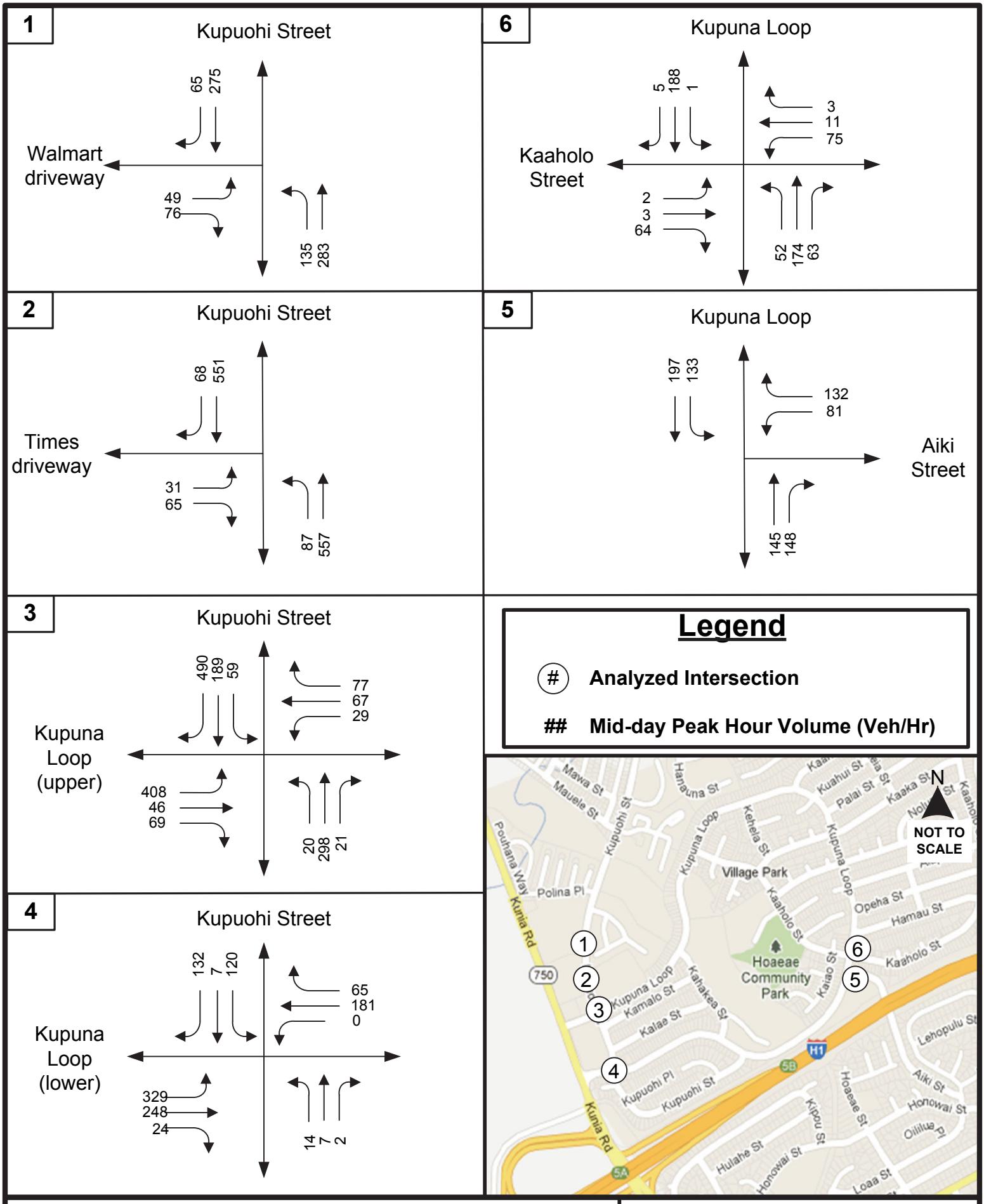

Figure 3: Existing (2012) Peak Hour Volume - Saturday

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d) ***Kupuohi Street at Kupuna Loop (lower)***

- Analysis of existing operations for Kupuohi Street at Kupuna Loop (lower) resulted in LOS F for the intersection during the PM peak and LOS F and E for the eastbound left-turn movement during the PM and weekend peaks, respectively.
- Unsafe traffic maneuvers were observed at the intersection partially due to the intersection lane configuration.
- Trucks have been observed making a U-turn to enter Kunia Shopping Center from Kupuna Loop (lower).
- Kupuna Loop (lower) traffic attempting to turn left onto Kupuohi Street often backs up onto Kunia Road. This also causes back up of vehicles trying to go straight in the eastbound direction.

e) ***Kupuna Loop at Aiki Street***

- Analysis of existing operations for Kupuna Loop (lower) at Aiki Street resulted in LOS F for the westbound left-turn movement during the AM peak.
- Vehicle volume traffic signal warrants passed.
- No pedestrian crosswalk exists at this intersection.

f) ***Kupuna Loop at Kaaholo Street (southeast location)***

- Analysis of existing intersection operations for Kupuna Loop (lower) at Kaaholo Street resulted in LOS F and E for the westbound approach during the AM and PM peaks, respectively.
- Vehicle volume traffic signal warrants passed.
- Poor line of sight was noted and observed for the southbound Kaaholo Street approach.
- Traffic and safety concerns as a result of the vehicular and pedestrian trips generated by Kaleiopuu Elementary School before and after school hours.

2. Roadway Operations

As documented in the Existing Traffic Operational Report, the following concerns were identified along the roadways in the study area.

a) ***Kupuna Loop***

- Road Width:
  - Measured 22 feet road width in eastbound and westbound direction, overall width of 44 feet, parking on both sides. This large travel lane width (22 feet - 7 feet = 15 feet) has the potential for traffic calming treatment in both directions.
- Speeding:
  - The posted speed limit is 25 mph throughout the loop although concerns with speeding were noted, and documented through speed studies, for the upper and lower segments. Speed study results (provided in Appendix H of the Existing

Traffic Operational Report) show average vehicle speed 4 mph over the posted speed limit and 85th percentile speeds 7-8 mph above the speed limit.
    - Reduction of average speeds 2-4 mph would bring the average speed to 25 mph, the posted speed limit. 85th percentile speeds would theoretically drop to 30 mph, just 5 mph over the posted speed limit.
    - It was noted that motorists are intimidating pedestrians attempting to cross streets, bicyclists wishing to ride here and those getting into and out of parked cars. This was observed due to high vehicle speeds and noted occurrences of motorists not yielding to pedestrians.
- Traffic Congestion:
    - Traffic congestion exists in the area between Kunia Road and Kupuohi Street due to the limited intersection spacing (approximately 325 feet between stop bars) as well as the higher volume from traffic accessing the commercial centers as well as Kunia Road.
    - Multiple lanes exist in either direction along these sections of road with plastic lane barriers along Kupuna Loop (lower) restricting left-turns into and out of the commercial center to the north.
- Parking:
    - Illegal parking near curbs was observed and a noted community concern.
    - Closely spaced driveways limit parking on streets.
    - Cars parked in driveways, extend into sidewalk which creates an obstacle for pedestrians.
    - Cars parked illegally on street in front of driveway.

b) ***Kupuohi Street***

- Conflicts:
    - Between the intersections of Kupuna Loop (upper) and Kupuna Loop (lower), conflicts exist between traffic movements due to the commercial center activity.
    - Handi-Van has been noted to park in a no-parking zone along Kupuohi Street, for off-loading access to the kidney center in the development.
- Pedestrian Access:
    - Pedestrians were observed crossing at unmarked locations, mauka of Kupuna Loop (upper) between residences and the shopping center.
    - Pedestrian crosswalk at Polina Place, mauka of Walmart, has a difficult line of sight as a result of its location set back from the crest of a vertical curve which obstructs views for southbound motorist.
    - Along Kupuohi Street, the school bus picks students up in the southbound direction at a location north of Polina Place and drops students off in the northbound direction south of Mauele Street (see Figure 10) but no crosswalks exist.

c) *Anonui Street*

- Speeding:
  - The posted speed limit along the corridor is 25 mph, although excessive speeding and racing has been reported along this corridor.
  - High average speeds were recorded through speed studies, showing average vehicle speed 8 mph over the posted speed limit and 85th percentile speeds 12-13 mph above the speed limit.
  - Anonui Street needs a drop in average speed as well as addressing the cases of extreme (20-30 mph above speed limit) speeding.
- Reckless Driving:
  - At the dead end, tire skids and circles exist which suggest reckless driving.
- Pedestrian Access:
  - There is a lack of pedestrian access to Anonui Street due to neighborhood walls.

d) *Other Roads*

Near Kupuna Loop (upper) and Kupuna Loop (lower), Kahakea Street is 26-28 feet wide with parking allowed on both sides of the street. This is known as a "Yield Street" due to it requiring vehicles to yield to approaching vehicles which brings down speed and increases roadway vigilance. It was noted that Kahakea Street is often used as a pass-through area from Waipahu to Walmart.

A series of traffic calming treatments were applied to Kaaholo Street in previous years including raised crosswalks, medians, and neck-downs. The combination of a large amount of vehicles dropping off and picking up students and the lack of available parking creates a situation where vehicles are queued along the road in both directions approaching the school. This stretch of road was not a part of the study area for this project although it warrants further study and may benefit from seeking Safe Routes to School funding.

3. Multi-Modal Operations

a) *Bus*

TheBus provides public transportation throughout Oahu with Route 97 Village Park Express and Route 434 Waipahu – Village Park serving the project area at bus stops shown on Figure 4. It was observed that not all bus stop locations correspond with marked pedestrian crossing locations (see Table 2). Specifically, locations 2 (Kupuna Loop at Kupuohi Street) and 6 (Kupuna Loop at Minoaka Place) should be considered for relocation closer to the nearest intersection crosswalk. Location 7 (Kupuna Loop at Kupuohi Street) is the park and ride lot with pedestrian and vehicle access available from both streets.

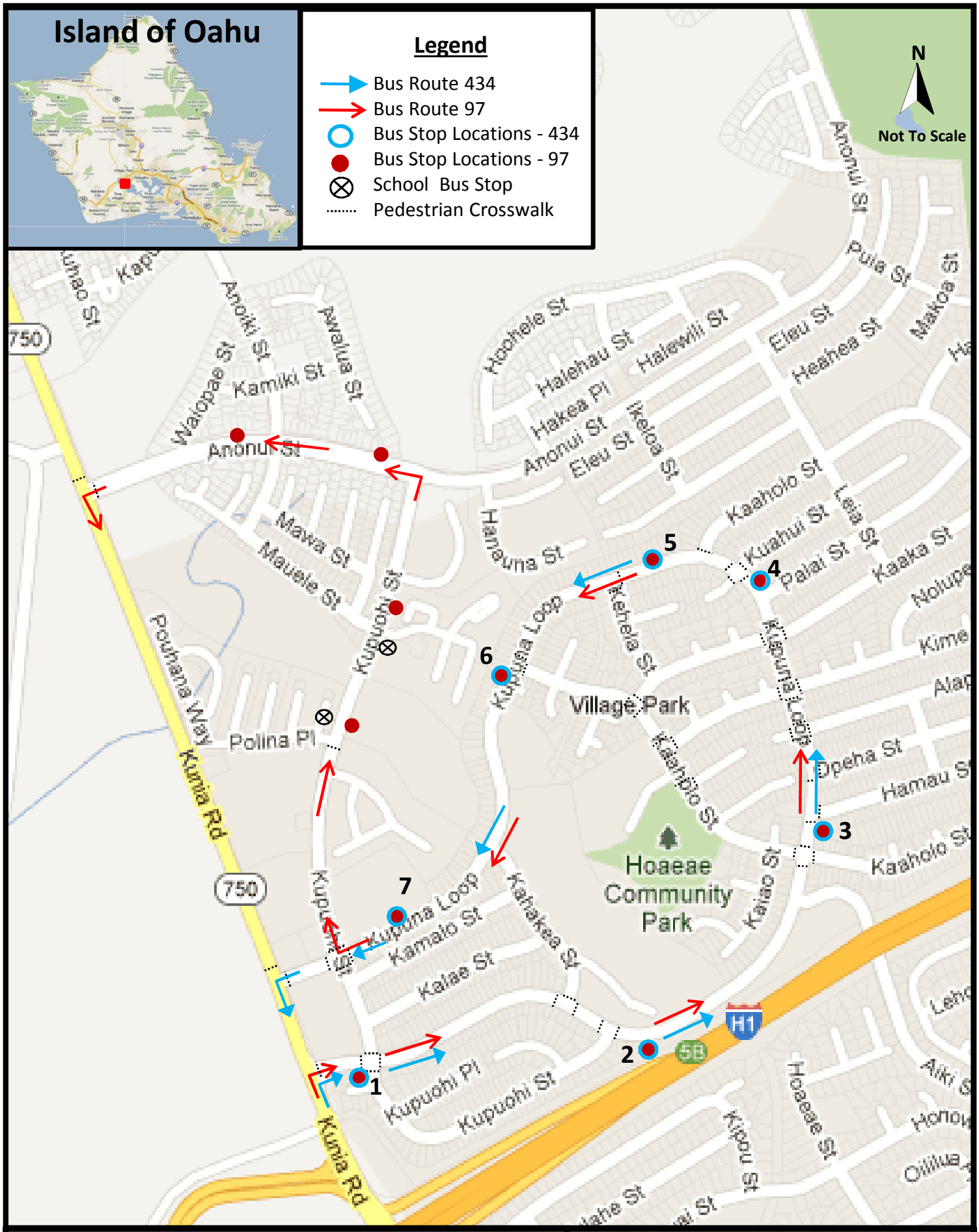

Figure 4: Bus Stop Locations Within Village Park

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Table 2: Bus Stop Pedestrian Access

Bus Stop	Kupuna Loop Bus Stop	Location	Closest Crosswalk
1	Kupuna Loop at Kupuohi Street	Near-side	Adjacent Kupuohi Street
2	Kupuna Loop at Kupuohi Street	Midblock	Kupuohi Street, 250 feet away
3	Kupuna Loop at Hamau Street	Near-side	Adjacent Hamau Street
4	Kupuna Loop at Palai Street	Midblock	Kuahui Street, 100 feet away
5	Kupuna Loop at Kehela Street	Midblock	Kehela Street, 100 feet away
6	Kupuna Loop at Minoaka Place	Midblock	Kaaholo Street, 250 feet away
7	Kupuna Loop at Kupuohi Street (Park and Ride)	Near-side	Kupuohi Street, 350 feet away

b) *Pedestrian*

Sidewalks exist along all roads in the study area. Marked crosswalks and curb ramps exist at various intersections, while pedestrian signals and pedestrian push buttons exist at the signalized intersections of Kupuohi Street at Kupuna Loop (upper) and at Kupuna Loop (lower). The average number of peak period pedestrian crossings per hour at the study intersections is shown in Table 3. This shows moderate pedestrian crossings at the intersections adjacent to the commercial center at all peak periods counted. There are also moderate pedestrian crossings at the intersections adjacent to the school during the weekday peak periods where the start of school coincides with the AM peak period.

Table 3: Average Peak Period Pedestrian Crossing Volumes

Intersection	Traffic Control	Crossings Per Hour		
		AM	PM	Weekend
Kupuohi Street at Walmart driveway (main entrance)	Stop sign	19	27	24
Kupuohi Street at Times Shopping driveway (main entrance)	Stop sign	25	38	28
Kupuohi Street at Kupuna Loop (upper)	Traffic Signal	16	28	24
Kupuohi Street at Kupuna Loop (lower)	Traffic Signal	21	28	7
Kupuna Loop at Aiki Street	Stop sign	1	4	2
Kupuna Loop at Kaaholo Street (southeast location) *	Stop sign	30	29	9

* Crosswalks exist across both legs of the uncontrolled Kupuna Loop approach.

c) *Bicycle*

Marked bike lanes and signage exist along parts of Kupuna Loop, Kupuohi Street, Anonui Street, and Aiki Street. The *Oahu Bike Plan, A Bicycle Master Plan* (HH&F, August 2012) only specifies locations along Kupuohi Street, between Kupuna Loop (upper) and Anonui Street, and Anonui

Street as having existing bike lakes. It also calls out Aiki Street as having a bike path. See Appendix A for existing and future bike lanes in the Village Park area as included in the *Oahu Bike Plan* (HH&F, August 2012).

The average number of bikes traveling per hour through the study intersections during the peak periods is shown in Table 4. A low volume of bikes were counted during the peak hours which may be due to the lack of bike path connectivity or the hills and street grades in the area which could discourage recreational riders.

Table 4: Average Peak Period Bike Volumes

Intersection	Avg. Bikes Per Hour		
	AM	PM	Weekend
Kupuohi Street at Walmart driveway (main entrance)	3	2	1
Kupuohi Street at Times Shopping driveway (main entrance)	6	4	1
Kupuohi Street at Kupuna Loop (upper)	4	8	9
Kupuohi Street at Kupuna Loop (lower)	1	0	1
Kupuna Loop at Aiki Street	2	4	5
Kupuna Loop at Kaaholo Street (southeast location)	2	3	5

An off-road paved pathway connects Kupuna Loop (lower) and Kupuna Loop (upper) east of Park View Villages. A chain crosses the entrance of the path off of Kupuna Loop (lower) with signage that states that it is private property. It was noted that this path is not maintained.

4. Other

Other areas of concern in the area exist at parks along Kupuna Loop (upper) and Kupuohi Street where the lack of lighting has resulted in undesirable activities at night. It was noted that security patrols the area.

B. Accident Analysis

Accident reports along roads in the study area between July 2009 and October 2012 were provided by the Honolulu Police Department. In that time, 60 accidents were reported in the study area. Accident data was tabulated and collision diagrams created to identify safety concerns and accident trends (see Appendix B). Specific details of the accident were left out to protect the confidentiality of the information.

This report and analysis only looked at accidents occurring along City and County roads and therefore stopped short of looking at accidents along Kunia Road, which is a State of Hawaii road. A total of 44 accidents were reported along Kunia Road between the H-1 overpass and 2 miles north of Anonui Street in this same time period. A total of 17 accidents occurred on Kunia Road nearby or at the intersections of Kupuna Loop (lower) and Kupuna Loop (upper). It should be

acknowledged that these intersections experience a higher volume of traffic than those in the study area and have many conflicting traffic movements.

Along Kupuna Loop the majority of accidents occurred in close proximity to the study intersections and along the western segments of the road. This is due to the higher volume of traffic and resulting conflict points. Along the eastern segment of the road, the few accidents mostly involved vehicles striking parked cars. Along Kupuohi Street, left-turn accidents were most common. Along Anonui Street, vehicles striking stationary objects were most common. Accidents around the study intersections included left-turn, rear end, and collisions with objects.

Significant accident variables, occurrence, and percentage of all accidents are included in Table 5. The variables have been separated by motorist injury, accident type, general location, and other contributing factors. Some accidents may fall into more than one of the noted variables.

Table 5: Significant Accident Variable Occurrence

Variables Included	Number of Accidents (60 total)	Percentage
Injured	26	43%
Death	1	2%
Rear End	5	8%
Collision with Object	37	62%
Lost Control	14	23%
Side Swipe	5	8%
Overturn	4	7%
Pedestrian/Bike	2	3%
Intersection	27	45%
Curve	9	15%
Nighttime	30	50%
Rainy	7	12%
DUI	6	10%
Speeding	3	5%
Driver Age (<25)	19	32%
Driver Age (>60)	5	8%

A study completed by the Federal Highway Administration, *Public Roads – Driving After Dark* (FHWA, 2002), noted that of an estimated 6.3 million highway crashes occurring in the United States in 2001, 2.1 million (33%) resulted in injury, and 37,795 (<1%) resulted in a fatality. Village Park accident data had a slightly higher average of accidents resulting in injury (42%) or death (2%). This is noteworthy due to the slow posted speed limit (25 mph) of the majority of roads in

Village Park as compared to the highway data being compared in the FHWA study and the general correlation between higher speeds and resulting injury.

The study *Public Roads – Driving After Dark* (FHWA, 2002) noted that 30% of accidents tallied occurred during nighttime hours and 50% of traffic fatalities occurred at night. A smaller volume of vehicles travel during nighttime hours as compared to daytime hours which results in a smaller volume of accidents although the FHWA study results show that these accidents have resulted in a higher likelihood of fatality. The accident data from Village Park had a higher nighttime accident rate (50%) as compared to the FHWA study which is cause for concern with the severity of these types of accidents. Street lighting exists along study roads although it is recommended that a follow-up study review for adequate luminescence.

As recorded by the National Highway Traffic Safety Administration (*NHSTA.dot.gov*), of the 51 traffic fatalities occurring on Oahu in 2011, speeding (41%), roadway departure (35%), and intersection related (27%) were included in a significant number of those (see Table 6). A large percentage of Village Park accidents included a collision with an object (62%) which is the result of vehicles departing the designated travel way. While speeding was only noted as being a factor in a small number (5%) of accidents in Village Park, the occurrence of speeding prior to an accident is difficult to ascertain after an accident has occurred and therefore may be underrepresented in the data. There were a large number of accidents at intersections (45%) in Village Park which is likely due to the high number of conflict points. Table 7 includes the breakdown of Village Park intersection accidents by type.

Table 6: Oahu Fatalities by Crash Type

Crash Type	Percentage
Alcohol Impaired	35%
Single Vehicle Crash	59%
Speeding Involved	41%
Rollover Involved	10%
Roadway Departure Involved	35%
Intersection Related	27%
Pedestrian Fatalities	31%
Bicyclist Fatalities	2%

Source: *NHTSA.dot.gov*

Table 7: Village Park Intersection Accidents by Type

Accident Type	Number of Accidents (27 total)	Percentage
Broadside Collision	12	44%
Rear-end	5	19%
Roadway Departure/Loss of Control	6	22%
Sideswipe	2	7%
Collision with Pedestrian	1	4%
Collision with Bike	1	4%

III. MITIGATIVE MEASURES

A. Accident Mitigative Measures

The *Traffic Engineering Handbook* (ITE, 1999) provides mitigative countermeasures to consider that can be used to lessen the occurrence of common accident patterns through site specific or overall improvements.

Some of these countermeasures are not applicable for roads in the Village Park study area although they provide a guide for general improvements to consider. Reducing the speed limit or installing rumble strips is not feasible at all locations and therefore other traffic calming measures should be considered to reduce speeding. Accident patterns such as colliding with a stationary object or sideswiping are a result of vehicles straying from their designated travel lane. Therefore it is suggested to improve travel way delineation such as installing wider pavement marking lines, improved reflectivity, or raised reflective pavement markers. Regular maintenance and upkeep of pavement marking and signage will ensure that both are still visible and communicating the intended message. Improved reflectivity will especially assist drivers at night.

B. Intersection

a) *Kupuohi Street at Kupuna Loop (upper)*

Due to the poor LOS during weekend peaks as well as community concerns with illegal traffic movements, the intersection was analyzed using a reconfigured lane configuration while also incorporating bike lanes and channelize vehicular movements. The addition of a right-turn overlap arrow for the southbound approach also helped alleviate some of the existing delay in the traffic model. The proposed changes are shown in red on Figure 5. Analysis of the modified signalized intersection resulted in LOS D or better during the peak hours for the intersection and all movements (see Table 8).

The intersection was also analyzed as a possible single-lane roundabout using methodology from the *National Cooperative Highway Research Program Report 572 – Roundabouts in the United States* (NCHRP, 2007). This resulted in LOS B or better for all approaches (see Table 8). Detailed analysis reports are provided in Appendix C. Existing roadway approaches have multiple lanes although potential mitigation measures suggest implementing a road diet that would result in the approaches being single lane, allowing for a single lane roundabout.

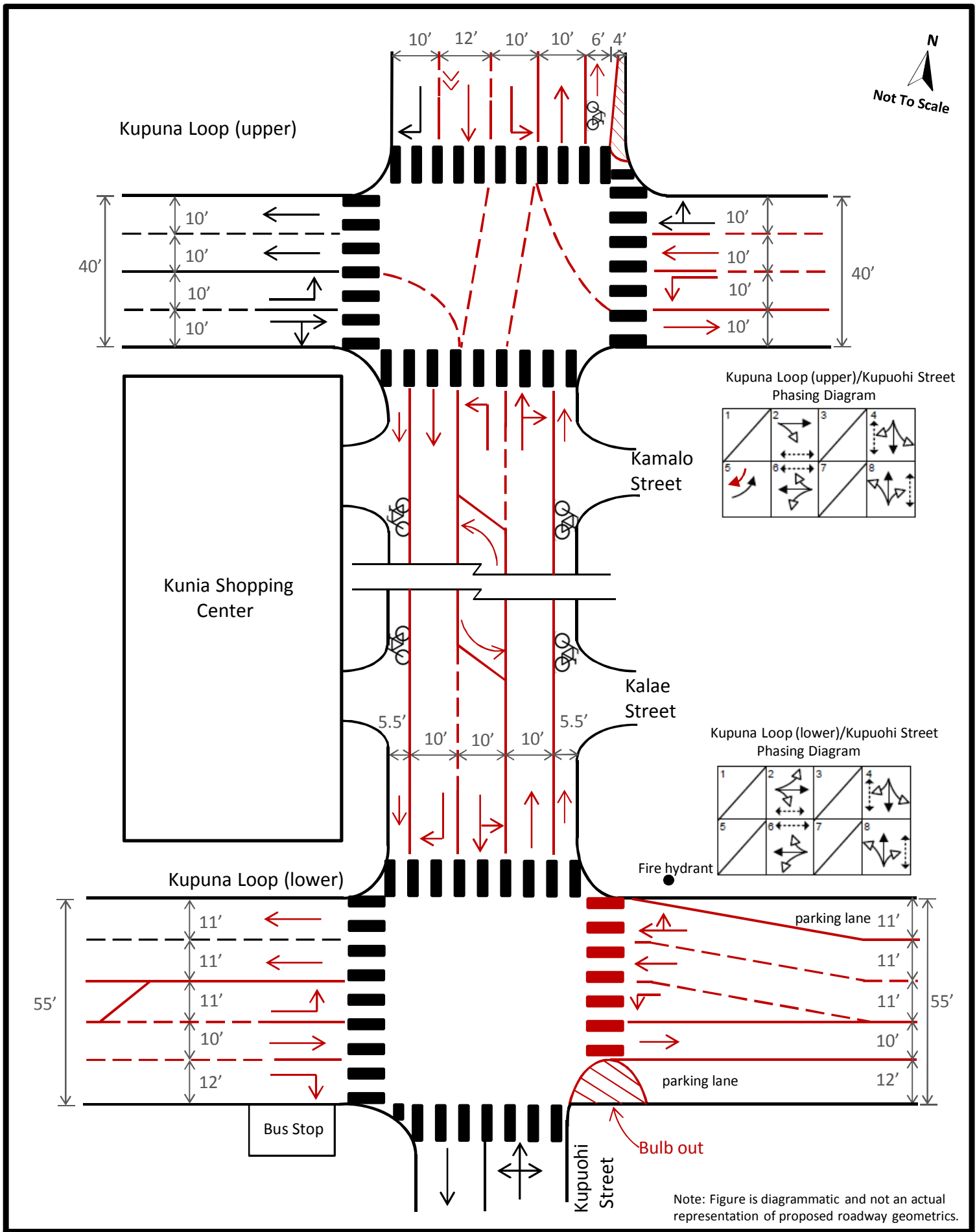

Figure 5: Kupuohi Street Intersections Lane Configuration

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Table 8: Kupuohi Street and Kupuna Loop (upper) Intersection with Modifications Level of Service

Intersection Control		AM			PM			Weekend		
Appr	**Mvmt**	**Delay**	**v/c**	**LOS**	**Delay**	**v/c**	**LOS**	**Delay**	**v/c**	**LOS**
Signalized Intersection		26.5	-	C	29.5	-	C	31.2	-	C
EB	L	33.0	0.39	C	34.7	0.67	C	35.7	0.71	D
	TR	9.5	0.10	A	9.2	0.16	A	7.6	0.11	A
WB	L	27.4	0.06	C	31.3	0.06	C	30.0	0.08	C
	T	28.6	0.16	C	32.4	0.16	C	30.9	0.17	C
	TR	29.0	0.18	C	34.7	0.30	C	31.7	0.21	C
NB	L	38.6	0.08	D	39.6	0.05	D	45.2	0.11	D
	TR	37.4	0.34	D	48.2	0.68	D	52.2	0.73	D
SB	L	36.9	0.31	D	49.7	0.37	D	54.6	0.43	D
	T	27.8	0.27	C	29.6	0.29	C	34.3	0.43	C
	R	12.2	0.28	B	11.6	0.42	B	14.8	0.55	B
Single-Lane Roundabout		-	-	-	-	-	-	-	-	-
EB	LTR	6.0	0.31	A	10.0	0.59	A	11.0	0.61	B
WB	LTR	6.0	0.22	A	10.0	0.31	A	10.0	0.32	A
NB	LTR	6.0	0.24	A	11.0	0.51	B	11.0	0.50	B
SB	LTR	7.0	0.47	A	9.0	0.57	A	13.0	0.73	B

As stated in *National Cooperative Highway Research Program Report 672 – Roundabouts: An Informational Guide, 2nd Edition (NCHRP Report 672)* (NCHRP, 2010), roundabouts are generally safer and operate with lower vehicle delay than other forms of intersections. Roundabouts have the added benefit of reducing pollution and gas consumption because they facilitate uninterrupted travel through the intersection rather than requiring a full stop, idling and acceleration from stop. Roundabouts also have fewer conflicting points (i.e. point in which the paths of a vehicle and another vehicle, pedestrian or bicycle cross) which increases safety for all transportation modes.

With the closely spaced existing signalized intersection of Kupuna Loop (upper) and Kunia Road, controlling vehicular platoon progression during the peak hours is helpful in reducing vehicles from queuing through the intersection and blocking other vehicular movements.

Due to the relatively low cost of the signalized intersection improvements and resulting appropriate LOS results, it is suggested that the signalized intersection reconfiguration be considered (see Appendix D – Mitigation #1). A conceptual design example of this mitigation measure is included in Appendix E.

b) *Kupuohi Street at Kupuna Loop (lower)*

Due to the poor LOS during PM and weekend peaks as well as community concerns with unsafe traffic movements, the intersection was analyzed using a reconfigured lane configuration (see

Figure 5) and optimized signal timing and bulb-outs to shorten pedestrian crossing distances. Analysis of the modified signalized intersection resulted in LOS C or better during the peak hours for the intersection and all movements (see Table 9). Additionally, the intersection was analyzed as a possible single lane roundabout which also resulted in LOS C or better (see Table 9). Detailed analysis reports are provided in Appendix C. Similar to the intersection with Kupuna Loop (upper), existing roadway approaches have multiple lanes although potential mitigation measures suggest implementing a road diet that would result in the approaches being single lane, allowing for a single lane roundabout.

Table 9: Kupuohi Street and Kupuna Loop (lower) Intersection with Modifications Level of Service

Intersection Control		AM			PM			Weekend		
Appr	**Mvmt**	**Delay**	**v/c**	**LOS**	**Delay**	**v/c**	**LOS**	**Delay**	**v/c**	**LOS**
Signalized Intersection		15.3	-	B	14.1	-	B	15.5	-	B
EB	L	16.6	0.32	B	14.0	0.50	B	14.2	0.47	B
	T	10.1	0.17	B	9.4	0.37	A	8.8	0.22	A
	R	8.9	0.01	A	6.7	0.03	A	7.4	0.03	A
WB	L	10.8	0.01	B	11.3	0.02	B	0.0	0.00	A
	T	11.0	0.26	B	7.2	0.12	A	8.0	0.12	A
	TR	11.0	0.26	B	7.3	0.12	A	8.0	0.12	A
NB	LTR	26.0	0.12	C	30.3	0.09	C	26.9	0.07	C
SB	LT	26.2	0.21	C	31.6	0.28	C	30.7	0.29	C
	R	26.1	0.24	C	30.5	0.24	C	30.1	0.31	C
Single Lane Roundabout		-	-	-	-	-	-	-	-	-
EB	LTR	6.0	0.33	A	19.0	0.83	C	9.0	0.60	A
WB	LTR	9.0	0.54	A	8.0	0.35	A	7.0	0.31	A
NB	LTR	6.0	0.06	A	9.0	0.06	A	7.0	0.04	A
SB	LTR	7.0	0.29	A	6.0	0.24	A	6.0	0.28	A

Similar to the intersection of Kupuna Loop (upper) and Kupuohi Street, due to the resulting LOS and controlled vehicle progression, it is suggested that the signalized intersection reconfiguration be considered (see Appendix D – Mitigation #1). A conceptual design example of this mitigation measure is included in Appendix E.

Additional concerns at the intersection included vehicles making a U-turn mid-block, between Kupuohi Street and Kunia Road, to circumvent the plastic barriers that restrict left-turns off of Kupuna Loop (lower) (see photo below). The installation of additional barriers, making sure not to interfere with legal intersection movements, would help deter this (see Appendix D – Mitigation #2).

Photo of existing plastic barriers along Kupuna Loop (lower), between Kupuohi Street and Kunia Road.

c) *Kupuna Loop at Aiki Street*

With traffic signal warrants passing, the intersection was analyzed as a signalized intersection, utilizing the existing lane configuration, as well as analyzing as a single-lane roundabout or traffic circle. This resulted in LOS C or better for the intersection and all movements (see Table 10). Detailed analysis reports are provided in Appendix C. Another option to improve intersection operations would be to lengthen the approaching turn lanes. This would not improve calculated LOS but would likely improve traffic operations in the field, by not having turning vehicles queue into the through-traveling lane, and result in the intersection not passing traffic signal warrants. Traffic signal warrants for this intersection are provided in Appendix F. Results suggest that a roundabout be considered at the intersection (see Appendix D – Mitigation #3). Marked crosswalks are not present across any legs of the intersection in the current configuration. With inclusion of a roundabout, crosswalks should be considered for all intersection legs. A conceptual design example of the proposed roundabout with added crosswalks is included in Appendix E. For comparison, a conceptual design cost estimate of a traffic signal and of a turn lane extension for the right-turn lane on Aiki Street will be included.

Table 10: Kupuna Loop at Aiki Street Intersection with Modifications Level of Service

Intersection Control		AM			PM			Weekend		
Appr	**Mvmt**	**Delay**	**v/c**	**LOS**	**Delay**	**v/c**	**LOS**	**Delay**	**v/c**	**LOS**
Signalized Intersection		6.3	-	A	11.0	-	B	8.0	-	A
WB	L	17.4	0.14	B	17.1	0.19	B	13.0	0.13	B
	R	19.4	0.30	B	21.5	0.48	C	14.1	0.23	B
NB	TR	7.0	0.36	A	10.9	0.58	B	10.9	0.36	B
SB	L	5.4	0.58	A	5.2	0.31	A	2.9	0.26	A
	T	1.1	0.42	A	0.4	0.18	A	1.1	0.22	A
Single-Lane Roundabout		-	-	-	-	-	-	-	-	-
WB	LR	5.0	0.19	A	8.0	0.38	A	5.0	0.22	A
NB	TR	8.0	0.41	A	9.0	0.57	A	6.0	0.29	A
SB	LT	11.0	0.70	B	5.0	0.30	A	6.0	0.32	A

d) ***Kupuna Loop at Kaaholo Street (southeast location)***

With traffic signal warrants passing, the intersection was analyzed as a signalized intersection, utilizing the existing lane configuration, as well as analyzing as a single-lane roundabout or traffic circle. This resulted in LOS C or better for the intersection and all movements (see Table 11). Detailed analysis reports are provided in Appendix C. Traffic signal warrants for this intersection are provided in Appendix F. Results suggest that a roundabout be considered at the intersection (see Appendix D – Mitigation #3). With the adjacent intersection being spaced relatively close, it is suggested to install roundabouts in succession to reduce vehicle speed, delay, and improve pedestrian access.

Table 11: Kupuna Loop at Kaaholo Street Intersection with Modifications Level of Service

Intersection Control		AM			PM			Weekend		
Appr	**Mvmt**	**Delay**	**v/c**	**LOS**	**Delay**	**v/c**	**LOS**	**Delay**	**v/c**	**LOS**
Signalized Intersection		13.9	-	B	5.8	-	A	12.9	-	B
EB	LTR	24.0	0.68	C	15.8	0.19	B	13.0	0.12	B
WB	LTR	17.7	0.29	B	15.7	0.18	B	13.2	0.16	B
NB	L	7.6	0.40	A	1.1	0.25	A	15.1	0.10	B
	TR	1.9	0.15	A	1.8	0.49	A	14.3	0.32	B
SB	L	6.8	0.00	A	7.0	0.00	A	12.6	0.00	B
	TR	10.3	0.47	B	8.3	0.20	A	10.3	0.25	B
Single Lane Roundabout		-	-	-	-	-	-	-	-	-
EB	LTR	12.0	0.54	B	5.0	0.11	A	5.0	0.08	A
WB	LTR	5.0	0.12	A	6.0	0.12	A	5.0	0.10	A
NB	LTR	5.0	0.28	A	7.0	0.49	A	5.0	0.26	A
SB	LTR	9.0	0.49	A	5.0	0.19	A	5.0	0.20	A

As a roundabout, the appropriate design vehicle has to be considered due to the school bus and TheBus traffic movements at the intersection. A roundabout here would also help control vehicle

speeds, provide safe pedestrian crossing and allow for bicycles to navigate the intersection. The roundabout may also assist with existing limited sight lines for vehicles approaching from Kaaholo Street. A conceptual design example of this mitigation measure is included in Appendix E. If deemed necessary for pedestrian safety, rectangular rapid flashing beacons could be used to supplement the crosswalk signage crossing the legs of the roundabout.

C. Roadway

a) *Kupuna Loop*

- Lane Configuration:
  - As a traffic calming measure, it is suggested to consider restriping the roadway with a 10-foot travel lane, with five-foot bike lane and a seven-foot parking lane. A 10-foot travel lane was included to accommodate the buses that travel along this road. Restriping is proposed to extend along the entirety of Kupuna Loop (upper and lower), east of Kupuohi Street (see Figure 6 and Appendix D – Mitigation #4). Parking lane striping does not currently exist for the segments along Kupuna Loop between Kehela Street and Kaaholo Street (southeast location) although the existence of accidents with parked vehicles suggests additional travel way delineation would be beneficial.

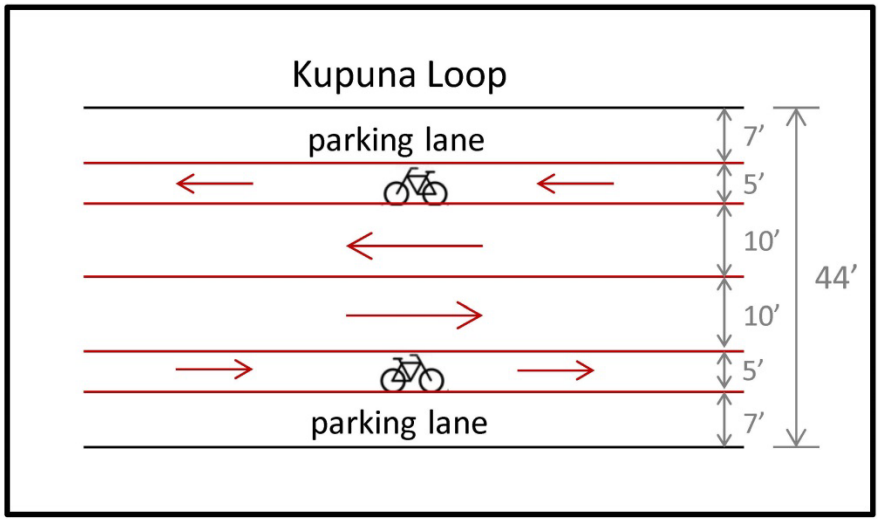

Figure 6: Kupuna Loop Pavement Marking

- To improve connectivity and safety for bicycle users, bike lanes should be considered. At the approach to Kupuohi Street, where sufficient road width may not exist for a dedicated bike lane, sharrows should be considered (see photo below).

Photo of existing striping with bike sharrows in travel lane and adjacent parking lane with raised reflectors spaced 20-feet apart along Wanaao Drive in Kailua, HI.

- For additional travel way delineation, supplemental raised reflectors, spaced at 20-feet apart, can be included on top of pavement marking to provide additional visual and audible notification for vehicles. Reflectors exist in the study area although some are older and losing their reflectivity which is most detrimental at night.

- Speeding:
  - As a traffic calming measure, *MUTCD* (FHWA, 2009) allows for the removal of centerlines, on straightaway approaches and other areas with adequate sight lines where ADT < 6,000.
    - Kupuna Loop (upper) has ADT = 4,400 although with only a short length of straightaway, it is not suggested to remove the centerline here.
    - Kupuna Loop (lower) has ADT = 10,400 and therefore it is not appropriate to remove the centerline here.
  - As a traffic calming measure, minor two-way stop controlled intersections along Kupuna Loop could have traffic circles installed with yield signs included for all approaches. These improvements should assist with traffic calming while also alleviating delay at the intersection. Traffic circle locations should not conflict with residential driveways or bus stops. While no national guidelines exist, a municipality in Georgia suggests traffic circles not be placed within 20-feet of a

driveway. This limits potential opportunities (see Appendix D – Mitigation #5). A conceptual design example of this mitigation measure is included in Appendix E.

- As an alternate traffic calming measure at unsignalized intersections along Kupuna Loop, bump outs (see photo below) and additional signage could be installed as a traffic calming measure to reduce the pedestrian crossing distance and slow vehicle speeds (see Appendix D – Mitigation #6). A conceptual design example of this mitigation measure is included in Appendix E.

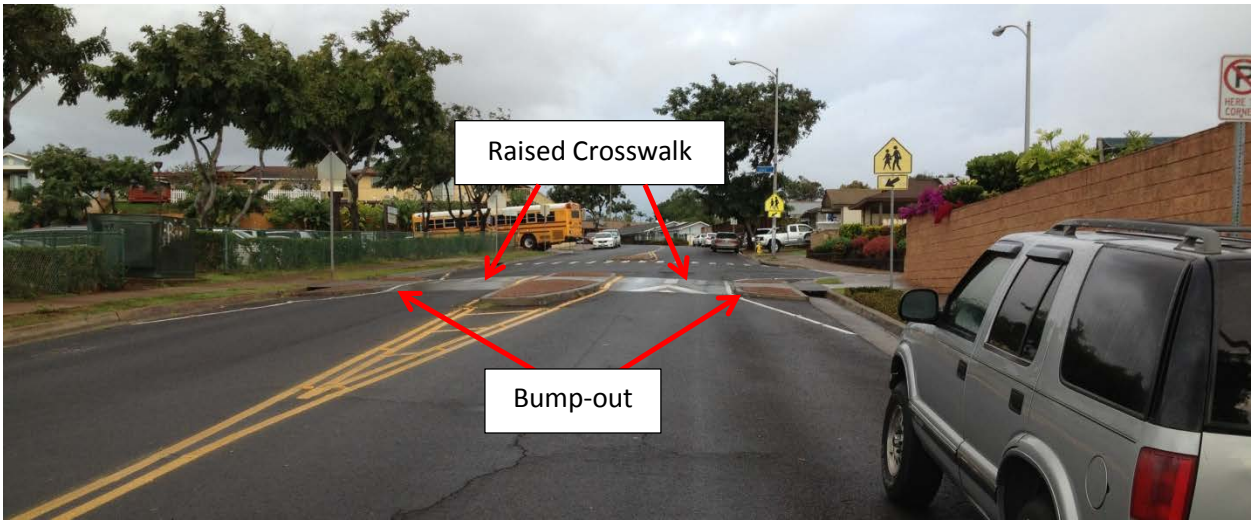

Photo of sample bump-out along Kaaholo Street, adjacent to Kaleiopuu Elementary School.

- To improve pedestrian crossing safety and to act as an additional traffic calming measure where intersection bump-outs are used, a raised crosswalk or median could be included at unsignalized intersections along Kupuna Loop (see photo above).
- To aware motorist of their speed, install speed feedback signs along Kupuna Loop at noted locations of speeding.

- Traffic Congestion:
  - To alleviate some of the peak period congestion in the block between Kunia Road and Kupuohi Street, altered intersection lane configuration and signal optimization should be considered.
  - To help reduce back-up and congestion, lowered cycle lengths and coordinated traffic signals along Kupuna Loop (lower) and Kupuna Loop (upper), at the intersections with Kunia Road and with Kupuohi Street, should be considered.
- Curves:
  - As a traffic calming measure and added delineation at curves in the road, provide a milled rumble strip along the centerline or a hatched pavement marking median. FHWA does not recommend using milled rumble strips in residential areas due to the resulting noise and therefore the hatched pavement marking median is

suggested because it has the same visual impact of a raised median without the physical barrier. Proposed locations are limited along the corridor due to the existence of driveways and the intent not to conflict with these locations (see Appendix D – Mitigation #7).

Photo of sample milled rumble strip along centerline along curve on Kalanianaole Highway near Haunama Bay.

- Parking:
  - To assist in limiting illegal parking adjacent to intersection corners (per the Honolulu Revised Ordinances), intersection bump-outs using curbing or pavement marking (see photo below) could be considered.

Photo of existing pavement marking bump-out at intersection of Kupuna Loop (upper) and Kehela Street.

b) ***Kupuohi Street***

- Conflicts:
  - As a traffic calming measure, between Kupuna Loop (lower) and Kupuna Loop (upper), a road diet should be considered, reconfiguring the roadway cross-section to a single through travel lane in each direction with dedicated left-turn lanes and bike lanes (see Figure 5 and Appendix D – Mitigation #8).
  - Between Polina Place and Anonui Street, a road diet with a single through-lane in each direction and addition of on-street parking (providing access to the park) with dedicated left-turn lanes (see Figure 7 and Appendix D – Mitigation #8) should be considered.

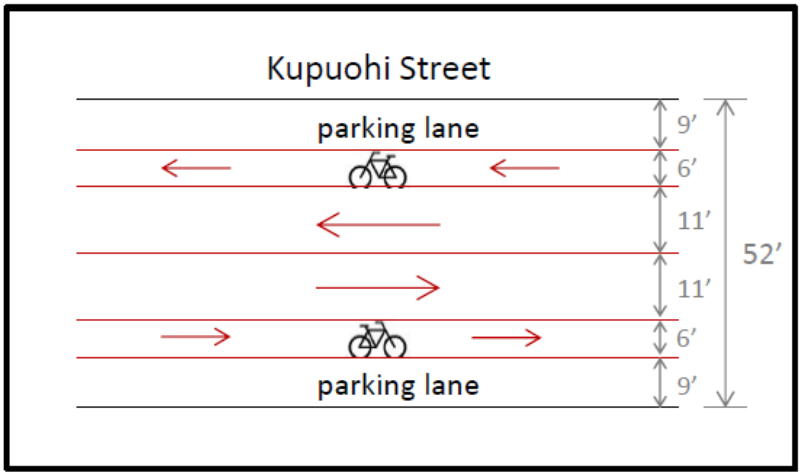

Figure 7: Kupuohi Street Pavement Marking

  - Between Kupuna Loop (upper) and Polina Place, the existing lane configuration has two lanes in each direction with no dedicated turn lanes. Analyzing the Kupuohi Street driveway intersections with Walmart and Times Shopping with a single through-lane and a combination of dedicated left-turn lanes and two-way left-turn center lane (TWLTCL) in either direction resulted in appropriate LOS (see Table 12). Detailed analysis reports are provided in Appendix C.

Table 12: Kupuohi Street driveway Intersections with Modifications Level of Service

Intersection	Appr	Mvmt	AM			PM			Weekend		
			Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c	LOS
Kupuohi Street and Walmart driveway	EB	LR	12.9	0.09	B	17.2	0.30	C	18.1	0.34	C
	NB	L	8.3	0.04	A	8.2	0.11	A	8.5	0.13	A
Kupuohi Street and Times driveway	EB	LR	13.9	0.09	B	25.3	0.42	D	26.1	0.38	D
	NB	L	8.4	0.04	A	8.8	0.08	A	9.3	0.10	A

- Between Kupuna Loop (upper) and Polina Place, a road diet should be considered with a single through-lane in each direction, bike lanes with buffer lane separation, and dedicated left-turn lanes (see Appendix D – Mitigation #8).

- Pedestrian Access:
  - The crosswalk across Kupuohi Street at Polina Place has a difficult line of sight and would benefit from including a raised median along with the proposed road diet (see photo below) to serve as a pedestrian refuge area with a shorter crossing distance (see Appendix D – Mitigation #9). Additional mitigation could include a pedestrian activated flashing beacon or a Rectangular Rapid Flashing Beacon (RRFB) for notifying approaching vehicles. This location aligns with a school bus stop pick-up location and would benefit from the improved accessibility. A conceptual design example of this mitigation measure is included in Appendix E.

Photo of sample median pedestrian refuge along Keolu Drive in Kailua, HI.

  - Coordinating the school bus stop drop-off location with a marked crosswalk and appropriate signage at the intersecting side streets would allow for safer pedestrian crossing locations (see Appendix D – Mitigation #9).
  - Guidelines for considering the installation of crossing treatments at uncontrolled locations are provided in the *Oahu Pedestrian Safety Study Update* (WOC, 2007). With a distance of ¼-mile between crosswalks at Kupuna Loop (upper) and Polina Place, warrants were checked for the installation of a marked crosswalk at a location mauka of the intersection with The Villas of Royal Kunia driveway and the makai Walmart driveway (see Figure 8 and Appendix D – Mitigation #9). Based on the roadway ADT, posted speed, hourly volume of pedestrians crossing, sight distance, and location of the nearest marked crossing, it was determined that warrants passed for the installation of a marked crosswalk with enhanced signs

(pedestrian crossing treatment warrant is provided in Appendix C). Sufficient vehicular stopping sight distance exists at this location, pedestrian connectivity is provided for the adjacent communities, and vehicle traffic to and from the commercial center is less than at a location further south. The crosswalk is north of an observed pedestrian path that had been worn through the existing grass and hedge, which should help redirect pedestrians and provide a single location to cross. It is also recommended to include a pedestrian activated Rectangular Rapid Flashing Beacon (RRFB) or High-Intensity Activated Crosswalk (HAWK) Beacon.

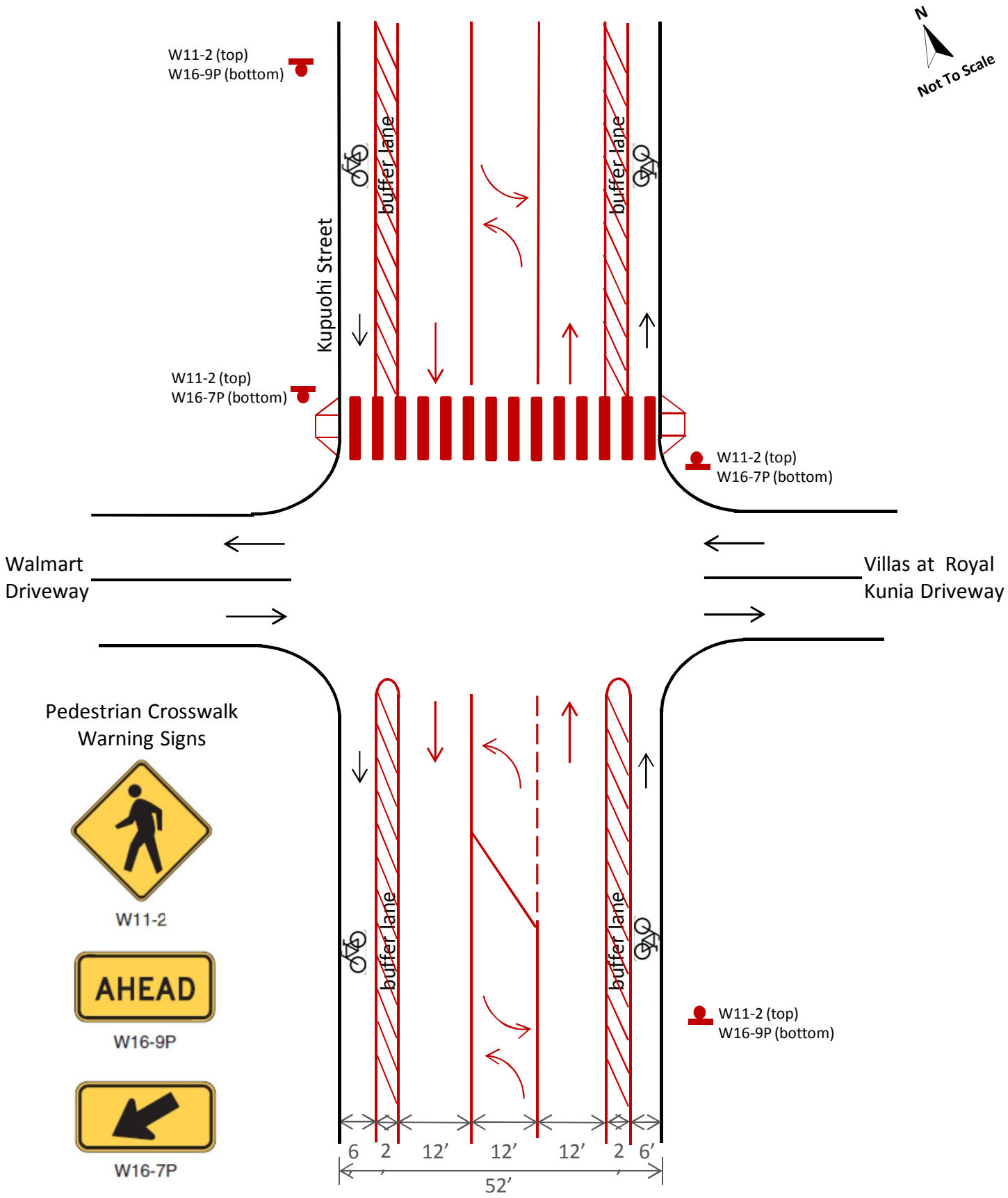

Figure 8: Kupuohi Street Pavement Markings and Pedestrian Crossing

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c) ***Anonui Street***

- Speeding:
  - Due to the low volumes and high speeds, a road diet should be considered, reconfiguring the roadway cross-section to a single through travel lane, with dedicated left-turn lanes, and bike lanes with buffer (see Figure 9 and Appendix D – Mitigation #8). Although Anonui Street is private from Kupuohi Street mauka, for continuity and desired results, the entire road should be considered for improvements along the sections with medians and without.
  - For overflow parking adjacent to the park (see photo below), a parking lane could be provided (see Appendix D – Mitigation #10).

Photo of existing pavement marking along Anonui Street adjacent to the park.

  - At the time in which future proposed developments in the area are built out and roadway capacity is needed, the additional travel lane could be added back.

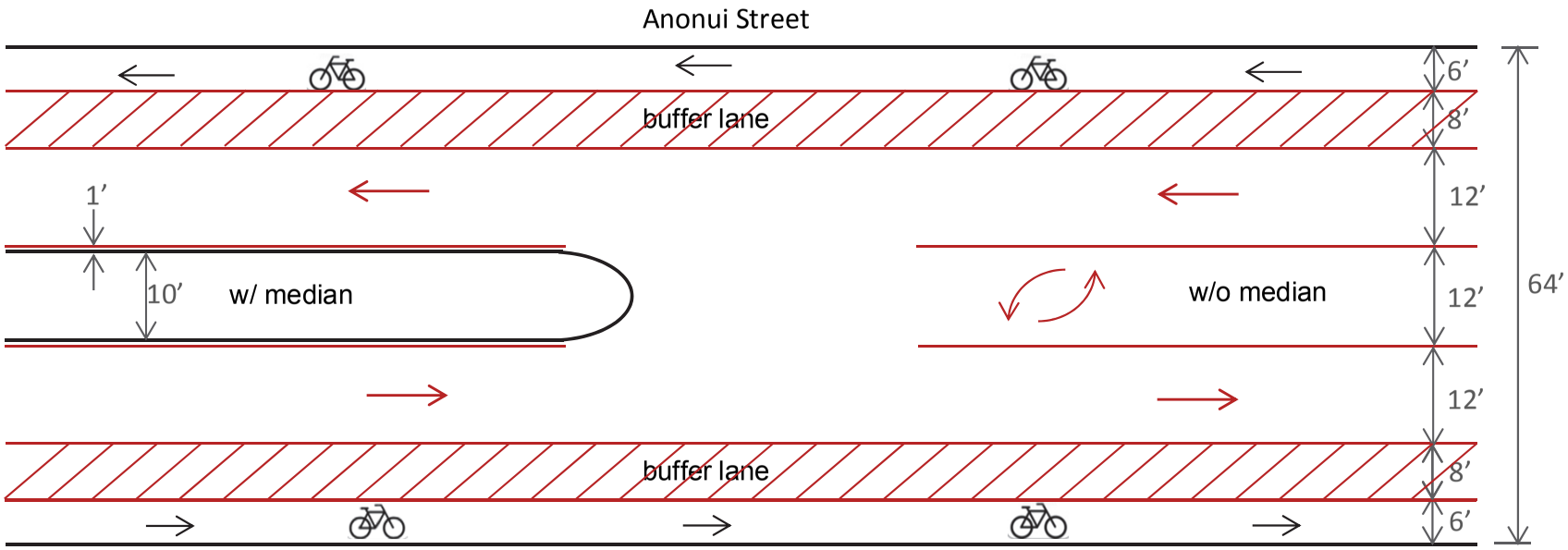

Figure 9: Anonui Street Pavement Marking

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- Reckless Driving:
    - With undesirable activities occurring at the dead end (see photo below), it is suggested to consider blocking off the end of the road with barriers (see Appendix D – Mitigation #11).

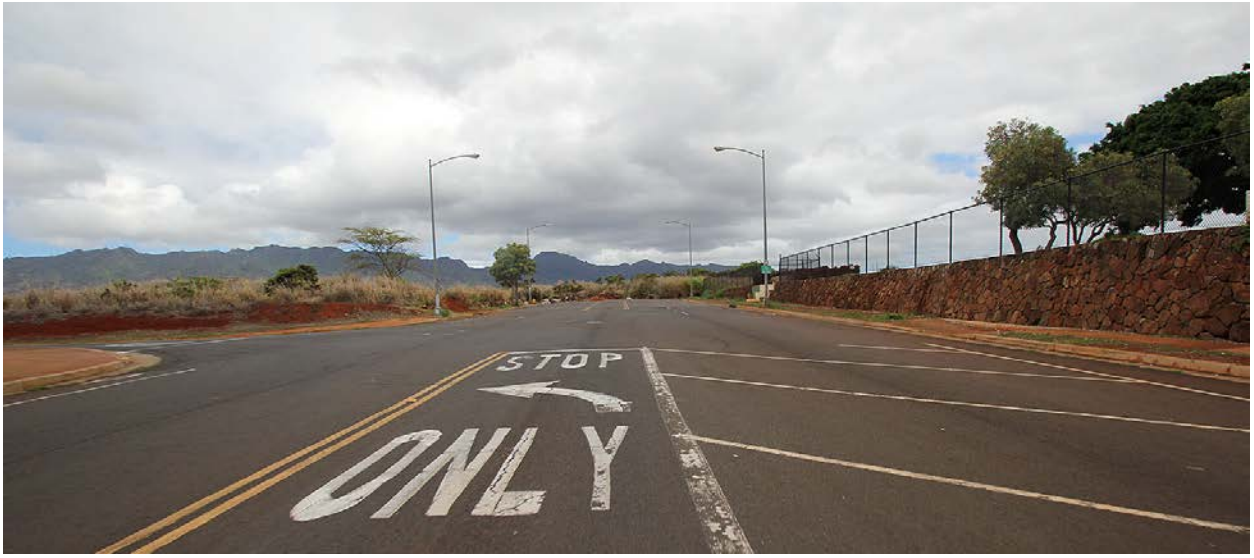

Photo of existing pavement marking at Anonui Street dead end.

- Pedestrian Access:
    - With walls and fences providing a physical barrier between the roadway and adjacent communities (see photo below), it is suggested to work with the neighborhood to improve walking access and pedestrian connectivity. This could potentially be accomplished by providing pedestrian paths connecting internal neighborhood cul-de-sacs to abutting roads.

Photo of neighborhood fences along Anonui Street.

D. Multi-Modal

1. Bus

Considering bus stop spacing, topography along the transportation network, trip generators, and adjacent property owners, existing locations were determined to be appropriate.

2. Pedestrian

Acceptable pedestrian access exists throughout the study area. Reduced vehicle speeds will increase safety for pedestrian crossings and the relocation of vehicles previously extending out of driveways and across sidewalks will allow for ease of travel.

3. Bicycle

Additional bike lanes and buffers throughout the study area will improve connectivity, making bicycle travel a more likely transportation option. The steep grades will remain a deterrent for many recreational riders.

E. Public Meeting

Members from DTS and the consultant project team presented to the residents of the Village Park Community Association on February 11, 2015. Councilmember Ron Menor and State Representative Ty Cullen were also in attendance. The proposed mitigation measures at several locations within the neighborhood were discussed as they related to known concerns. Conceptual design plans of these mitigation measures were also displayed. There were no objections to the proposed mitigation measures. Community members inquired when these changes could be implemented. For mitigation measures that can be accomplished using pavement marking, DTS members noted that they will work with the Department of Facility Maintenance and Department of Design and Construction to examine the possibility of implementing these changes during the rehabilitation of the streets in the project area. A community member also noted that Walmart trucks idle in the outside lane along Kupuohi Street which would conflict with the proposed bike lane and buffer. It is the responsibility of individual stores to provide off-street loading areas and therefore the proposed mitigation measure along Kupuohi Street will remain.

IV. RECOMMENDATIONS

Analysis of accident data in the study showed the majority of accidents occurring in close proximity to the study intersections. A large number (62%) of accidents along all study roads involved collisions with objects outside of the travel way. A possible cause for the accidents is excessive speed which is in line with community concerns. Improved roadway pavement marking and travel way delineation are suggested countermeasures.

Site specific mitigative measures to consider are included in Table 13 and the proposed location of these measures are shown on Figure 10 and Figure 11. Conceptual designs for select locations are included in Appendix E with estimated construction costs in Table 14.

Table 13: Proposed Mitigation Measures

ID #	Mitigation	Locations
1	Reconfiguration of pavement marking and timing at signalized intersections	Kupuna Loop (upper) at Kupuohi Street
		Kupuna Loop (lower) at Kupuohi Street
2	Installation of additional barriers	Kupuna Loop (lower) between Kunia Road and Kupuohi Street
3	Single-lane roundabout	Kupuna Loop (lower) at Aiki Street
		Kupuna Loop (lower) at Kaaholo Street
4	Restripe roadway	Kupuna Loop east of Kupuohi Street
5	Traffic circle	Kupuna Loop (lower) at Kupuohi Street (lower)
		Kupuna Loop at Hamau Street
6	Traffic calming measures: bump-outs and additional signage	Kupuna Loop (upper) at Kaaholo Street (NW)
		Kupuna Loop (upper) at Kehela Street
		Kupuna Loop (upper) at Kahakea Street
		Kupuna Loop (lower) at Kahakea Street
7	Milled rumble strips or hatched pavement marking median	Kupuna Loop (lower) between Kupuohi Street (lower) and Aiki Street
8	Road Diet	Kupuohi Street between Anonui Street and Kupuna Loop (upper)
		Kupuohi Street between Kupuna Loop (upper) and Kupuna Loop (lower)
		All throughout Anonui Street
9	Marked crosswalks, median refuge, and pedestrian activated flashing beacon	Kupuohi Street at Polina Place
		Kupuohi Street at Walmart driveway (makai)/ The Villas at Royal Kunia driveway
		Kupuohi Street at Mauele Street
10	Overflow parking	Anonui Street near Community Park
11	Road block	North end of Anonui Street

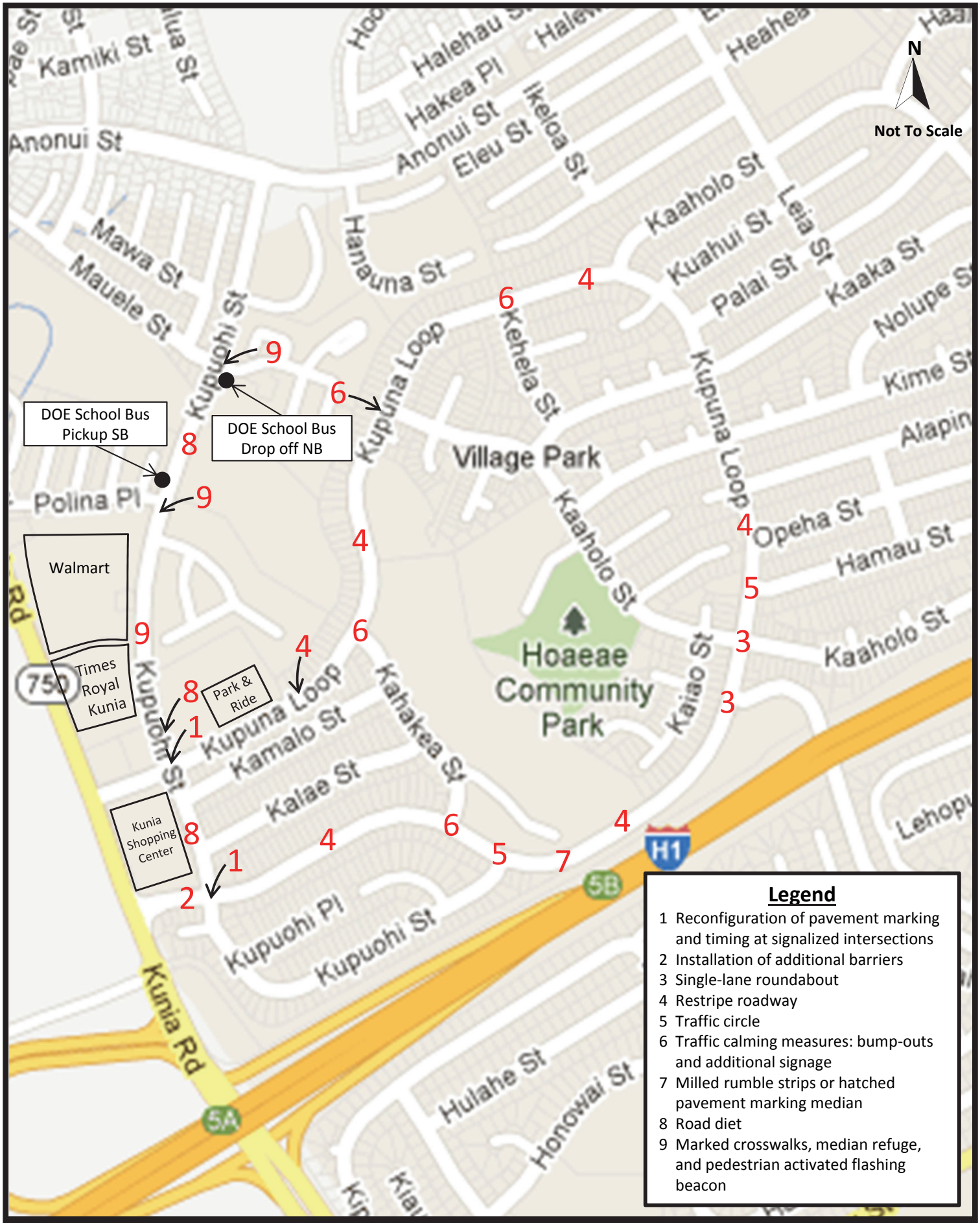

Figure 10: Village Park Mitigation Map

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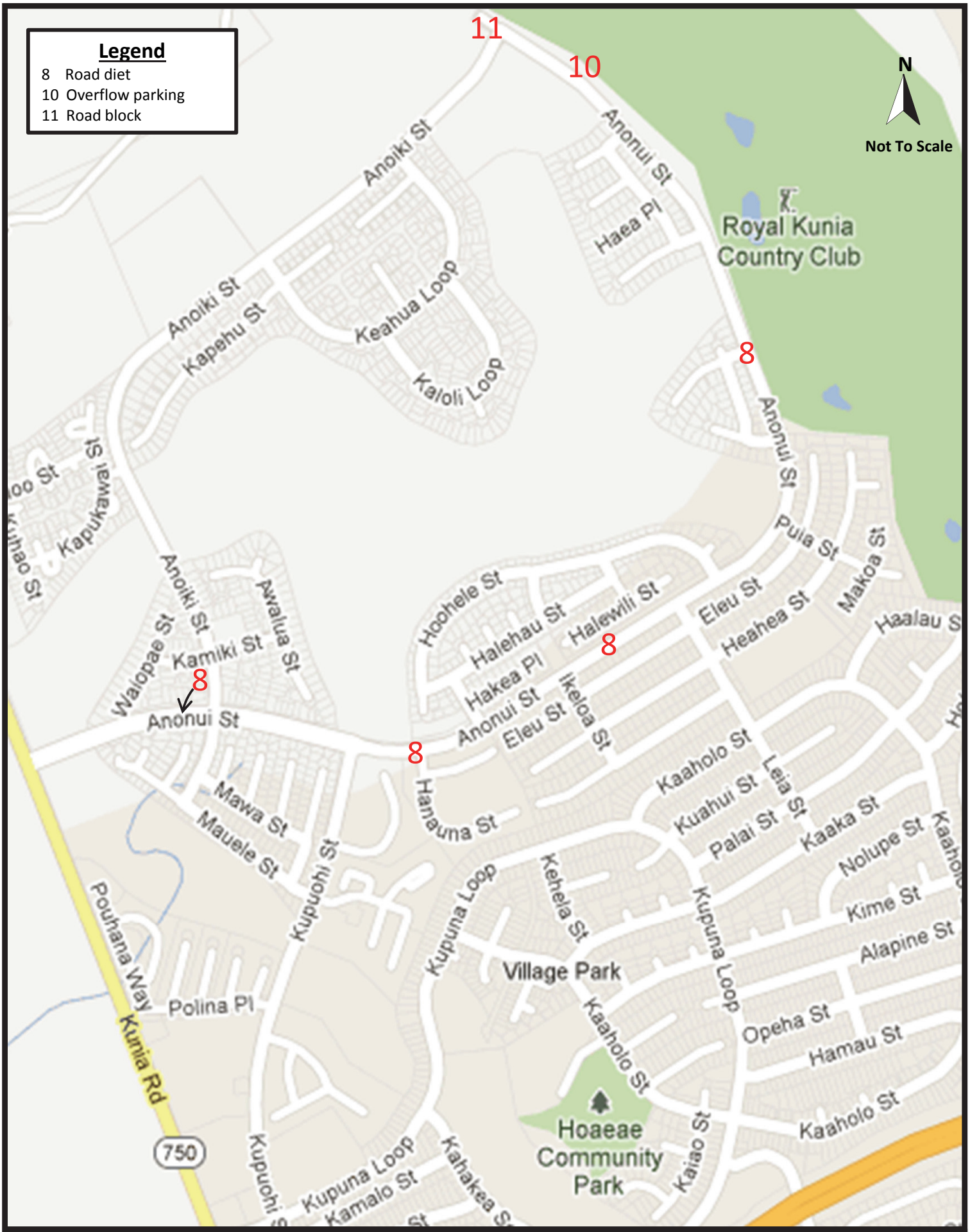

Figure 11: Royal Kunia Mitigation Map

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Table 14: Mitigation Measure Estimated Cost

ID #	Mitigation	Locations	Estimated Cost
1	Reconfiguration of pavement marking and timing at signalized intersections	Kupuna Loop (upper) at Kupuohi Street	$115,000+
		Kupuna Loop (lower) at Kupuohi Street	
3	Single-lane roundabout	Kupuna Loop (lower) at Aiki Street ^	$969,000+
		Kupuna Loop (lower) at Kaaholo Street	
5	Traffic circle	Kupuna Loop (lower) at Kupuohi Street (lower) *	$120,000
6	Traffic calming measures: bump-outs and additional signage	Kupuna Loop (upper) at Kaaholo Street (NW)	$106,000
9	Marked crosswalks, median refuge, and pedestrian activated flashing beacon	Kupuohi Street at Polina Place	$159,000

^ - Intersection of Kupuna Loop (lower) at Aiki Street: Traffic Signal - $500,000; Lane Reconfiguration - $95,000
+ - This represents the total construction cost estimate of the specified mitigating measure for both intersections. The cost to install a traffic signal at both intersections would be approximately $1,000,000.

V. REFERENCES

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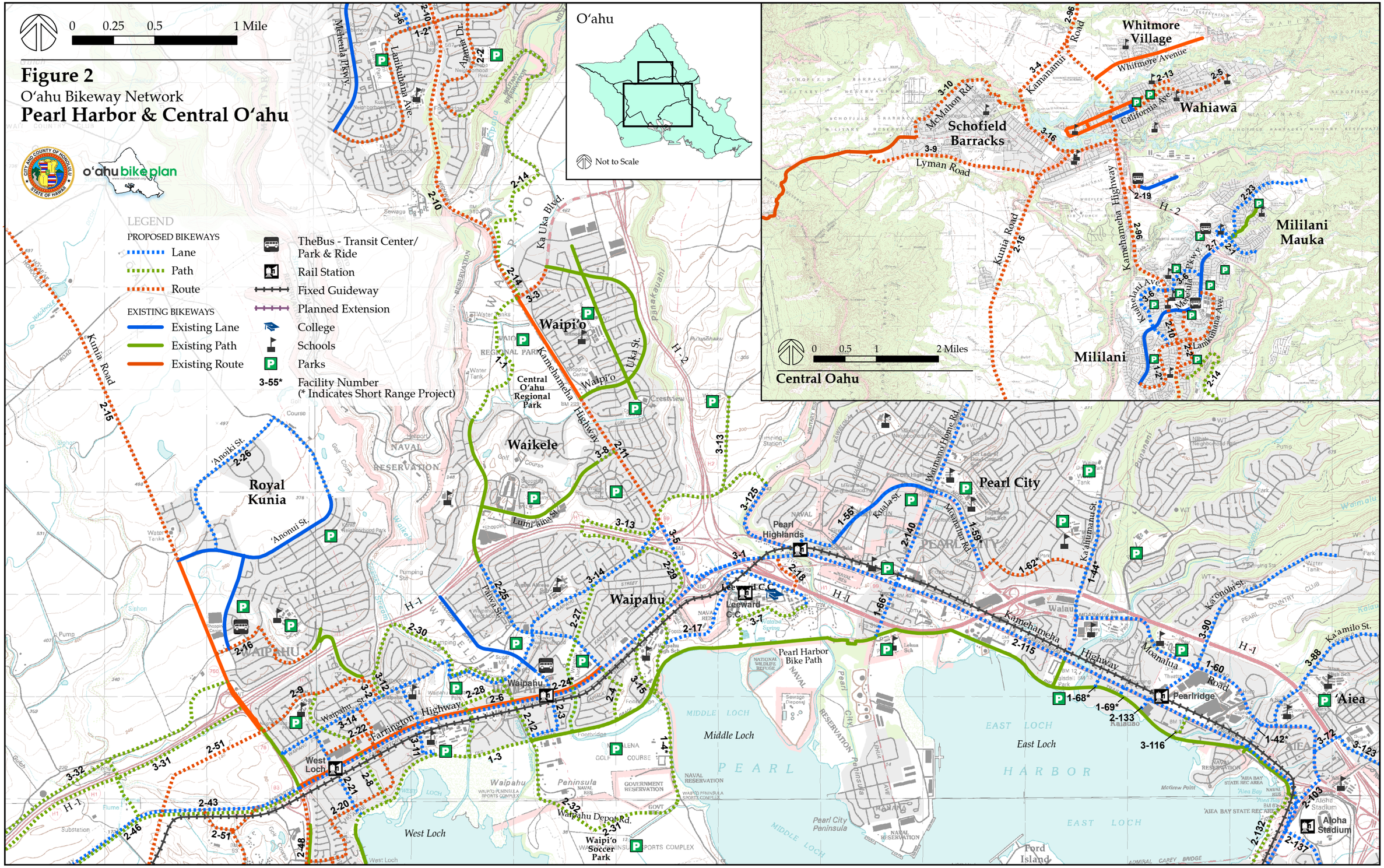
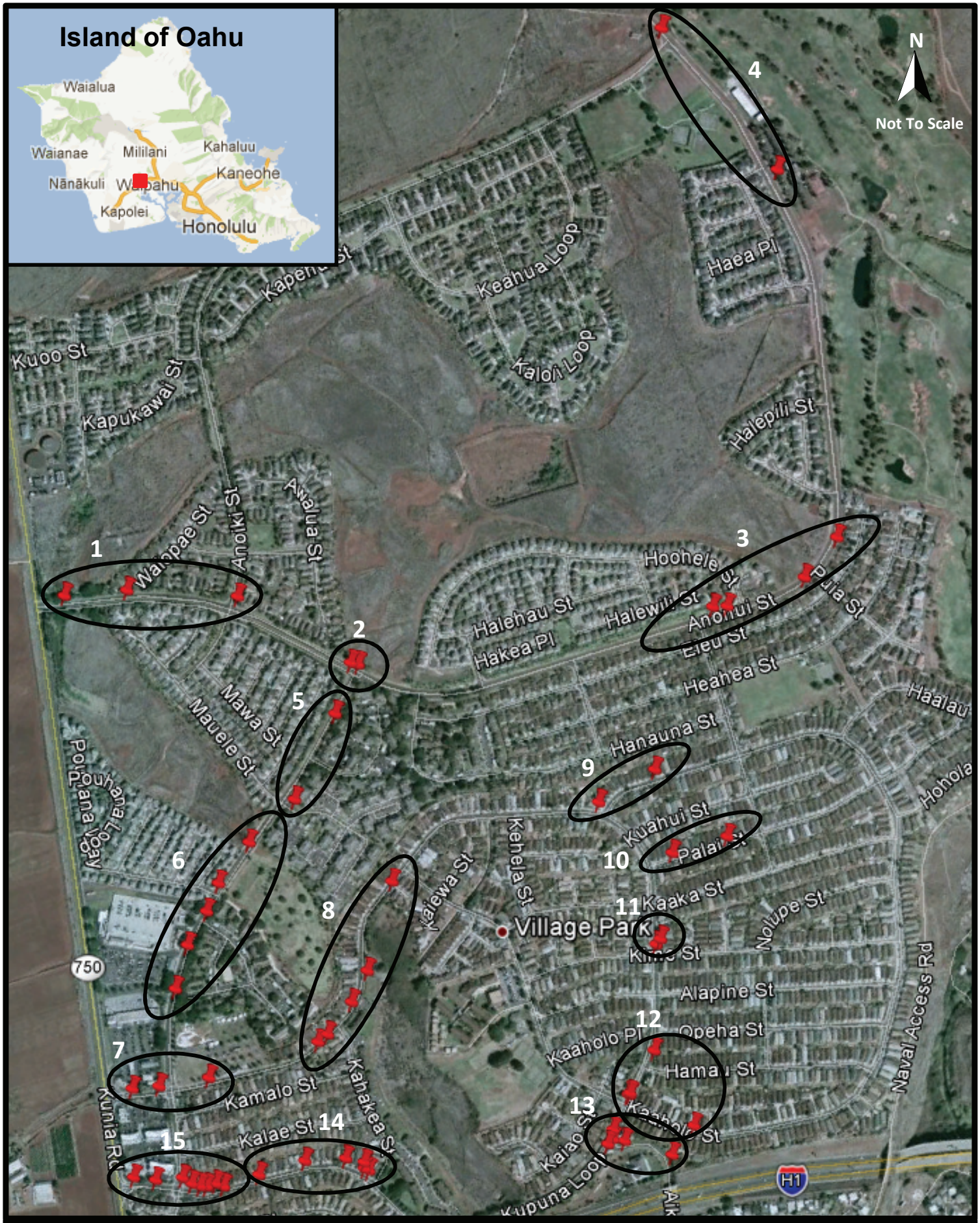
APPENDIX A
Oahu Bike Plans – Village Park


0 0.25 0.5 1 Mile
Figure 2
O'ahu Bikeway Network
Pearl Harbor & Central O'ahu
o'ahu bike plan
LEGEND
PROPOSED BIKEWAYS
Lane
Path
Route
EXISTING BIKEWAYS
Existing Lane
Existing Path
Existing Route
TheBus - Transit Center/ Park & Ride
Rail Station
Fixed Guideway
Planned Extension
College
Schools
Parks
3-55* Facility Number (* Indicates Short Range Project)
O'ahu
Not to Scale
Central Oahu
0 0.5 1 2 Miles
Whitmore Village
Wahiawā
Schofield Barracks
Mililani Mauka
Mililani
Waipi'o
Waikele
Royal Kunia
Pearl City
Pearl Highlands
Waipahu
Pearlridge
'Aiea
Aloha Stadium
Central O'ahu Regional Park
Waipi'o Soccer Park
West Loch
Middle Loch
East Loch
Pearl Harbor Bike Path
PEARL HARBOR
Ford Island
Pearl City Peninsula
Leeward C.C.
Kunia Road
Farrington Highway
Kamehameha Highway
Moanalua Road
Lyman Road
Kunia Road
Waipahu Depot Rd.
Ka Uka Blvd.
Waipi'o Uka St.
Mililani Pkwy.
Meheula Pkwy.
Lanikuhana Ave.
Anonui St.
Anoiki St.
Luamanaiina St.
Waipahu St.
Kuala St.
Moanalua Rd.
Waimano Home Rd.
Kaahumanu St.
Ka'onohi St.
Ka'amilo St.
California Ave.
Whitmore Avenue
Kamananui Road
McMahon Rd.
H-1
H-2

APPENDIX B
Collision Diagrams

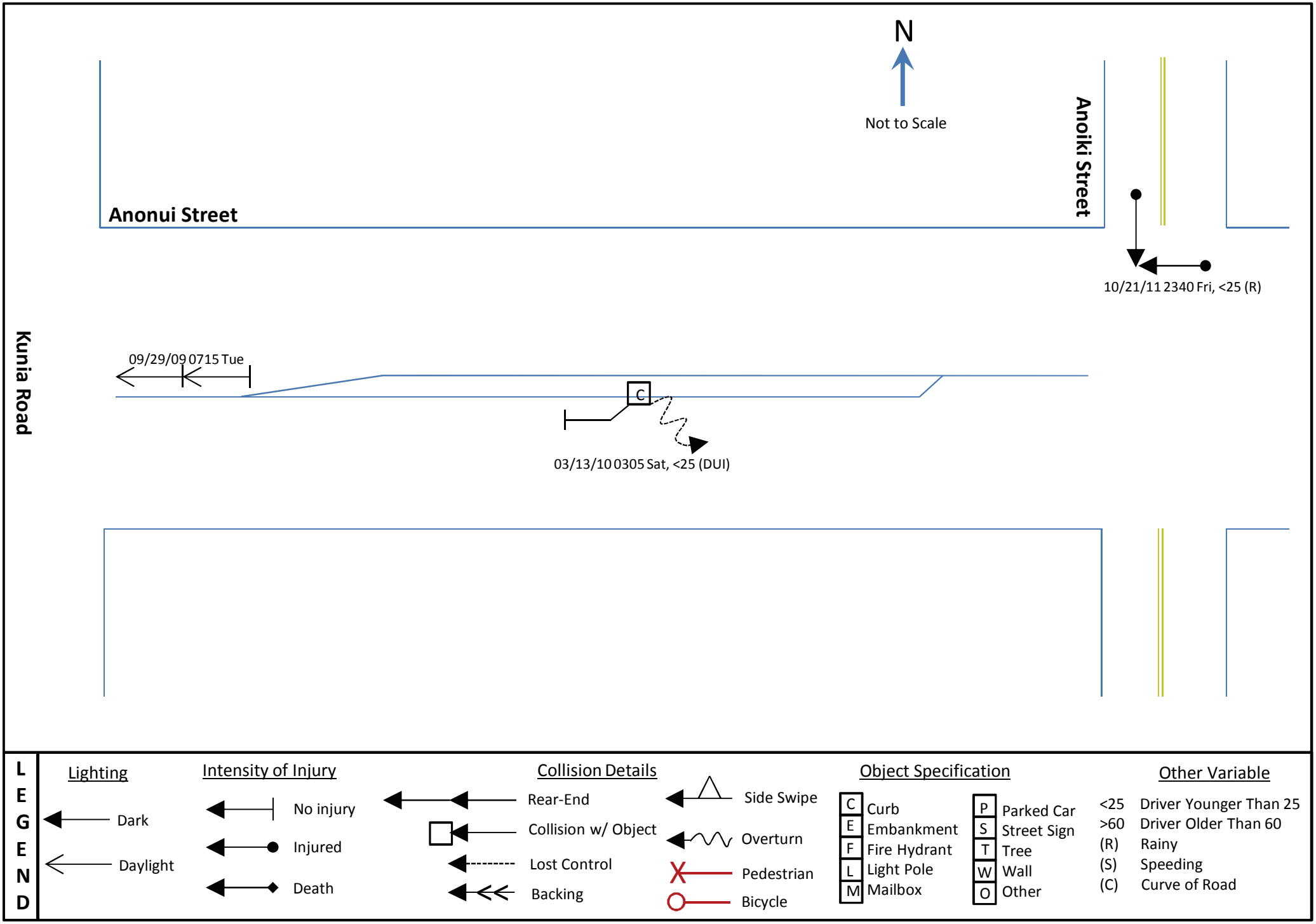


Collision Diagram Key Map

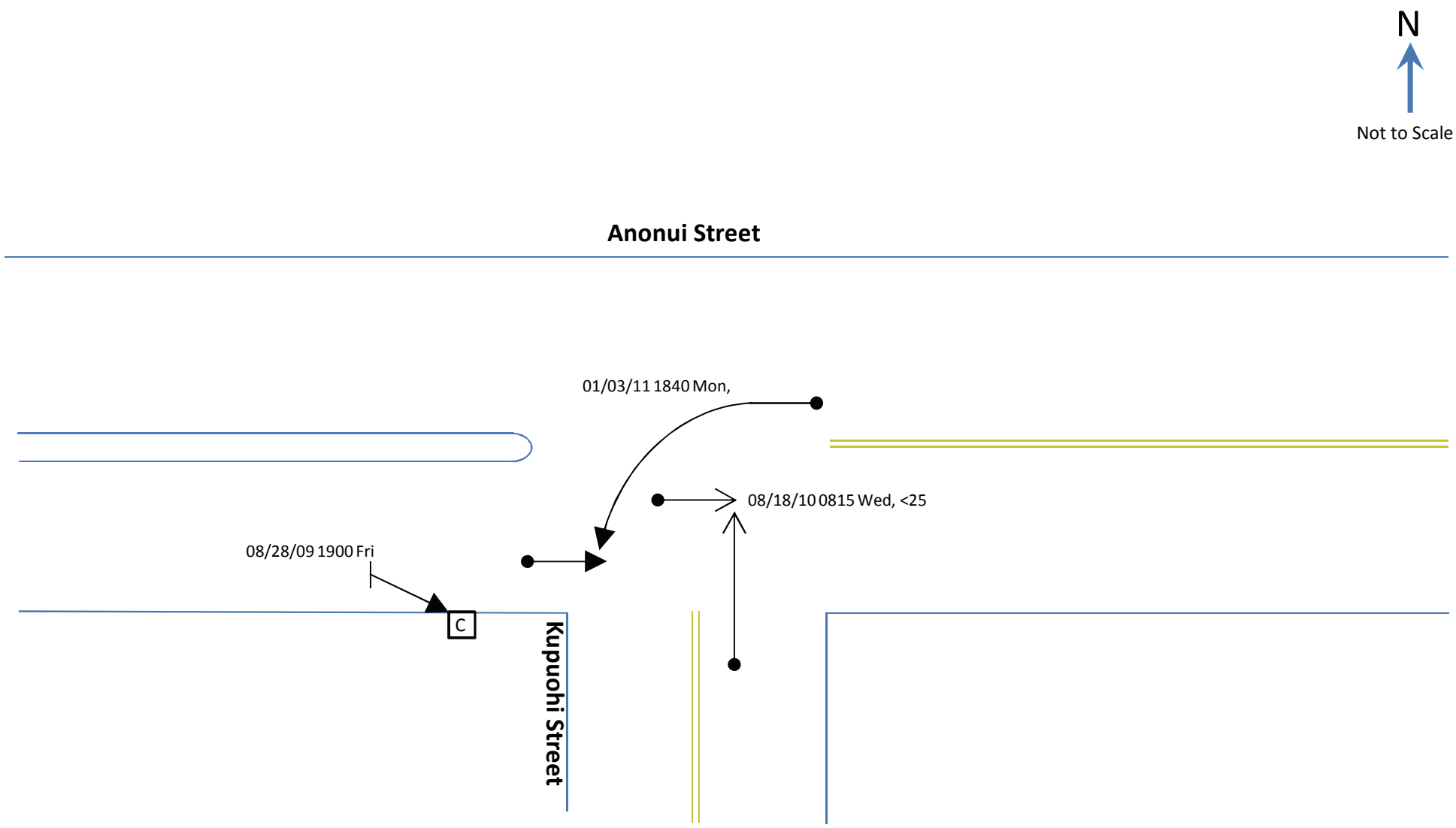
Village Park Corridor Study – Kunia, Hawaii

SSFM INTERNATIONAL

Location #1 – Anonui Street (Kunia Road - Anoiki Street)



Location #2 – Anonui Street & Kupuohi Street Intersection



LEGEND

Lighting
- Dark
- Daylight

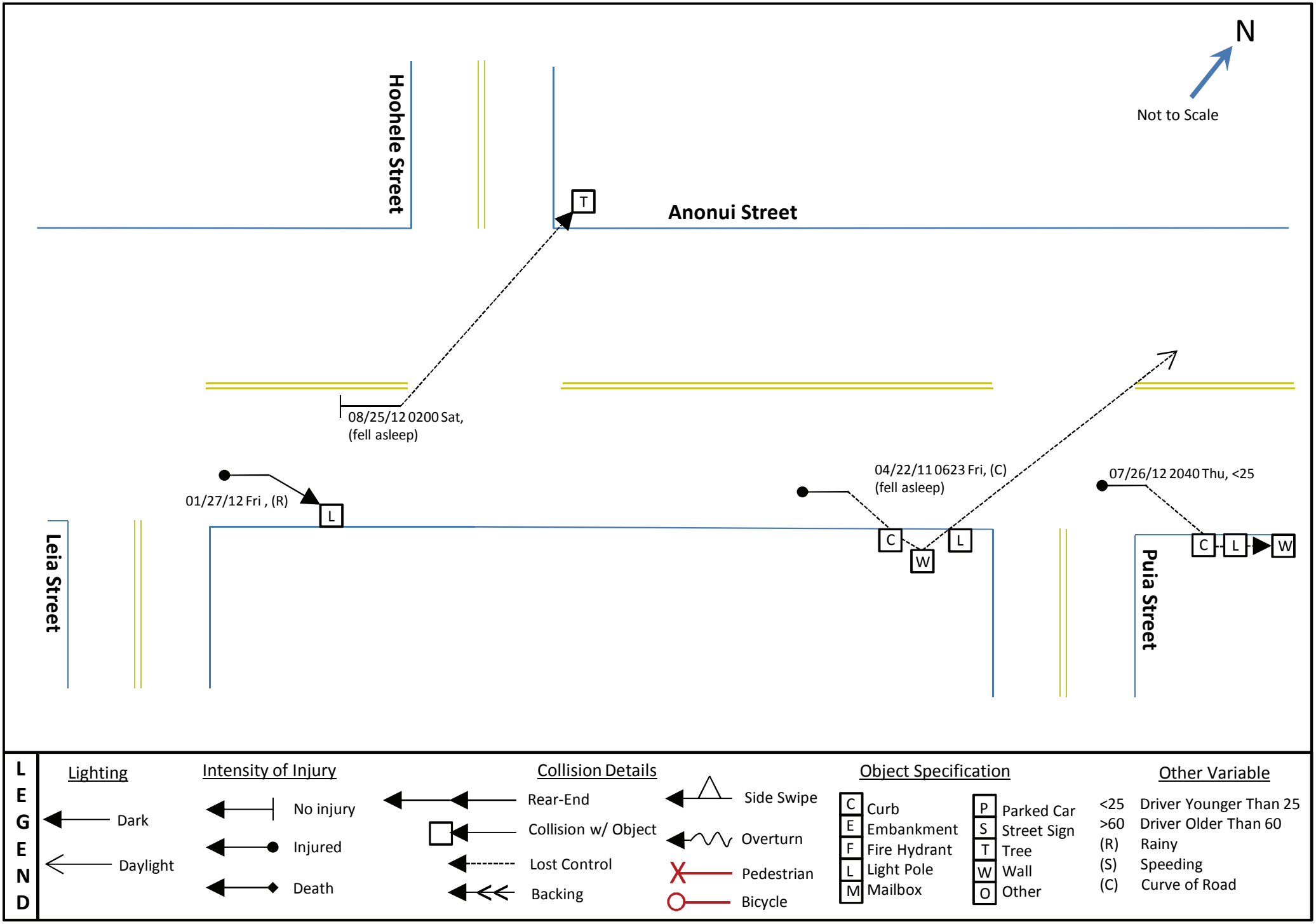
Intensity of Injury
- No injury
- Injured
- Death

Collision Details
- Rear-End
- Collision w/ Object
- Lost Control
- Backing
- Side Swipe
- Overturn
- Pedestrian
- Bicycle

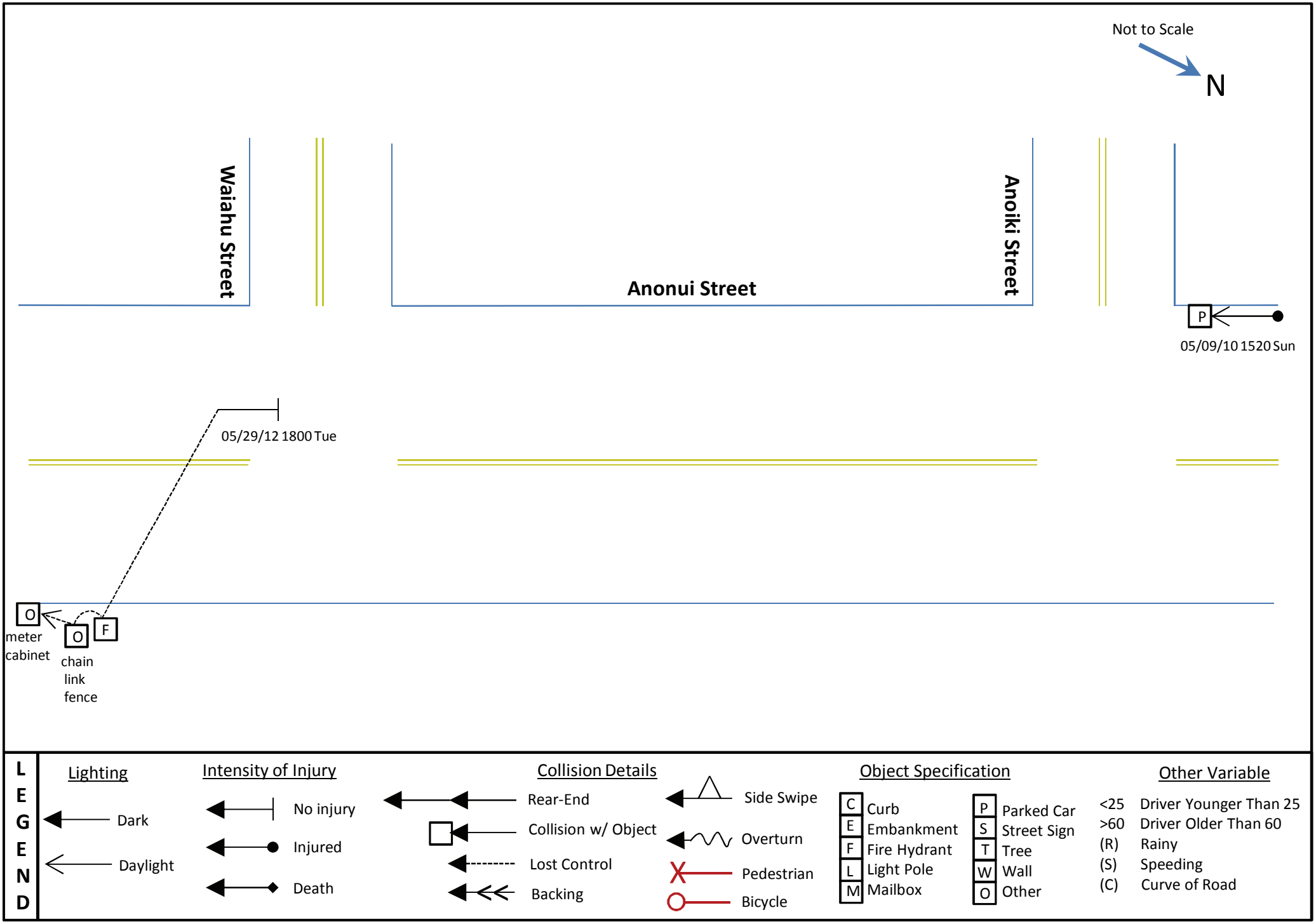
Object Specification
- C Curb
- E Embankment
- F Fire Hydrant
- L Light Pole
- M Mailbox
- P Parked Car
- S Street Sign
- T Tree
- W Wall
- O Other

Other Variable
- <25 Driver Younger Than 25
- >60 Driver Older Than 60
- (R) Rainy
- (S) Speeding
- (C) Curve of Road

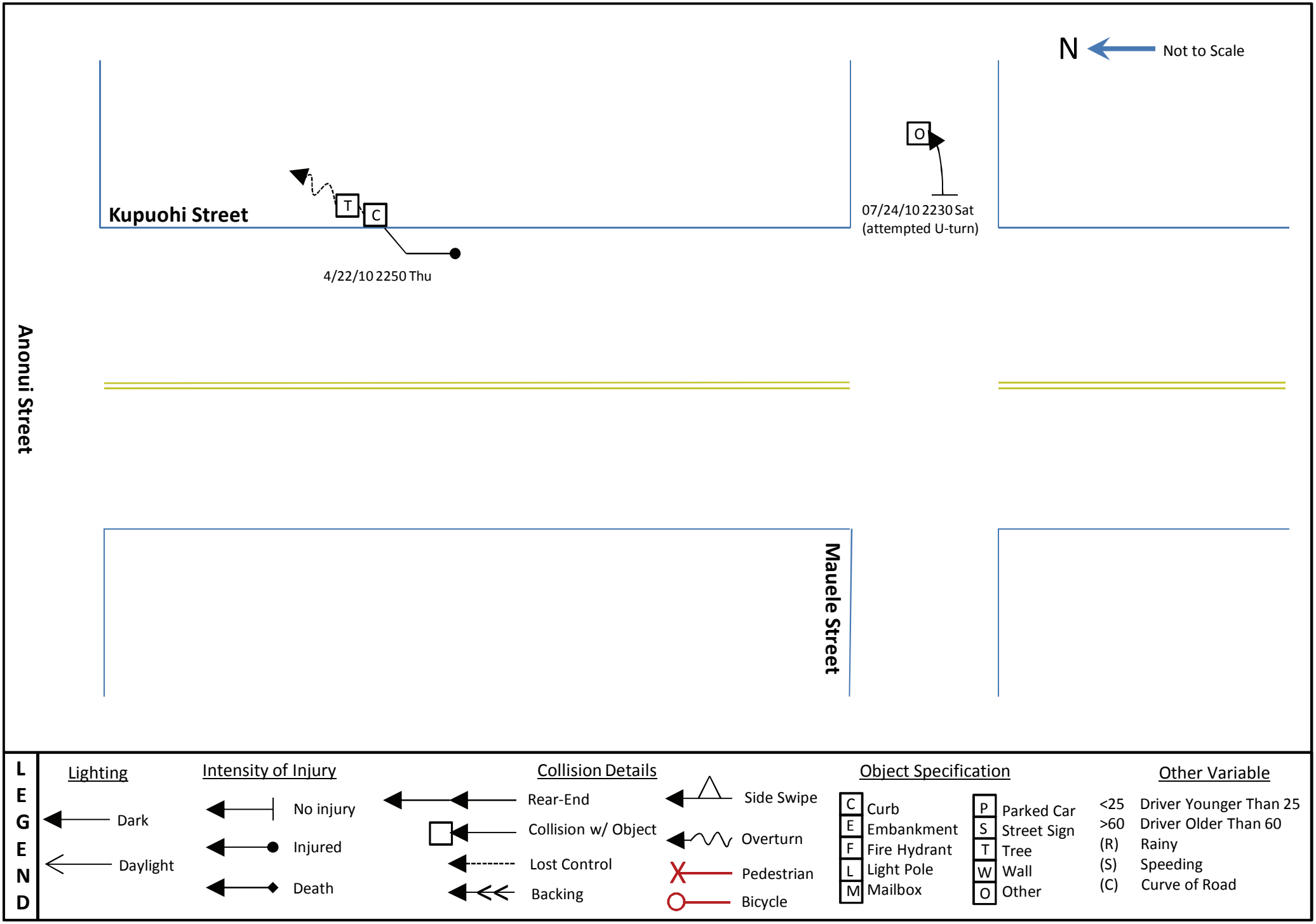
Location #3 – Anonui Street (Leia Street - Puia Street)



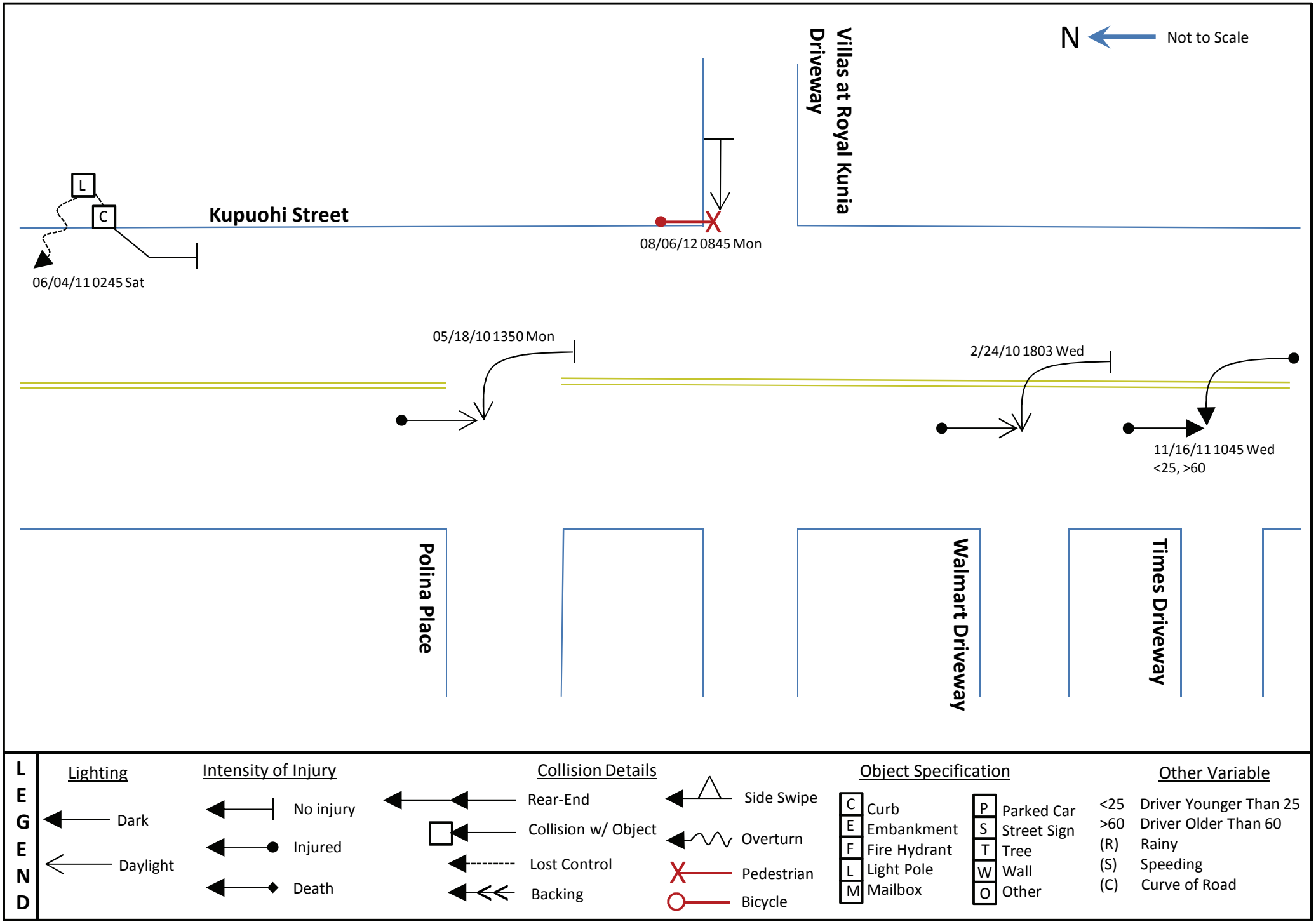
Location #4 – Anonui Street (Waiahu Street - Anoiki Street)



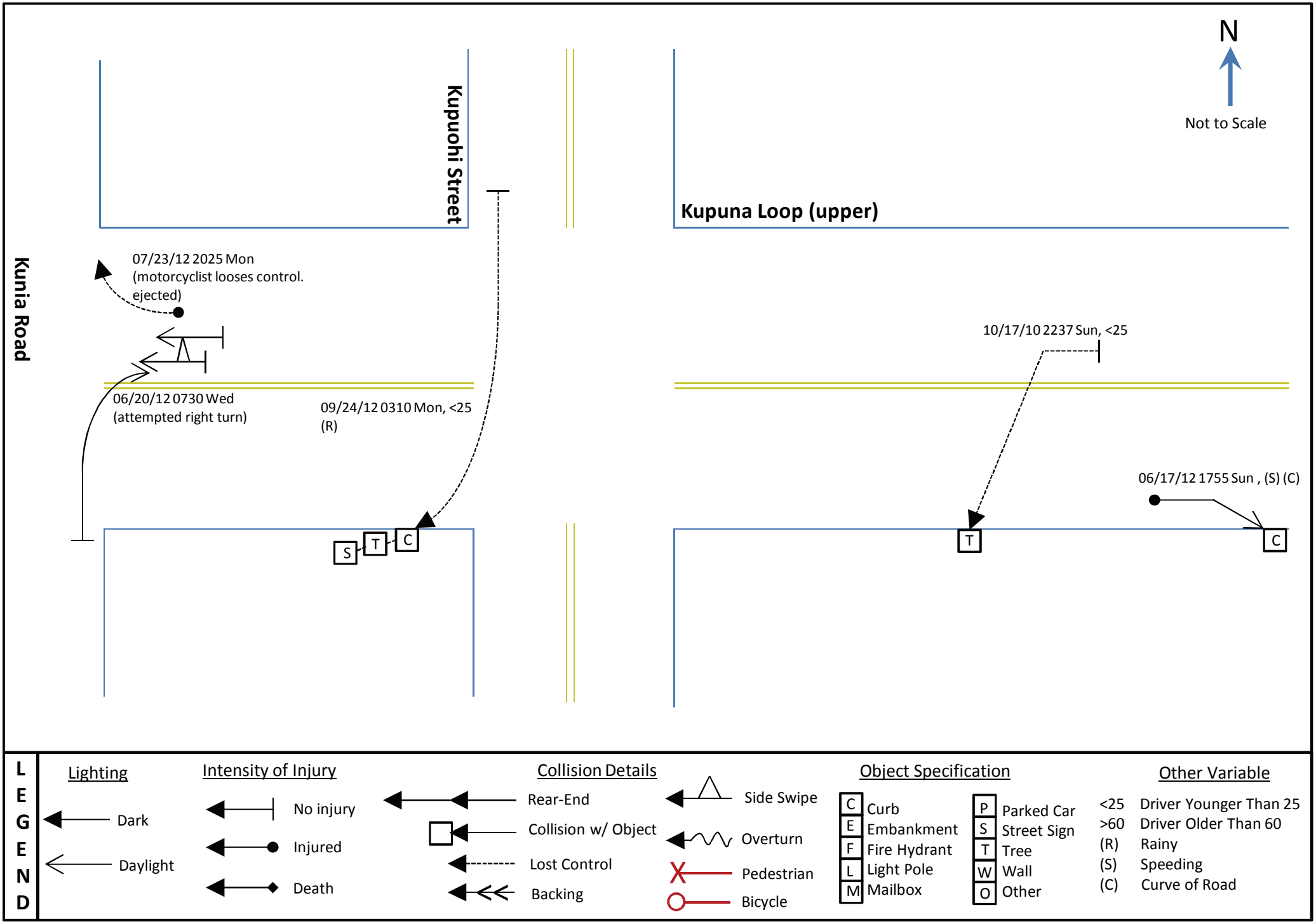
Location #5 – Kupuohi Street (Anonui Street - Maule Street)



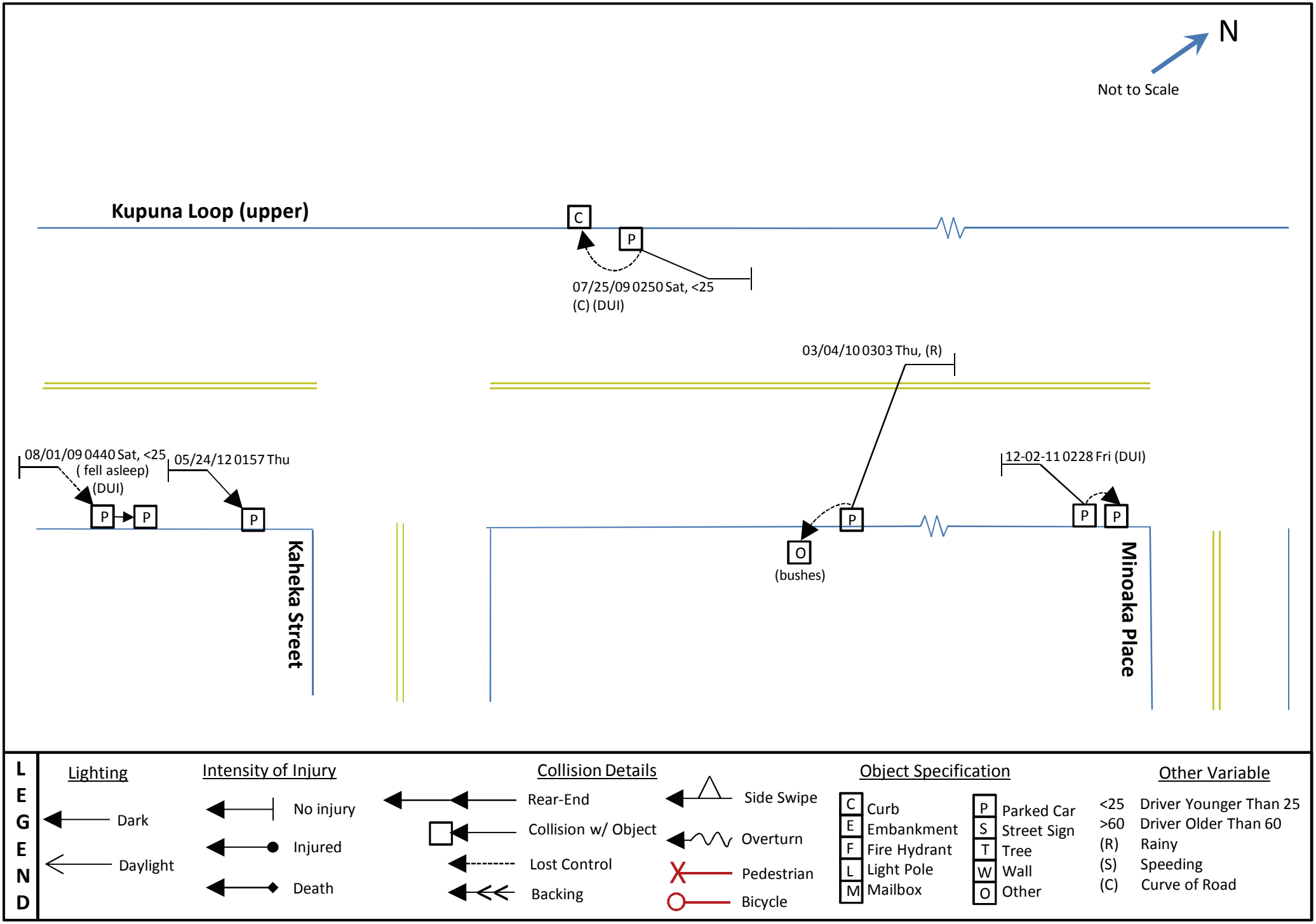
Location #6 – Kupuohi Street (Maule Street - Times Driveway)



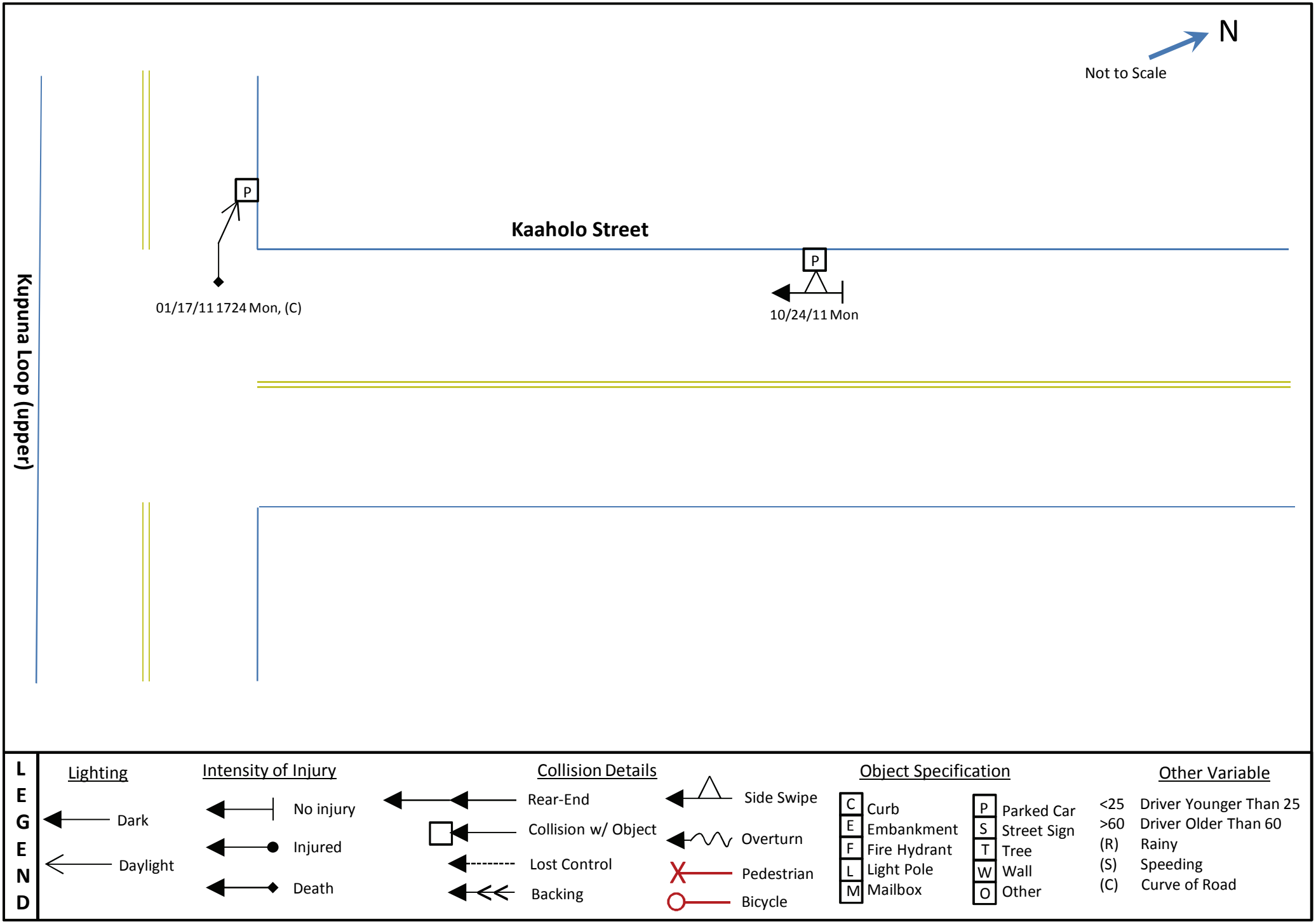
Location #7 – Kupuna Loop (upper) & Kupuohi Street Intersection



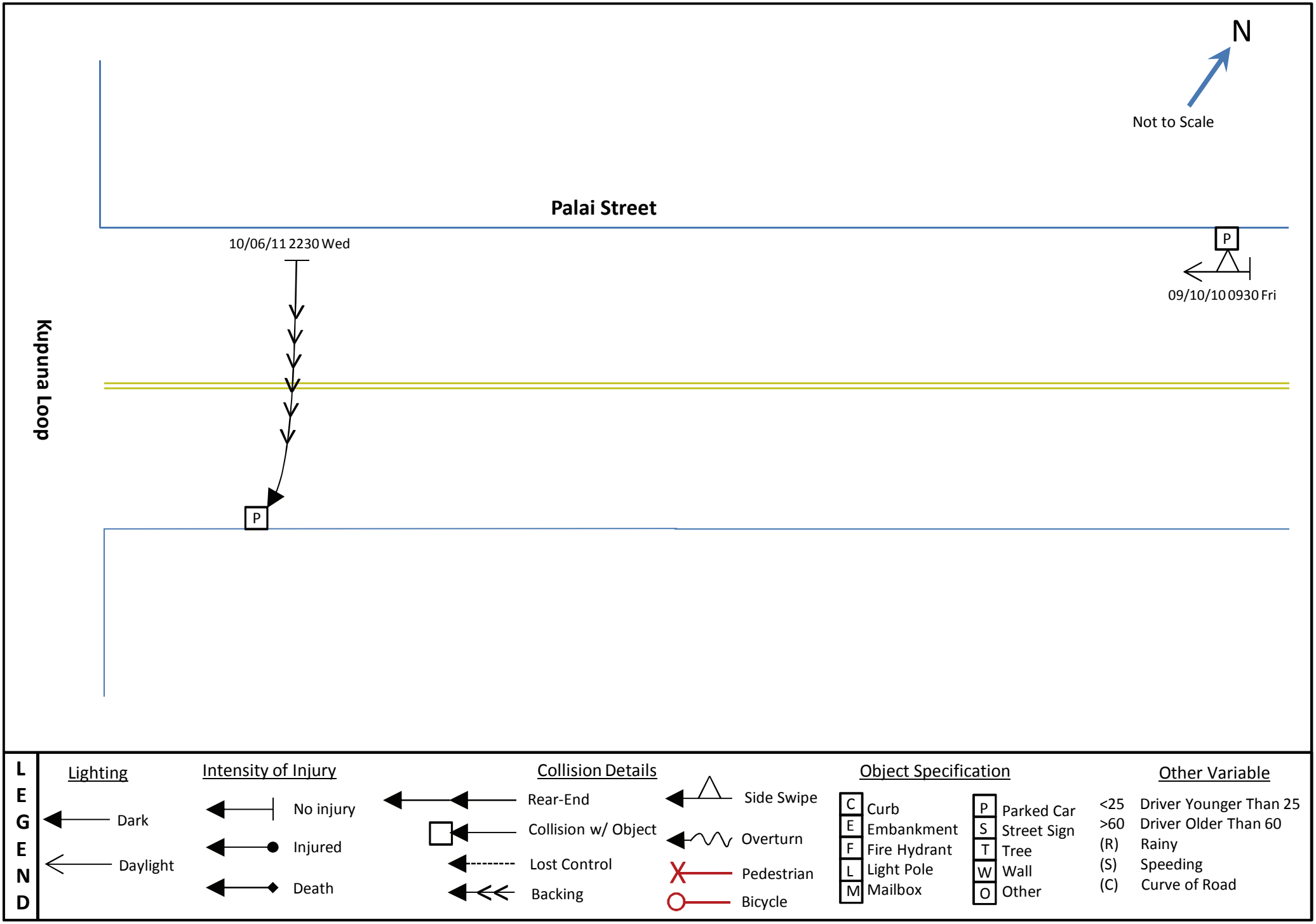
Location #8 – Kupuna Loop (upper) (Kaheka Street - Minoaka Place)



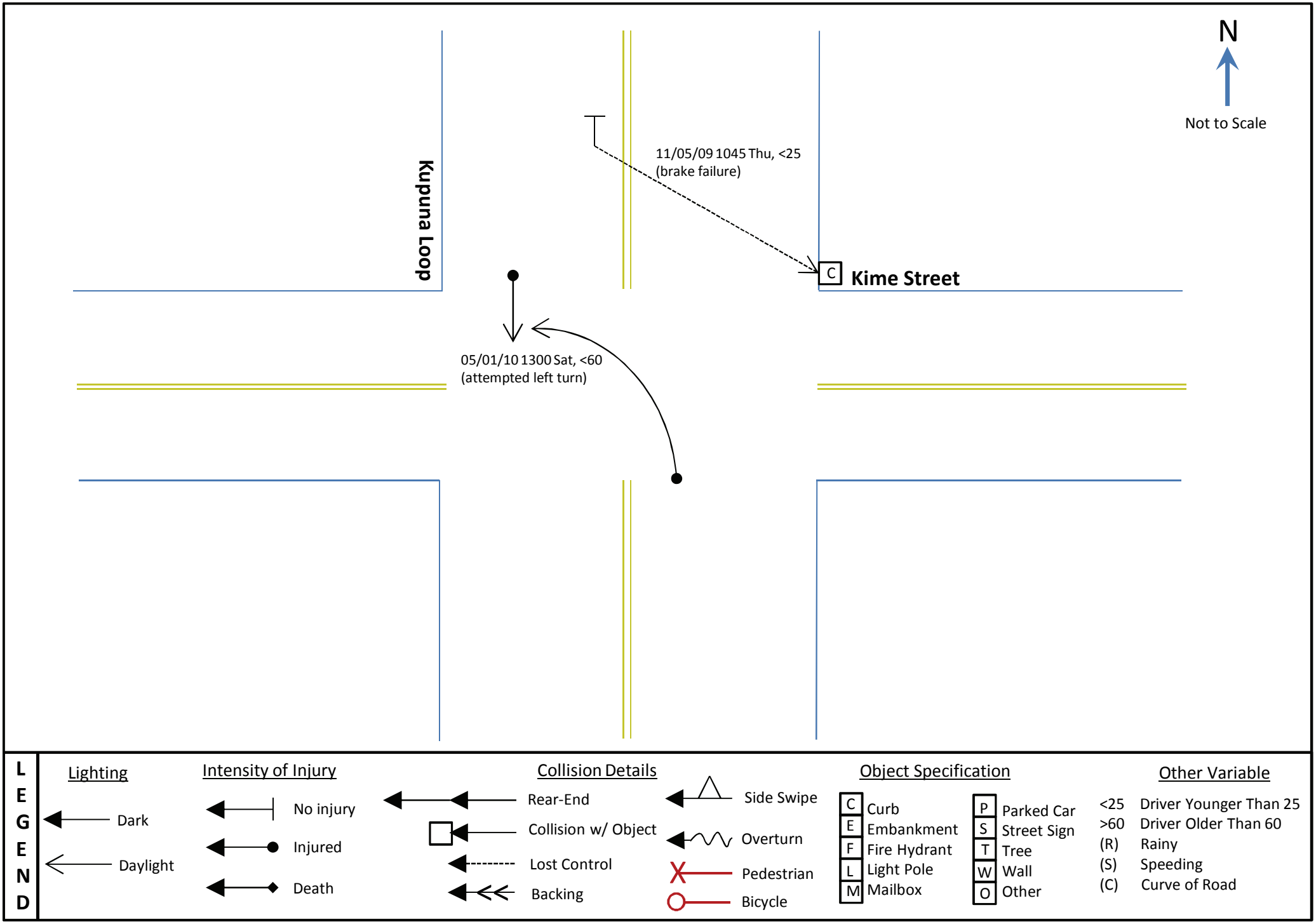
Location #9 – Kaaholo Street (Kupuna Loop (upper) - Leia Street)



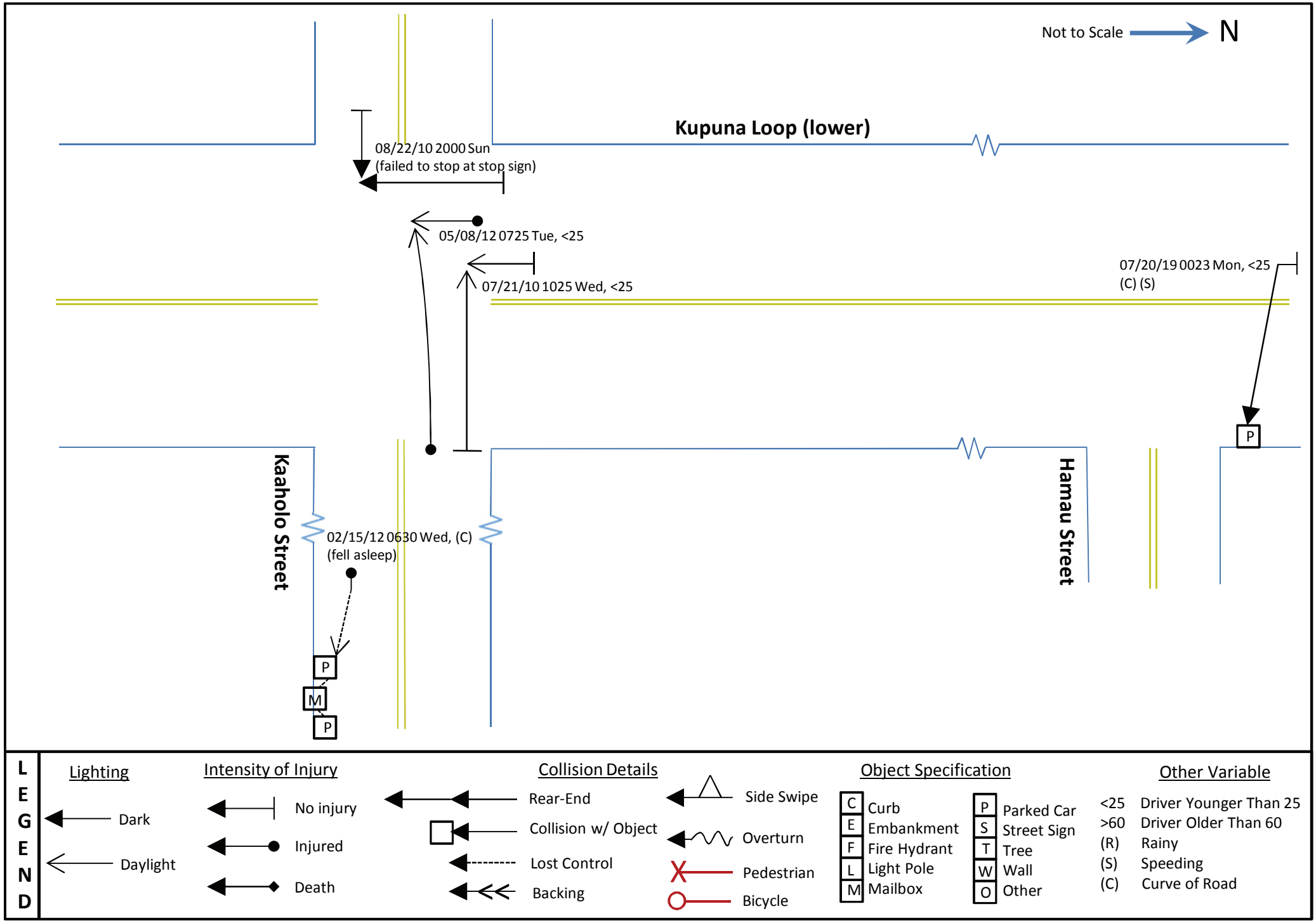
Location #10 – Palai Street (Kupuna Loop (upper) - Leia Street)



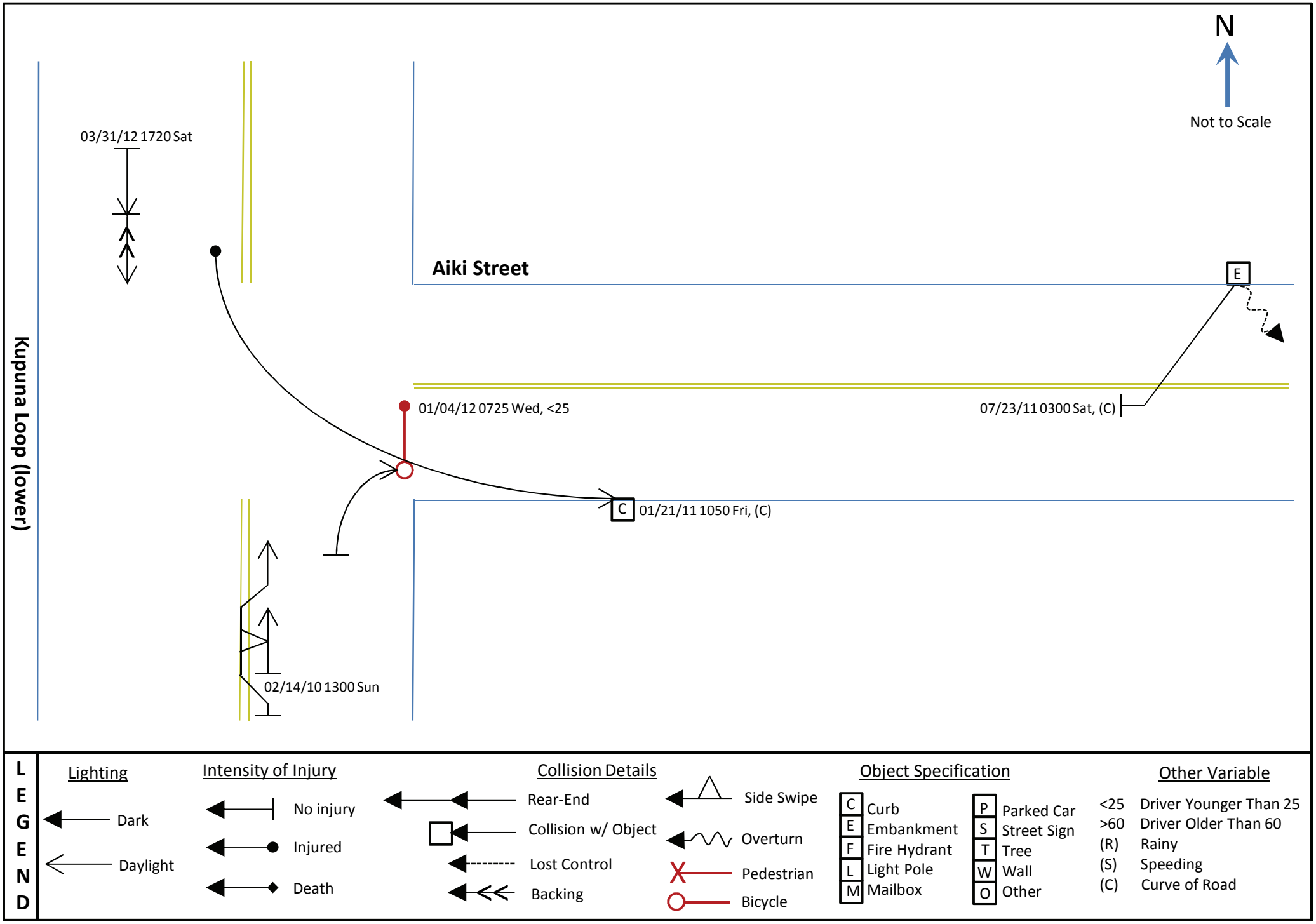
Location #11 – Kupuna Loop & Kime Street Intersection



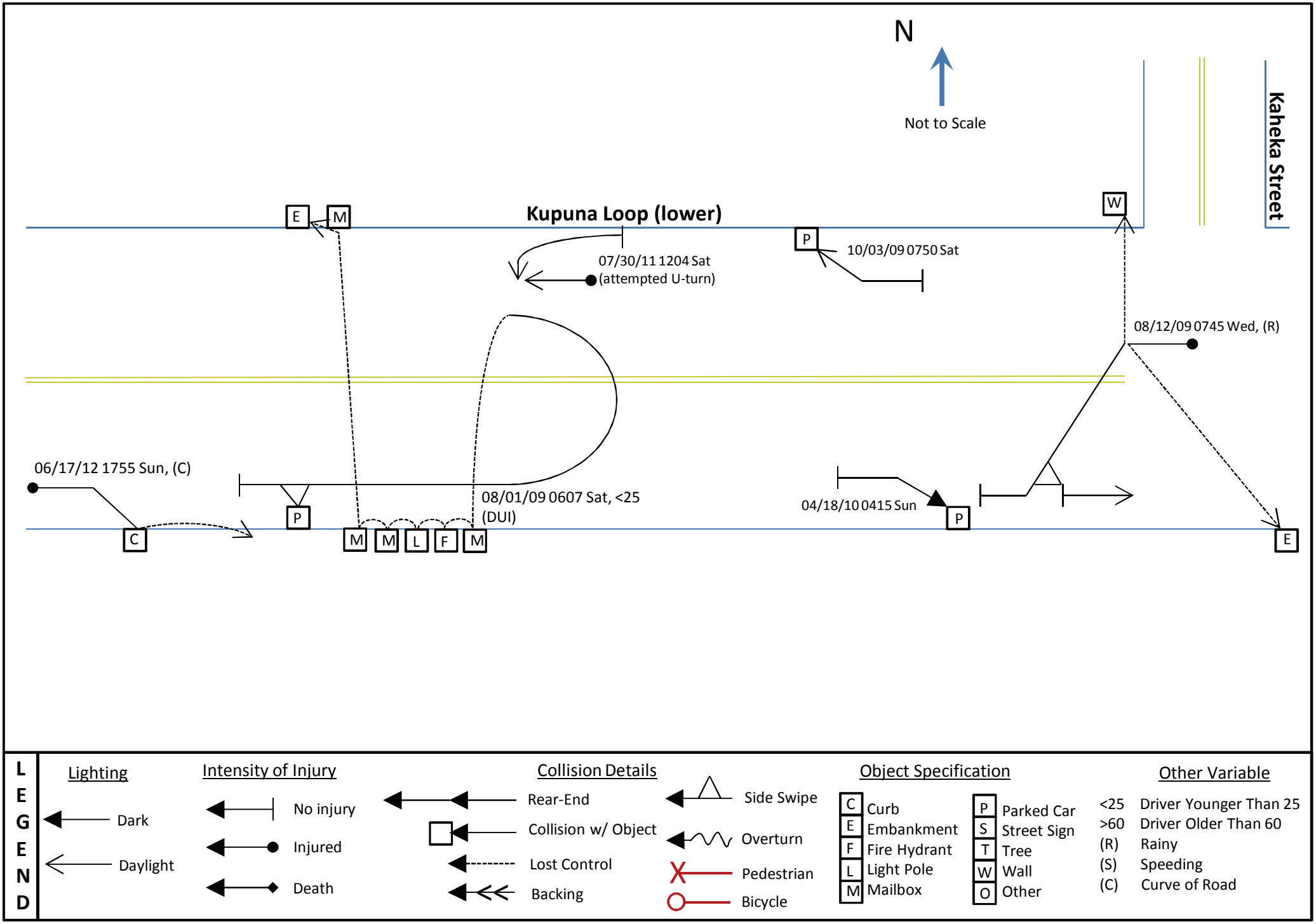
Location #12 – Kupuna Loop (lower) (Kaaholo Street - Hamau Street)



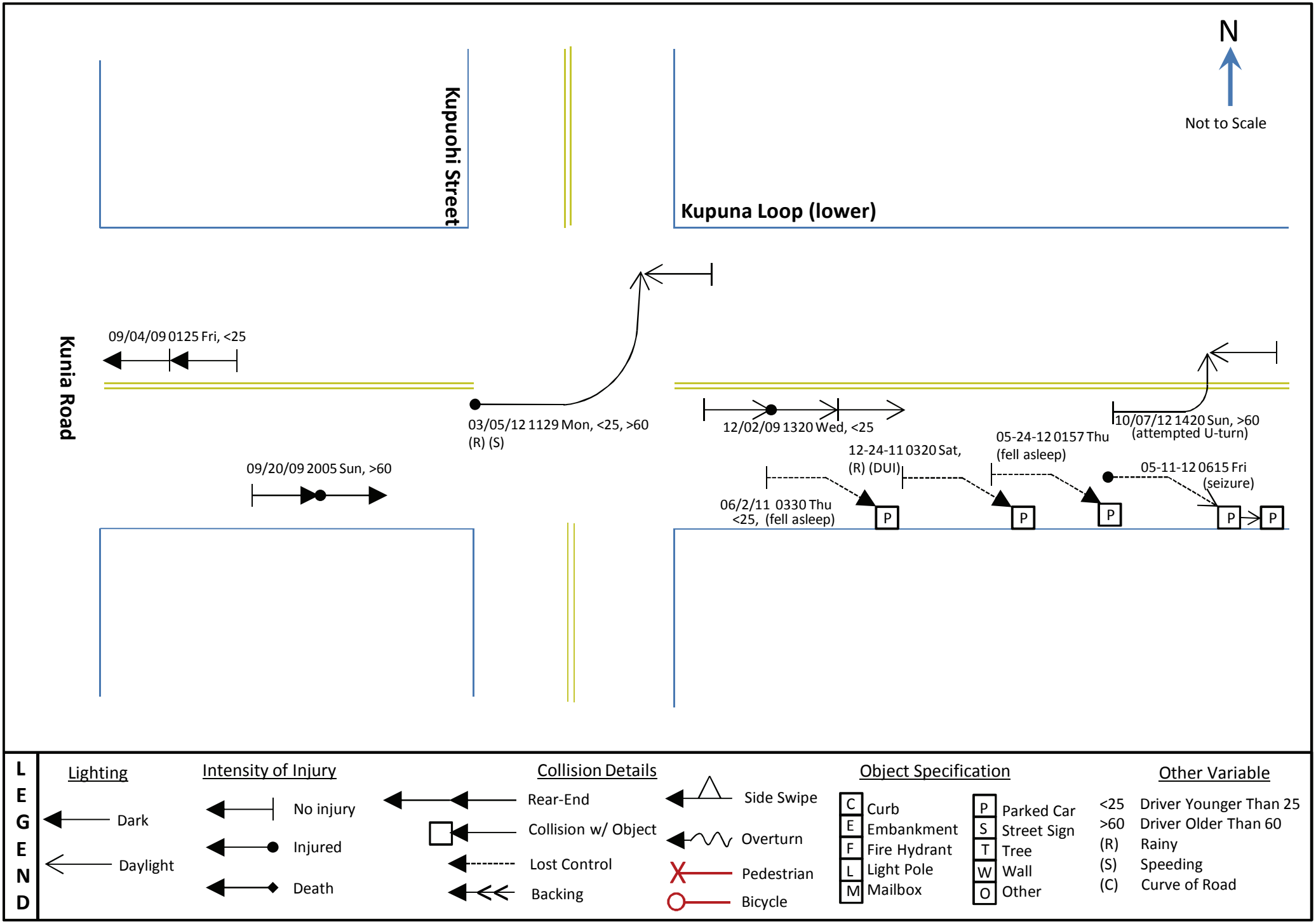
Location #13 – Kupuna Loop (lower) & Aiki Street Intersection



Location #14 – Kupuna Loop (lower) (Kupuohi Street - Kaheka Street)



Location #15 – Kupuna Loop (lower) & Kupuohi Street Intersection



APPENDIX C
Level of Service Analysis Reports

Kupuohi Street at
Kupuna Loop (upper)

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	174	36	55	24	77	74	22	159	18	95	144	235
Number	5	2	12	1	6	16	3	8	18	7	4	14
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	184.5	184.5	184.5	184.5	184.5	184.5	184.5	184.5	184.5	184.5	184.5	184.5
Lanes	1	1	0	1	2	0	1	1	0	1	1	1
Cap, veh/h	457	380	586	419	482	416	306	487	56	316	553	878
Arrive On Green	0.26	0.58	0.58	0.27	0.27	0.27	0.10	0.10	0.10	0.30	0.30	0.30
Sat Flow, veh/h	1757	656	1010	1284	1784	1541	980	1623	188	1184	1845	1568
Grp Volume(v), veh/h	179	0	94	25	77	78	23	0	183	98	148	242
Grp Sat Flow(s),veh/h/ln	1757	0	1666	1284	1752	1573	980	0	1811	1184	1845	1568
Q Serve(g_s), s	8.4	0.0	2.5	1.4	3.4	3.8	2.2	0.0	9.4	7.2	6.1	8.0
Cycle Q Clear(g_c), s	8.4	0.0	2.5	1.4	3.4	3.8	8.3	0.0	9.4	16.6	6.1	8.0
Prop In Lane	1.00		0.61	1.00		0.98	1.00		0.10	1.00		1.00
Lane Grp Cap(c), veh/h	457	0	966	419	473	425	306	0	543	316	553	878
V/C Ratio(X)	0.39	0.00	0.10	0.06	0.16	0.18	0.08	0.00	0.34	0.31	0.27	0.28
Avail Cap(c_a), veh/h	457	0	966	419	473	425	306	0	543	316	553	878
HCM Platoon Ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	30.5	0.0	9.3	27.2	27.9	28.0	38.1	0.0	35.8	34.4	26.6	11.4
Incr Delay (d2), s/veh	2.5	0.0	0.2	0.3	0.7	0.9	0.5	0.0	1.7	2.5	1.2	0.8
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	4.0	0.0	1.0	0.5	1.6	1.6	0.6	0.0	4.9	2.4	3.0	3.1
Lane Grp Delay (d), s/veh	33.0	0.0	9.5	27.4	28.6	29.0	38.6	0.0	37.4	36.9	27.8	12.2
Lane Grp LOS	C		A	C	C	C	D		D	D	C	B
Approach Vol, veh/h		273			180			206			488	
Approach Delay, s/veh		24.9			28.6			37.6			21.9	
Approach LOS		C			C			D			C	

Timer												
Assigned Phs	5	2			6			8			4	
Phs Duration (G+Y+Rc), s	31.0	64.0			33.0			36.0			36.0	
Change Period (Y+Rc), s	5.0	6.0			6.0			6.0			6.0	
Max Green Setting (Gmax), s	26.0	58.0			27.0			30.0			30.0	
Max Q Clear Time (g_c+I1), s	10.4	4.5			5.8			11.4			18.6	
Green Ext Time (p_c), s	0.2	2.6			2.2			3.1			2.6	

Intersection Summary	
HCM 2010 Ctrl Delay	26.5
HCM 2010 LOS	C

Notes

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	371	79	79	20	58	98	12	304	29	59	144	388
Number	5	2	12	1	6	16	3	8	18	7	4	14
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1
Lanes	1	1	0	1	2	0	1	1	0	1	1	1
Cap, veh/h	591	519	519	341	393	352	256	473	45	170	527	975
Arrive On Green	0.33	0.60	0.60	0.22	0.22	0.22	0.09	0.09	0.09	0.28	0.28	0.28
Sat Flow, veh/h	1792	864	864	1224	1787	1599	850	1690	162	1033	1881	1599
Grp Volume(v), veh/h	395	0	168	21	62	104	13	0	354	63	153	413
Grp Sat Flow(s),veh/h/ln	1792	0	1729	1224	1787	1599	850	0	1853	1033	1881	1599
Q Serve(g_s), s	18.9	0.0	4.3	1.4	2.8	5.4	1.4	0.0	18.5	5.9	6.4	13.6
Cycle Q Clear(g_c), s	18.9	0.0	4.3	1.4	2.8	5.4	7.8	0.0	18.5	24.4	6.4	13.6
Prop In Lane	1.00		0.50	1.00		1.00	1.00		0.09	1.00		1.00
Lane Grp Cap(c), veh/h	591	0	1037	341	393	352	256	0	519	170	527	975
V/C Ratio(X)	0.67	0.00	0.16	0.06	0.16	0.30	0.05	0.00	0.68	0.37	0.29	0.42
Avail Cap(c_a), veh/h	591	0	1037	341	393	352	256	0	519	170	527	975
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	28.8	0.0	8.9	31.0	31.5	32.5	39.2	0.0	41.1	43.6	28.2	10.3
Incr Delay (d2), s/veh	5.9	0.0	0.3	0.3	0.9	2.1	0.4	0.0	7.1	6.1	1.4	1.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	9.3	0.0	1.8	0.5	1.4	2.4	0.4	0.0	10.3	1.8	3.2	5.3
Lane Grp Delay (d), s/veh	34.7	0.0	9.2	31.3	32.4	34.7	39.6	0.0	48.2	49.7	29.6	11.6
Lane Grp LOS	C		A	C	C	C	D		D	D	C	B
Approach Vol, veh/h		563			187			367			629	
Approach Delay, s/veh		27.1			33.5			47.9			19.8	
Approach LOS		C			C			D			B	

Timer												
Assigned Phs	5	2			6			8			4	
Phs Duration (G+Y+Rc), s	38.0	66.0			28.0			34.0			34.0	
Change Period (Y+Rc), s	5.0	6.0			6.0			6.0			6.0	
Max Green Setting (Gmax), s	33.0	60.0			22.0			28.0			28.0	
Max Q Clear Time (g_c+I1), s	20.9	6.3			7.4			20.5			26.4	
Green Ext Time (p_c), s	0.5	3.6			2.5			3.1			0.9	

Intersection Summary	
HCM 2010 Ctrl Delay	29.5
HCM 2010 LOS	C

Notes

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	408	46	69	29	67	77	20	298	21	59	189	490
Number	5	2	12	1	6	16	3	8	18	7	4	14
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1
Lanes	1	1	0	1	2	0	1	1	0	1	1	1
Cap, veh/h	609	431	641	378	429	384	190	435	30	147	470	943
Arrive On Green	0.34	0.63	0.63	0.24	0.24	0.24	0.08	0.08	0.08	0.25	0.25	0.25
Sat Flow, veh/h	1792	683	1018	1277	1787	1599	735	1739	121	1047	1881	1599
Grp Volume(v), veh/h	434	0	122	31	71	82	21	0	339	63	201	521
Grp Sat Flow(s),veh/h/ln	1792	0	1702	1277	1787	1599	735	0	1860	1047	1881	1599
Q Serve(g_s), s	21.1	0.0	2.9	1.9	3.1	4.1	2.7	0.0	17.8	5.9	9.0	19.8
Cycle Q Clear(g_c), s	21.1	0.0	2.9	1.9	3.1	4.1	11.7	0.0	17.8	23.7	9.0	19.8
Prop In Lane	1.00		0.60	1.00		1.00	1.00		0.06	1.00		1.00
Lane Grp Cap(c), veh/h	609	0	1072	378	429	384	190	0	465	147	470	943
V/C Ratio(X)	0.71	0.00	0.11	0.08	0.17	0.21	0.11	0.00	0.73	0.43	0.43	0.55
Avail Cap(c_a), veh/h	609	0	1072	378	429	384	190	0	465	147	470	943
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	28.7	0.0	7.4	29.6	30.1	30.4	44.1	0.0	42.6	45.8	31.5	12.5
Incr Delay (d2), s/veh	6.9	0.0	0.2	0.4	0.8	1.3	1.2	0.0	9.7	8.8	2.8	2.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	10.5	0.0	1.1	0.6	1.5	1.8	0.6	0.0	10.2	2.0	4.6	7.8
Lane Grp Delay (d), s/veh	35.7	0.0	7.6	30.0	30.9	31.7	45.2	0.0	52.2	54.6	34.3	14.8
Lane Grp LOS	D		A	C	C	C	D		D	D	C	B
Approach Vol, veh/h		556			184			360			785	
Approach Delay, s/veh		29.5			31.1			51.8			23.0	
Approach LOS		C			C			D			C	

Timer												
Assigned Phs	5	2			6			8			4	
Phs Duration (G+Y+Rc), s	39.0	69.0			30.0			31.0			31.0	
Change Period (Y+Rc), s	5.0	6.0			6.0			6.0			6.0	
Max Green Setting (Gmax), s	34.0	63.0			24.0			25.0			25.0	
Max Q Clear Time (g_c+I1), s	23.1	4.9			6.1			19.8			25.7	
Green Ext Time (p_c), s	0.6	3.0			2.3			2.7			0.0	

Intersection Summary												
HCM 2010 Ctrl Delay			31.2									
HCM 2010 LOS			C									

Notes

Kupuohi Street at Kupuna Loop (upper)
AM Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	174	v_{WL} =	24	v_{NL} =	22	v_{SL} =	95
TH traffic	v_{ET} =	36	v_{WT} =	77	v_{NT} =	159	v_{ST} =	144
RT traffic	v_{ER} =	55	v_{WR} =	74	v_{NR} =	18	v_{SR} =	235
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	263	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	265
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	355	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	175
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	305	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	199
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	123	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	474

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	265	175	199	474
Entry Capacity by Leg (veh/hr)	869	792	833	999
(v/c) Ratio by Leg	0.31	0.22	0.24	0.47
Control Delay by Leg (sec/veh)	6	6	6	7
95th Percentile Back of Queue by Leg (veh)	2	1	1	3

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuohi Street at Kupuna Loop (upper)
PM Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	371	v_{WL} =	20	v_{NL} =	12	v_{SL} =	59
TH traffic	v_{ET} =	79	v_{WT} =	58	v_{NT} =	304	v_{ST} =	144
RT traffic	v_{ER} =	79	v_{WR} =	98	v_{NR} =	29	v_{SR} =	388
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	223	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	529
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	687	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	176
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	509	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	345
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	90	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	591

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	529	176	345	591
Entry Capacity by Leg (veh/hr)	904	568	679	1033
(v/c) Ratio by Leg	0.59	0.31	0.51	0.57
Control Delay by Leg (sec/veh)	10	10	11	9
95th Percentile Back of Queue by Leg (veh)	4	2	3	4

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuohi Street at Kupuna Loop (upper)
Saturday Midday Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	408	v_{WL} =	29	v_{NL} =	20	v_{SL} =	59
TH traffic	v_{ET} =	46	v_{WT} =	67	v_{NT} =	298	v_{ST} =	189
RT traffic	v_{ER} =	69	v_{WR} =	77	v_{NR} =	21	v_{SR} =	490
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	277	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	523
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	726	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	173
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	513	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	339
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	116	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	738

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	523	173	339	738
Entry Capacity by Leg (veh/hr)	857	547	677	1006
(v/c) Ratio by Leg	0.61	0.32	0.50	0.73
Control Delay by Leg (sec/veh)	11	10	11	13
95th Percentile Back of Queue by Leg (veh)	5	2	3	7

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuohi Street at
Kupuna Loop (lower)

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	155	170	7	4	397	100	30	8	10	96	5	114
Number	5	2	12	1	6	16	3	8	18	7	4	14
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	186.3	186.3	186.3	186.3	186.3	190.0	190.0	186.3	190.0	190.0	186.3	186.3
Adj Flow Rate, veh/h	163	179	7	4	418	105	32	8	11	101	5	120
Adj No. of Lanes	1	1	1	1	2	0	0	1	0	0	1	1
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	515	1080	918	711	1630	406	282	73	81	484	22	507
Arrive On Green	0.58	0.58	0.58	0.58	0.58	0.58	0.32	0.32	0.32	0.32	0.32	0.32
Sat Flow, veh/h	876	1863	1583	1193	2809	699	698	227	254	1292	70	1583
Grp Volume(v), veh/h	163	179	7	4	262	261	51	0	0	106	0	120
Grp Sat Flow(s),veh/h/ln	876	1863	1583	1193	1770	1739	1179	0	0	1362	0	1583
Q Serve(g_s), s	11.3	4.5	0.2	0.2	7.3	7.4	1.2	0.0	0.0	0.0	0.0	5.6
Cycle Q Clear(g_c), s	18.7	4.5	0.2	4.6	7.3	7.4	7.7	0.0	0.0	6.4	0.0	5.6
Prop In Lane	1.00		1.00	1.00		0.40	0.63		0.22	0.95		1.00
Lane Grp Cap(c), veh/h	515	1080	918	711	1026	1009	436	0	0	506	0	507
V/C Ratio(X)	0.32	0.17	0.01	0.01	0.26	0.26	0.12	0.00	0.00	0.21	0.00	0.24
Avail Cap(c_a), veh/h	515	1080	918	711	1026	1009	436	0	0	506	0	507
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	15.0	9.8	8.9	10.8	10.4	10.4	25.5	0.0	0.0	25.3	0.0	25.0
Incr Delay (d2), s/veh	1.6	0.3	0.0	0.0	0.6	0.6	0.5	0.0	0.0	0.9	0.0	1.1
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	2.9	2.4	0.1	0.1	3.7	3.7	1.1	0.0	0.0	2.3	0.0	2.6
LnGrp Delay(d),s/veh	16.6	10.1	8.9	10.8	11.0	11.0	26.0	0.0	0.0	26.2	0.0	26.1
LnGrp LOS	B	B	A	B	B	B	C			C		C
Approach Vol, veh/h		349			527			51			226	
Approach Delay, s/veh		13.1			11.0			26.0			26.2	
Approach LOS		B			B			C			C	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		63.0		37.0		63.0		37.0
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0
Max Green Setting (Gmax), s		58.0		32.0		58.0		32.0
Max Q Clear Time (g_c+I1), s		20.7		8.4		9.4		9.7
Green Ext Time (p_c), s		6.5		1.3		6.7		1.3

Intersection Summary	
HCM 2010 Ctrl Delay	15.3
HCM 2010 LOS	B

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	362	431	30	9	198	64	20	5	3	112	7	95
Number	5	2	12	1	6	16	3	8	18	7	4	14
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	188.1	188.1	188.1	188.1	188.1	190.0	190.0	188.1	190.0	190.0	188.1	188.1
Adj Flow Rate, veh/h	377	449	31	9	206	67	21	5	3	117	7	99
Adj No. of Lanes	1	1	1	1	2	0	0	1	0	0	1	1
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	1	1	1	1	1	1	1	1	1	1	1	1
Cap, veh/h	750	1204	1023	557	1711	541	253	58	29	417	23	416
Arrive On Green	0.64	0.64	0.64	0.64	0.64	0.64	0.26	0.26	0.26	0.26	0.26	0.26
Sat Flow, veh/h	1113	1881	1599	920	2673	846	732	223	110	1336	89	1599
Grp Volume(v), veh/h	377	449	31	9	136	137	29	0	0	124	0	99
Grp Sat Flow(s),veh/h/ln	1113	1881	1599	920	1787	1732	1066	0	0	1425	0	1599
Q Serve(g_s), s	20.0	11.3	0.7	0.5	3.0	3.1	0.7	0.0	0.0	0.0	0.0	4.9
Cycle Q Clear(g_c), s	23.1	11.3	0.7	11.8	3.0	3.1	7.9	0.0	0.0	7.2	0.0	4.9
Prop In Lane	1.00		1.00	1.00		0.49	0.72		0.10	0.94		1.00
Lane Grp Cap(c), veh/h	750	1204	1023	557	1144	1108	339	0	0	440	0	416
V/C Ratio(X)	0.50	0.37	0.03	0.02	0.12	0.12	0.09	0.00	0.00	0.28	0.00	0.24
Avail Cap(c_a), veh/h	750	1204	1023	557	1144	1108	339	0	0	440	0	416
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	11.6	8.5	6.6	11.3	7.0	7.0	29.8	0.0	0.0	30.0	0.0	29.2
Incr Delay (d2), s/veh	2.4	0.9	0.1	0.1	0.2	0.2	0.5	0.0	0.0	1.6	0.0	1.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	6.6	6.0	0.3	0.1	1.5	1.6	0.7	0.0	0.0	3.0	0.0	2.3
LnGrp Delay(d),s/veh	14.0	9.4	6.7	11.3	7.2	7.3	30.3	0.0	0.0	31.6	0.0	30.5
LnGrp LOS	B	A	A	B	A	A	C			C		C
Approach Vol, veh/h		857			282			29			223	
Approach Delay, s/veh		11.3			7.4			30.3			31.1	
Approach LOS		B			A			C			C	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		69.0		31.0		69.0		31.0
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0
Max Green Setting (Gmax), s		64.0		26.0		64.0		26.0
Max Q Clear Time (g_c+I1), s		25.1		9.2		13.8		9.9
Green Ext Time (p_c), s		8.1		1.1		8.3		1.0

Intersection Summary	
HCM 2010 Ctrl Delay	14.1
HCM 2010 LOS	B

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	329	248	24	0	181	65	14	7	2	120	7	132
Number	5	2	12	1	6	16	3	8	18	7	4	14
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	188.1	188.1	188.1	188.1	188.1	190.0	190.0	188.1	190.0	190.0	188.1	188.1
Adj Flow Rate, veh/h	343	258	25	0	189	68	15	7	2	125	7	138
Adj No. of Lanes	1	1	1	1	2	0	0	1	0	0	1	1
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	1	1	1	1	1	1	1	1	1	1	1	1
Cap, veh/h	737	1166	991	72	1613	562	229	100	25	431	22	448
Arrive On Green	0.62	0.62	0.62	0.00	0.62	0.62	0.28	0.28	0.28	0.28	0.28	0.28
Sat Flow, veh/h	1129	1881	1599	1103	2602	907	609	357	88	1288	80	1599
Grp Volume(v), veh/h	343	258	25	0	128	129	24	0	0	132	0	138
Grp Sat Flow(s),veh/h/ln	1129	1881	1599	1103	1787	1721	1054	0	0	1367	0	1599
Q Serve(g_s), s	17.9	6.0	0.6	0.0	2.9	3.1	0.1	0.0	0.0	0.0	0.0	6.8
Cycle Q Clear(g_c), s	21.0	6.0	0.6	0.0	2.9	3.1	8.8	0.0	0.0	8.7	0.0	6.8
Prop In Lane	1.00		1.00	1.00		0.53	0.62		0.08	0.95		1.00
Lane Grp Cap(c), veh/h	737	1166	991	72	1108	1067	354	0	0	453	0	448
V/C Ratio(X)	0.47	0.22	0.03	0.00	0.12	0.12	0.07	0.00	0.00	0.29	0.00	0.31
Avail Cap(c_a), veh/h	737	1166	991	72	1108	1067	354	0	0	453	0	448
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	12.1	8.4	7.3	0.0	7.8	7.8	26.5	0.0	0.0	29.0	0.0	28.4
Incr Delay (d2), s/veh	2.1	0.4	0.0	0.0	0.2	0.2	0.4	0.0	0.0	1.6	0.0	1.8
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	6.0	3.2	0.3	0.0	1.5	1.5	0.5	0.0	0.0	3.1	0.0	3.2
LnGrp Delay(d),s/veh	14.2	8.8	7.4	0.0	8.0	8.0	26.9	0.0	0.0	30.7	0.0	30.1
LnGrp LOS	B	A	A		A	A	C			C		C
Approach Vol, veh/h		626			257			24			270	
Approach Delay, s/veh		11.7			8.0			26.9			30.4	
Approach LOS		B			A			C			C	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		67.0		33.0		67.0		33.0
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0
Max Green Setting (Gmax), s		62.0		28.0		62.0		28.0
Max Q Clear Time (g_c+I1), s		23.0		10.7		5.1		10.8
Green Ext Time (p_c), s		5.5		1.2		5.7		1.2

Intersection Summary	
HCM 2010 Ctrl Delay	15.5
HCM 2010 LOS	B

Kupuohi Street at Kupuna Loop (lower)
AM Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	155	v_{WL} =	4	v_{NL} =	30	v_{SL} =	96
TH traffic	v_{ET} =	170	v_{WT} =	397	v_{NT} =	8	v_{ST} =	5
RT traffic	v_{ER} =	7	v_{WR} =	100	v_{NR} =	10	v_{SR} =	114
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	105	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	332
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	193	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	501
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	421	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	48
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	431	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	215

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	332	501	48	215
Entry Capacity by Leg (veh/hr)	1017	932	742	734
(v/c) Ratio by Leg	0.33	0.54	0.06	0.29
Control Delay by Leg (sec/veh)	6	9	6	7
95th Percentile Back of Queue by Leg (veh)	2	4	1	2

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuohi Street at Kupuna Loop (lower)
PM Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	362	v_{WL} =	9	v_{NL} =	20	v_{SL} =	112
TH traffic	v_{ET} =	431	v_{WT} =	198	v_{NT} =	5	v_{ST} =	7
RT traffic	v_{ER} =	30	v_{WR} =	64	v_{NR} =	3	v_{SR} =	95
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	128	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	823
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	387	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	271
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	905	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	28
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	227	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	214

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	823	271	28	214
Entry Capacity by Leg (veh/hr)	994	767	457	901
(v/c) Ratio by Leg	0.83	0.35	0.06	0.24
Control Delay by Leg (sec/veh)	19	8	9	6
95th Percentile Back of Queue by Leg (veh)	10	2	1	1

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuohi Street at Kupuna Loop (lower)
Saturday Midday Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	329	v_{WL} =	0	v_{NL} =	14	v_{SL} =	120
TH traffic	v_{ET} =	248	v_{WT} =	181	v_{NT} =	7	v_{ST} =	7
RT traffic	v_{ER} =	24	v_{WR} =	65	v_{NR} =	2	v_{SR} =	132
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	127	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	601
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	350	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	246
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	697	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	23
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	195	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	259

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	601	246	23	259
Entry Capacity by Leg (veh/hr)	995	796	563	930
(v/c) Ratio by Leg	0.60	0.31	0.04	0.28
Control Delay by Leg (sec/veh)	9	7	7	6
95th Percentile Back of Queue by Leg (veh)	5	2	1	2

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuna Loop at
Aiki Street

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	60	114	200	134	322	418
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	186.3	186.3	186.3	186.3
Lanes	1	1	1	0	1	1
Cap, veh/h	473	422	625	419	615	1118
Arrive On Green	0.27	0.27	0.60	0.60	1.00	1.00
Sat Flow, veh/h	1774	1583	1041	699	1007	1863
Grp Volume(v), veh/h	67	127	0	371	358	464
Grp Sat Flow(s),veh/h/ln	1774	1583	0	1739	1007	1863
Q Serve(g_s), s	1.7	3.8	0.0	6.5	9.5	0.0
Cycle Q Clear(g_c), s	1.7	3.8	0.0	6.5	16.0	0.0
Prop In Lane	1.00	1.00		0.40	1.00	
Lane Grp Cap(c), veh/h	473	422	0	1044	615	1118
V/C Ratio(X)	0.14	0.30	0.00	0.36	0.58	0.42
Avail Cap(c_a), veh/h	473	422	0	1044	615	1118
HCM Platoon Ratio	0.00	0.00	671088.63	671088.63	0.00	671088.63
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	16.8	17.5	0.0	6.1	1.4	0.0
Incr Delay (d2), s/veh	0.6	1.8	0.0	0.9	4.0	1.1
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	0.8	1.6	0.0	2.4	0.7	0.4
Lane Grp Delay (d), s/veh	17.4	19.4	0.0	7.0	5.4	1.1
Lane Grp LOS	B	B		A	A	A
Approach Vol, veh/h	194		371			822
Approach Delay, s/veh	18.7		7.0			3.0
Approach LOS	B		A			A

Timer						
Assigned Phs			2			6
Phs Duration (G+Y+Rc), s			40.0			40.0
Change Period (Y+Rc), s			4.0			4.0
Max Green Setting (Gmax), s			36.0			36.0
Max Q Clear Time (g_c+I1), s			8.5			18.0
Green Ext Time (p_c), s			7.8			6.7

Intersection Summary						
HCM 2010 Ctrl Delay			6.3			
HCM 2010 LOS			A			

Notes

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	91	212	347	218	123	186
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	190.0	190.0	190.0	190.0	190.0	190.0
Lanes	1	1	1	0	1	1
Cap, veh/h	513	458	619	389	417	1077
Arrive On Green	0.28	0.28	0.57	0.57	1.00	1.00
Sat Flow, veh/h	1810	1615	1092	687	841	1900
Grp Volume(v), veh/h	95	221	0	588	128	194
Grp Sat Flow(s),veh/h/ln	1810	1615	0	1779	841	1900
Q Serve(g_s), s	2.4	6.8	0.0	12.8	4.7	0.0
Cycle Q Clear(g_c), s	2.4	6.8	0.0	12.8	17.6	0.0
Prop In Lane	1.00	1.00		0.39	1.00	
Lane Grp Cap(c), veh/h	513	458	0	1008	417	1077
V/C Ratio(X)	0.19	0.48	0.00	0.58	0.31	0.18
Avail Cap(c_a), veh/h	513	458	0	1008	417	1077
HCM Platoon Ratio	0.00	0.00	671088.63	671088.63	0.00	671088.63
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	16.3	17.9	0.0	8.4	3.3	0.0
Incr Delay (d2), s/veh	0.8	3.6	0.0	2.5	1.9	0.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	1.1	3.0	0.0	5.3	0.7	0.1
Lane Grp Delay (d), s/veh	17.1	21.5	0.0	10.9	5.2	0.4
Lane Grp LOS	B	C		B	A	A
Approach Vol, veh/h	316		588			322
Approach Delay, s/veh	20.1		10.9			2.3
Approach LOS	C		B			A

Timer						
Assigned Phs			2			6
Phs Duration (G+Y+Rc), s			39.0			39.0
Change Period (Y+Rc), s			5.0			5.0
Max Green Setting (Gmax), s			34.0			34.0
Max Q Clear Time (g_c+I1), s			14.8			19.6
Green Ext Time (p_c), s			5.9			5.1

Intersection Summary						
HCM 2010 Ctrl Delay			11.0			
HCM 2010 LOS			B			

Notes

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	81	132	140	148	133	197
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	190.0	190.0	190.0	190.0	190.0	190.0
Lanes	1	1	1	0	1	1
Cap, veh/h	663	592	410	432	532	918
Arrive On Green	0.37	0.37	0.48	0.48	0.97	0.97
Sat Flow, veh/h	1810	1615	848	894	1096	1900
Grp Volume(v), veh/h	84	138	0	300	139	205
Grp Sat Flow(s),veh/h/ln	1810	1615	0	1742	1096	1900
Q Serve(g_s), s	1.8	3.6	0.0	6.4	2.5	0.3
Cycle Q Clear(g_c), s	1.8	3.6	0.0	6.4	9.0	0.3
Prop In Lane	1.00	1.00		0.51	1.00	
Lane Grp Cap(c), veh/h	663	592	0	842	532	918
V/C Ratio(X)	0.13	0.23	0.00	0.36	0.26	0.22
Avail Cap(c_a), veh/h	663	592	0	842	532	918
HCM Platoon Ratio	0.00	0.00	671088.63	671088.63	0.00	671088.63
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	12.6	13.2	0.0	9.7	1.7	0.5
Incr Delay (d2), s/veh	0.4	0.9	0.0	1.2	1.2	0.6
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	0.8	1.4	0.0	2.6	0.3	0.2
Lane Grp Delay (d), s/veh	13.0	14.1	0.0	10.9	2.9	1.1
Lane Grp LOS	B	B		B	A	A
Approach Vol, veh/h	222		300			344
Approach Delay, s/veh	13.7		10.9			1.8
Approach LOS	B		B			A

Timer						
Assigned Phs			2			6
Phs Duration (G+Y+Rc), s			34.0			34.0
Change Period (Y+Rc), s			5.0			5.0
Max Green Setting (Gmax), s			29.0			29.0
Max Q Clear Time (g_c+I1), s			8.4			11.0
Green Ext Time (p_c), s			3.7			3.5

Intersection Summary						
HCM 2010 Ctrl Delay			8.0			
HCM 2010 LOS			A			

Notes

Kupuna Loop at Aiki Street
AM Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	0	v_{WL} =	60	v_{NL} =	0	v_{SL} =	322
TH traffic	v_{ET} =	0	v_{WT} =	0	v_{NT} =	200	v_{ST} =	418
RT traffic	v_{ER} =	0	v_{WR} =	114	v_{NR} =	134	v_{SR} =	0
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	800	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	0
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	200	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	174
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	322	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	334
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	60	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	740

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	0	174	334	740
Entry Capacity by Leg (veh/hr)	508	925	819	1064
(v/c) Ratio by Leg	0.00	0.19	0.41	0.70
Control Delay by Leg (sec/veh)	0	5	8	11
95th Percentile Back of Queue by Leg (veh)	0	1	3	7

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuna Loop at Aiki Street
PM Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	0	v_{WL} =	91	v_{NL} =	0	v_{SL} =	123
TH traffic	v_{ET} =	0	v_{WT} =	0	v_{NT} =	347	v_{ST} =	186
RT traffic	v_{ER} =	0	v_{WR} =	212	v_{NR} =	218	v_{SR} =	0
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	400	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	0
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	347	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	303
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	123	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	565
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	91	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	309

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	0	303	565	309
Entry Capacity by Leg (veh/hr)	757	799	999	1032
(v/c) Ratio by Leg	0.00	0.38	0.57	0.30
Control Delay by Leg (sec/veh)	0	8	9	5
95th Percentile Back of Queue by Leg (veh)	0	2	4	2

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuna Loop at Aiki Street
Saturday Midday Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	0	v_{WL} =	81	v_{NL} =	0	v_{SL} =	133
TH traffic	v_{ET} =	0	v_{WT} =	0	v_{NT} =	140	v_{ST} =	197
RT traffic	v_{ER} =	0	v_{WR} =	132	v_{NR} =	148	v_{SR} =	0
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	411	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	0
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	140	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	213
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	133	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	288
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	81	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	330

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	0	213	288	330
Entry Capacity by Leg (veh/hr)	749	982	989	1042
(v/c) Ratio by Leg	0.00	0.22	0.29	0.32
Control Delay by Leg (sec/veh)	0	5	6	6
95th Percentile Back of Queue by Leg (veh)	0	1	2	2

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuna Loop at
Kaaholo Street

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	46	13	318	73	19	4	172	100	30	3	403	23
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	186.3	186.3	186.3	186.3	186.3	186.3	186.3	186.3	186.3	186.3
Lanes	0	1	0	0	1	0	1	1	0	1	1	0
Cap, veh/h	108	42	451	279	65	10	469	733	222	770	931	53
Arrive On Green	0.33	0.33	0.33	0.33	0.33	0.33	0.89	0.89	0.89	0.53	0.53	0.53
Sat Flow, veh/h	123	127	1352	521	195	29	925	1374	416	1241	1746	100
Grp Volume(v), veh/h	410	0	0	104	0	0	187	0	142	3	0	463
Grp Sat Flow(s),veh/h/ln	1602	0	0	744	0	0	925	0	1789	1241	0	1845
Q Serve(g_s), s	5.1	0.0	0.0	0.0	0.0	0.0	6.8	0.0	0.6	0.1	0.0	9.4
Cycle Q Clear(g_c), s	13.5	0.0	0.0	8.5	0.0	0.0	16.2	0.0	0.6	0.7	0.0	9.4
Prop In Lane	0.12		0.84	0.76		0.04	1.00		0.23	1.00		0.05
Lane Grp Cap(c), veh/h	601	0	0	354	0	0	469	0	954	770	0	984
V/C Ratio(X)	0.68	0.00	0.00	0.29	0.00	0.00	0.40	0.00	0.15	0.00	0.00	0.47
Avail Cap(c_a), veh/h	601	0	0	354	0	0	469	0	954	770	0	984
HCM Platoon Ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	671088.63	671088.63	0.00	671088.63	671088.63
Upstream Filter(I)	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	17.8	0.0	0.0	15.6	0.0	0.0	5.0	0.0	1.6	6.8	0.0	8.7
Incr Delay (d2), s/veh	6.1	0.0	0.0	2.1	0.0	0.0	2.5	0.0	0.3	0.0	0.0	1.6
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	6.0	0.0	0.0	1.3	0.0	0.0	1.2	0.0	0.3	0.0	0.0	4.0
Lane Grp Delay (d), s/veh	24.0	0.0	0.0	17.7	0.0	0.0	7.6	0.0	1.9	6.8	0.0	10.3
Lane Grp LOS	C			B			A		A	A		B
Approach Vol, veh/h		410			104			329			466	
Approach Delay, s/veh		24.0			17.7			5.1			10.3	
Approach LOS		C			B			A			B	

Timer				
Assigned Phs	4	8	2	6
Phs Duration (G+Y+Rc), s	24.0	24.0	36.0	36.0
Change Period (Y+Rc), s	4.0	4.0	4.0	4.0
Max Green Setting (Gmax), s	20.0	20.0	32.0	32.0
Max Q Clear Time (g_c+I1), s	15.5	10.5	18.2	11.4
Green Ext Time (p_c), s	1.4	2.5	3.9	4.6

Intersection Summary	
HCM 2010 Ctrl Delay	13.9
HCM 2010 LOS	B

Notes

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	5	5	89	75	4	7	151	289	112	3	163	8
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1
Lanes	0	1	0	0	1	0	1	1	0	1	1	0
Cap, veh/h	71	47	457	480	26	36	673	667	259	608	919	45
Arrive On Green	0.32	0.32	0.32	0.32	0.32	0.32	1.00	1.00	1.00	0.52	0.52	0.52
Sat Flow, veh/h	25	149	1445	1162	81	113	1198	1292	501	945	1778	87
Grp Volume(v), veh/h	112	0	0	96	0	0	170	0	451	3	0	192
Grp Sat Flow(s),veh/h/ln	1618	0	0	1356	0	0	1198	0	1793	945	0	1866
Q Serve(g_s), s	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.1	0.0	3.3
Cycle Q Clear(g_c), s	3.0	0.0	0.0	2.9	0.0	0.0	4.6	0.0	0.0	0.1	0.0	3.3
Prop In Lane	0.05		0.89	0.87		0.08	1.00		0.28	1.00		0.05
Lane Grp Cap(c), veh/h	576	0	0	542	0	0	673	0	926	608	0	964
V/C Ratio(X)	0.19	0.00	0.00	0.18	0.00	0.00	0.25	0.00	0.49	0.00	0.00	0.20
Avail Cap(c_a), veh/h	576	0	0	542	0	0	673	0	926	608	0	964
HCM Platoon Ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	671088.63	671088.63	0.00	671088.63	671088.63
Upstream Filter(I)	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	15.0	0.0	0.0	15.0	0.0	0.0	0.2	0.0	0.0	7.0	0.0	7.8
Incr Delay (d2), s/veh	0.8	0.0	0.0	0.7	0.0	0.0	0.9	0.0	1.8	0.0	0.0	0.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	1.2	0.0	0.0	1.1	0.0	0.0	0.2	0.0	0.5	0.0	0.0	1.4
Lane Grp Delay (d), s/veh	15.8	0.0	0.0	15.7	0.0	0.0	1.1	0.0	1.8	7.0	0.0	8.3
Lane Grp LOS	B			B			A		A	A		A
Approach Vol, veh/h		112			96			621			195	
Approach Delay, s/veh		15.8			15.7			1.6			8.3	
Approach LOS		B			B			A			A	

Timer				
Assigned Phs	4	8	2	6
Phs Duration (G+Y+Rc), s	24.0	24.0	36.0	36.0
Change Period (Y+Rc), s	5.0	5.0	5.0	5.0
Max Green Setting (Gmax), s	19.0	19.0	31.0	31.0
Max Q Clear Time (g_c+I1), s	5.0	4.9	6.6	5.3
Green Ext Time (p_c), s	1.0	1.0	5.1	5.2

Intersection Summary	
HCM 2010 Ctrl Delay	5.8
HCM 2010 LOS	A

Notes

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	2	3	64	75	11	3	52	174	63	1	188	5
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1
Lanes	0	1	0	0	1	0	1	1	0	1	1	0
Cap, veh/h	64	36	553	547	73	16	585	616	223	515	849	24
Arrive On Green	0.37	0.37	0.37	0.37	0.37	0.37	0.31	0.31	0.31	0.47	0.47	0.47
Sat Flow, veh/h	8	97	1508	1188	199	43	1171	1319	478	1119	1820	52
Grp Volume(v), veh/h	77	0	0	99	0	0	58	0	267	1	0	217
Grp Sat Flow(s),veh/h/ln	1612	0	0	1431	0	0	1171	0	1797	1119	0	1872
Q Serve(g_s), s	0.0	0.0	0.0	0.3	0.0	0.0	2.3	0.0	6.8	0.0	0.0	4.2
Cycle Q Clear(g_c), s	1.9	0.0	0.0	2.2	0.0	0.0	6.5	0.0	6.8	6.8	0.0	4.2
Prop In Lane	0.03		0.94	0.85		0.03	1.00		0.27	1.00		0.03
Lane Grp Cap(c), veh/h	653	0	0	636	0	0	585	0	839	515	0	874
V/C Ratio(X)	0.12	0.00	0.00	0.16	0.00	0.00	0.10	0.00	0.32	0.00	0.00	0.25
Avail Cap(c_a), veh/h	653	0	0	636	0	0	585	0	839	515	0	874
HCM Platoon Ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	671088.63	671088.63	0.00	671088.63	671088.63
Upstream Filter(I)	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	12.6	0.0	0.0	12.7	0.0	0.0	14.8	0.0	13.3	12.6	0.0	9.7
Incr Delay (d2), s/veh	0.4	0.0	0.0	0.5	0.0	0.0	0.3	0.0	1.0	0.0	0.0	0.7
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	0.8	0.0	0.0	1.0	0.0	0.0	0.7	0.0	3.1	0.0	0.0	1.9
Lane Grp Delay (d), s/veh	13.0	0.0	0.0	13.2	0.0	0.0	15.1	0.0	14.3	12.6	0.0	10.3
Lane Grp LOS	B			B			B		B	B		B
Approach Vol, veh/h		77			99			325			218	
Approach Delay, s/veh		13.0			13.2			14.5			10.3	
Approach LOS		B			B			B			B	

Timer				
Assigned Phs	4	8	2	6
Phs Duration (G+Y+Rc), s	27.0	27.0	33.0	33.0
Change Period (Y+Rc), s	5.0	5.0	5.0	5.0
Max Green Setting (Gmax), s	22.0	22.0	28.0	28.0
Max Q Clear Time (g_c+I1), s	3.9	4.2	8.8	8.8
Green Ext Time (p_c), s	0.9	0.9	3.1	3.1

Intersection Summary	
HCM 2010 Ctrl Delay	12.9
HCM 2010 LOS	B

Notes

Kupuna Loop at Kaaholo Street
AM Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	46	v_{WL} =	73	v_{NL} =	172	v_{SL} =	3
TH traffic	v_{ET} =	13	v_{WT} =	19	v_{NT} =	100	v_{ST} =	403
RT traffic	v_{ER} =	318	v_{WR} =	4	v_{NR} =	30	v_{SR} =	23
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	479	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	377
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	318	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	96
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	62	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	302
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	264	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	429

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	377	96	302	429
Entry Capacity by Leg (veh/hr)	700	822	1062	868
(v/c) Ratio by Leg	0.54	0.12	0.28	0.49
Control Delay by Leg (sec/veh)	12	5	5	9
95th Percentile Back of Queue by Leg (veh)	4	1	2	3

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuna Loop at Kaaholo Street
PM Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	5	v_{WL} =	75	v_{NL} =	151	v_{SL} =	3
TH traffic	v_{ET} =	5	v_{WT} =	4	v_{NT} =	289	v_{ST} =	163
RT traffic	v_{ER} =	89	v_{WR} =	7	v_{NR} =	112	v_{SR} =	8
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	241	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	99
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	445	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	86
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	13	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	552
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	230	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	174

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	99	86	552	174
Entry Capacity by Leg (veh/hr)	888	724	1115	898
(v/c) Ratio by Leg	0.11	0.12	0.49	0.19
Control Delay by Leg (sec/veh)	5	6	7	5
95th Percentile Back of Queue by Leg (veh)	1	1	3	1

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuna Loop at Kaaholo Street
Saturday Midday Peak Hour

SINGLE LANE ROUNDABOUT OPERATIONAL ANALYSIS (based on NCHRP Report 572)

Design Hour Volumes	EB		WB		NB		SB	
LT traffic	v_{EL} =	2	v_{WL} =	75	v_{NL} =	52	v_{SL} =	1
TH traffic	v_{ET} =	3	v_{WT} =	11	v_{NT} =	174	v_{ST} =	188
RT traffic	v_{ER} =	64	v_{WR} =	3	v_{NR} =	63	v_{SR} =	5
U-Turn traffic	v_{EU} =	0	v_{WU} =	0	v_{NU} =	0	v_{SU} =	0

Conflicting Flow Volumes by Leg (veh/hr)	Conflicting Flows	Entering Volumes by Leg (veh/hr)	
$v_{c(EB)} = v_{WL} + v_{WU} + v_{SL} + v_{SU} + v_{ST} =$	264	$v_{EB} = v_{EL} + v_{ET} + v_{ER} + v_{EU} =$	69
$v_{c(WB)} = v_{EL} + v_{EU} + v_{NL} + v_{NU} + v_{NT} =$	228	$v_{WB} = v_{WL} + v_{WT} + v_{WR} + v_{WU} =$	89
$v_{c(NB)} = v_{SL} + v_{SU} + v_{EL} + v_{EU} + v_{ET} =$	6	$v_{NB} = v_{NL} + v_{NT} + v_{NR} + v_{NU} =$	289
$v_{c(SB)} = v_{NL} + v_{NU} + v_{WL} + v_{WU} + v_{WT} =$	138	$v_{SB} = v_{SL} + v_{ST} + v_{SR} + v_{SU} =$	194

Capacity Analysis	EB Leg	WB Leg	NB Leg	SB Leg
Entry Volume by Leg, v (veh/hr)	69	89	289	194
Entry Capacity by Leg (veh/hr)	868	900	1123	984
(v/c) Ratio by Leg	0.08	0.10	0.26	0.20
Control Delay by Leg (sec/veh)	5	5	5	5
95th Percentile Back of Queue by Leg (veh)	1	1	2	1

$$c = 1130 \cdot \exp(-0.0010 \cdot v_c)$$

where

c = entry capacity (pcu/h)

v_c = conflicting flow (pcu/h)

$$Q_{95} \approx 900T \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(1 - \frac{v_x}{c_{m,x}}\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}} \right] \left(\frac{c_{m,x}}{3600}\right)$$

$$d = \frac{3600}{c_{m,x}} + 900T \times \left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}} \right]$$

Kupuohi Street at
Walmart driveway (main)
and
Kupuohi Street at
Times driveway (main)

Intersection	
Intersection Delay, s/veh	1.4

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Vol, veh/h	19	25	43	164	385	15
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	None	None	None	None	None	None
Storage Length	0	0	250			0
Median Width	12			12	12	
Grade, %	0%			0%	0%	
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94
Heavy Vehicles, %	3	3	3	3	3	3
Mvmt Flow	20	27	46	174	410	16
Number of Lanes	1	0	1	1	1	0

Major/Minor				Major 1	Major 2	
Conflicting Flow All	684	418	426	0	-	0
Stage 1	418	-	-	-	-	-
Stage 2	266	-	-	-	-	-
Follow-up Headway	3.527	3.327	2.227	-	-	-
Pot Capacity-1 Maneuver	413	633	1128	-	-	-
Stage 1	662	-	-	-	-	-
Stage 2	776	-	-	-	-	-
Time blocked-Platoon, %	0	0	0	-	-	-
Mov Capacity-1 Maneuver	396	633	1128	-	-	-
Mov Capacity-2 Maneuver	396	-	-	-	-	-
Stage 1	662	-	-	-	-	-
Stage 2	744	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	12.9	1.7	0
HCM LOS	B	-	-

Minor Lane / Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Cap, veh/h	1128	-	503	-	-
HCM Control Delay, s	8.326	-	12.9	-	-
HCM Lane V/C Ratio	0.04	-	0.09	-	-
HCM Lane LOS	A	-	B	-	-
HCM 95th-tile Q, veh	0.1	-	0.3	-	-

Notes

~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection	
Intersection Delay, s/veh	1

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Vol, veh/h	14	22	36	310	410	21
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	None	None	None	None	None	None
Storage Length	0	0	150			0
Median Width	12			12	12	
Grade, %	0%			0%	0%	
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93
Heavy Vehicles, %	3	3	3	3	3	3
Mvmt Flow	15	24	39	333	441	23
Number of Lanes	1	0	1	1	1	0

Major/Minor				Major 1	Major 2	
Conflicting Flow All	863	452	463	0	-	0
Stage 1	452	-	-	-	-	-
Stage 2	411	-	-	-	-	-
Follow-up Headway	3.527	3.327	2.227	-	-	-
Pot Capacity-1 Maneuver	324	605	1093	-	-	-
Stage 1	639	-	-	-	-	-
Stage 2	667	-	-	-	-	-
Time blocked-Platoon, %	0	0	0	-	-	-
Mov Capacity-1 Maneuver	312	605	1093	-	-	-
Mov Capacity-2 Maneuver	312	-	-	-	-	-
Stage 1	639	-	-	-	-	-
Stage 2	643	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	13.9	0.9	0
HCM LOS	B	-	-

Minor Lane / Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Cap, veh/h	1093	-	443	-	-
HCM Control Delay, s	8.415	-	13.9	-	-
HCM Lane V/C Ratio	0.04	-	0.09	-	-
HCM Lane LOS	A	-	B	-	-
HCM 95th-tile Q, veh	0.1	-	0.3	-	-

Notes

~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection	
Intersection Delay, s/veh	3.6

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Vol, veh/h	49	67	127	322	239	43
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	None	None	None	None	None	None
Storage Length	0	0	250			0
Median Width	12			12	12	
Grade, %	0%			0%	0%	
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90
Heavy Vehicles, %	1	1	1	1	1	1
Mvmt Flow	54	74	141	358	266	48
Number of Lanes	1	0	1	1	1	0

Major/Minor				Major 1	Major 2	
Conflicting Flow All	929	289	313	0	-	0
Stage 1	289	-	-	-	-	-
Stage 2	640	-	-	-	-	-
Follow-up Headway	3.509	3.309	2.209	-	-	-
Pot Capacity-1 Maneuver	298	752	1253	-	-	-
Stage 1	762	-	-	-	-	-
Stage 2	527	-	-	-	-	-
Time blocked-Platoon, %	0	0	0	-	-	-
Mov Capacity-1 Maneuver	264	752	1253	-	-	-
Mov Capacity-2 Maneuver	264	-	-	-	-	-
Stage 1	762	-	-	-	-	-
Stage 2	468	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	17.2	2.3	0
HCM LOS	C	-	-

Minor Lane / Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Cap, veh/h	1253	-	422	-	-
HCM Control Delay, s	8.237	-	17.2	-	-
HCM Lane V/C Ratio	0.11	-	0.30	-	-
HCM Lane LOS	A	-	C	-	-
HCM 95th-tile Q, veh	0.4	-	1.3	-	-

Notes

~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection	
Intersection Delay, s/veh	2.9

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Vol, veh/h	44	76	82	561	457	49
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	None	None	None	None	None	None
Storage Length	0	0	150			0
Median Width	12			12	12	
Grade, %	0%			0%	0%	
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94
Heavy Vehicles, %	1	1	1	1	1	1
Mvmt Flow	47	81	87	597	486	52
Number of Lanes	1	0	1	1	1	0

Major/Minor				Major 1	Major 2	
Conflicting Flow All	1283	512	538	0	-	0
Stage 1	512	-	-	-	-	-
Stage 2	771	-	-	-	-	-
Follow-up Headway	3.509	3.309	2.209	-	-	-
Pot Capacity-1 Maneuver	183	564	1035	-	-	-
Stage 1	604	-	-	-	-	-
Stage 2	458	-	-	-	-	-
Time blocked-Platoon, %	0	0	0	-	-	-
Mov Capacity-1 Maneuver	168	564	1035	-	-	-
Mov Capacity-2 Maneuver	168	-	-	-	-	-
Stage 1	604	-	-	-	-	-
Stage 2	420	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	25.3	1.1	0
HCM LOS	D	-	-

Minor Lane / Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Cap, veh/h	1035	-	303	-	-
HCM Control Delay, s	8.798	-	25.3	-	-
HCM Lane V/C Ratio	0.08	-	0.42	-	-
HCM Lane LOS	A	-	D	-	-
HCM 95th-tile Q, veh	0.3	-	2.0	-	-

Notes

~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection	
Intersection Delay, s/veh	3.8

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Vol, veh/h	49	76	135	283	275	65
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	None	None	None	None	None	None
Storage Length	0	0	250			0
Median Width	12			12	12	
Grade, %	0%			0%	0%	
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90
Heavy Vehicles, %	1	1	1	1	1	1
Mvmt Flow	54	84	150	314	306	72
Number of Lanes	1	0	1	1	1	0

Major/Minor				Major 1	Major 2	
Conflicting Flow All	956	342	378	0	-	0
Stage 1	342	-	-	-	-	-
Stage 2	614	-	-	-	-	-
Follow-up Headway	3.509	3.309	2.209	-	-	-
Pot Capacity-1 Maneuver	287	703	1186	-	-	-
Stage 1	722	-	-	-	-	-
Stage 2	542	-	-	-	-	-
Time blocked-Platoon, %	0	0	0	-	-	-
Mov Capacity-1 Maneuver	251	703	1186	-	-	-
Mov Capacity-2 Maneuver	251	-	-	-	-	-
Stage 1	722	-	-	-	-	-
Stage 2	473	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	18.1	2.7	0
HCM LOS	C	-	-

Minor Lane / Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Cap, veh/h	1186	-	412	-	-
HCM Control Delay, s	8.474	-	18.1	-	-
HCM Lane V/C Ratio	0.13	-	0.34	-	-
HCM Lane LOS	A	-	C	-	-
HCM 95th-tile Q, veh	0.4	-	1.5	-	-

Notes

~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection	
Intersection Delay, s/veh	2.5

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Vol, veh/h	31	65	87	557	551	68
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	None	None	None	None	None	None
Storage Length	0	0	150			0
Median Width	12			12	12	
Grade, %	0%			0%	0%	
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94
Heavy Vehicles, %	1	1	1	1	1	1
Mvmt Flow	33	69	93	593	586	72
Number of Lanes	1	0	1	1	1	0

Major/Minor				Major 1	Major 2	
Conflicting Flow All	1400	622	659	0	-	0
Stage 1	622	-	-	-	-	-
Stage 2	778	-	-	-	-	-
Follow-up Headway	3.509	3.309	2.209	-	-	-
Pot Capacity-1 Maneuver	155	489	934	-	-	-
Stage 1	537	-	-	-	-	-
Stage 2	455	-	-	-	-	-
Time blocked-Platoon, %	0	0	0	-	-	-
Mov Capacity-1 Maneuver	140	489	934	-	-	-
Mov Capacity-2 Maneuver	140	-	-	-	-	-
Stage 1	537	-	-	-	-	-
Stage 2	410	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	26.1	1.3	0
HCM LOS	D	-	-

Minor Lane / Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Cap, veh/h	934	-	271	-	-
HCM Control Delay, s	9.278	-	26.1	-	-
HCM Lane V/C Ratio	0.10	-	0.38	-	-
HCM Lane LOS	A	-	D	-	-
HCM 95th-tile Q, veh	0.3	-	1.7	-	-

Notes

~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Figure 1-1
Crossing Location Field Evaluation Worksheet

Step 1 – Location Description

Major Street: Kupuohi Street Crossing Location: Walmart Driveway (makai)

Is this a multi-use path crossing? ☒ Yes ☐ No Posted Speed Limit: 25 mph

Existing Traffic Control: ☐ Stop Sign ☐ Traffic Signal ☒ Uncontrolled

Existing Crossing Treatments (if any): None

Nearby Pedestrian Generators (school, bus stop, commercial development, etc.): Walmart, Times Supermarket, Royal Kunia Park and Ride

Step 2 – Physical Data

Roadway Configuration:
- ☐ 2-Lane
- ☒ 3-Lane
- ☐ 4-Lane w/ Raised Median
- ☐ 4-Lane w/out Raised Median
- ☐ 6-Lane
- ☐ Other: _____

Nearest Marked or Protected Pedestrian Crossing: Kupuna Loop (upper) Distance to: 625 ft

(For uncontrolled location only) Available Sight Distance (ASD) = 600 ft (Left) 600 ft (Right)

Is ASD ≥ 10x Speed Limit? ☒ Yes ☐ No If no, are improvements to ASD feasible? ☐ Yes ☐ No

Step 3 – Traffic Data

Pedestrian Crossing Volumes (including bicyclists):

AM Peak Hour TOTAL = 9 peds/hr including N/A young/elderly/disabled peds/hr

Time of Study: 6:30 AM to 7:30 AM Date: 8/28/2012

Mid-Day Peak Hour TOTAL = 18 peds/hr including N/A young/elderly/disabled peds/hr

Time of Study: 11:45 AM to 12:45 PM Date: 8/25/2012 (Saturday)

PM Peak Hour TOTAL = 23 peds/hr including N/A young/elderly/disabled peds/hr

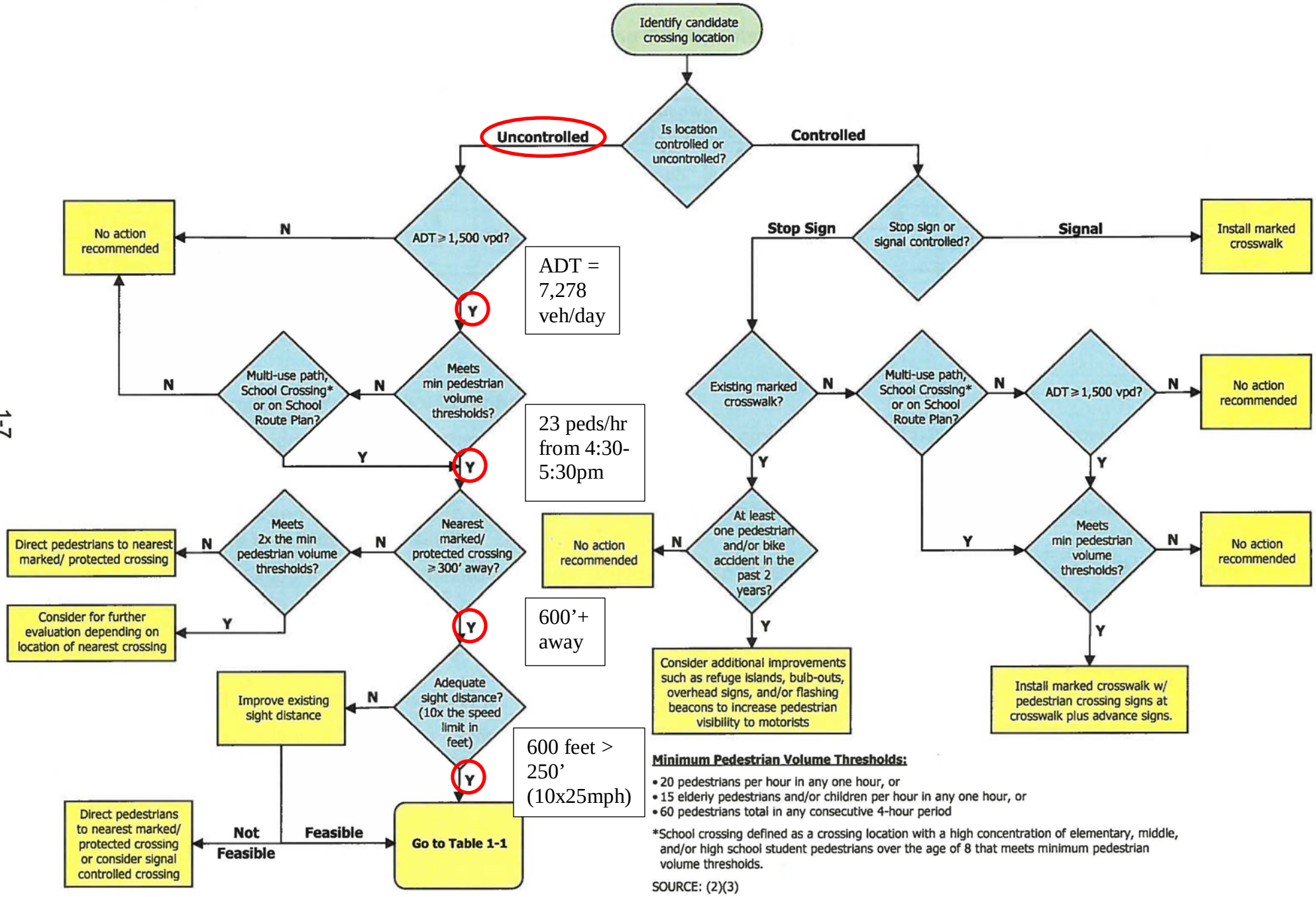
Time of Study: 4:30 PM to 5:30 PM Date: 8/28/2012

Major Street Vehicular Volume: ADT = 7,278 veh/day

Step 4 – Apply Data to Figure 1-2 and Table 1-1

Recommended Treatment(s): A – Install marked crosswalk with enhanced signs.

Figure 1-2 – Pedestrian Crossing Treatment Flowchart



Minimum Pedestrian Volume Thresholds:

- 20 pedestrians per hour in any one hour, or
- 15 elderly pedestrians and/or children per hour in any one hour, or
- 60 pedestrians total in any consecutive 4-hour period

*School crossing defined as a crossing location with a high concentration of elementary, middle, and/or high school student pedestrians over the age of 8 that meets minimum pedestrian volume thresholds.

SOURCE: (2)(3)

Table 1-1 – Criteria for Crossing Treatments at Uncontrolled Locations

Roadway Configuration	Roadway ADT and Posted Speed											
	1,500-9,000 vpd			9,000-12,000 vpd			12,000-15,000 vpd			> 15,000 vpd		
	≤30 mph	35 mph	40 mph	≤30 mph	35 mph	40 mph	≤30 mph	35 mph	40 mph	≤30 mph	35 mph	40 mph
1 or 2 Lanes	A	A	B	A	A	B	A	A	C	A	B	C
3 Lanes	A	A	B	A	B	B	B	B	C	B	C	C
4 or 5 Lanes With Raised Median	A	A	B	A	B	C	B	B	C	C	C	C
4 or 5 Lanes Without Raised Median	A	B	C	B	B	C	C	C	C	C	C	C
6 or More Lanes	C	C	C	C	C	C	C	C	C	C	C	C

A **Install marked crosswalk with enhanced signs**

Specific Guidance: Install marked crosswalk with pedestrian crossing sign (W11-2) and down arrow (W16-7p) plus advance warning signs. Use S1-1 signs for School Crossing locations.

B **Install marked crosswalk with enhanced signs and geometric improvements to increase pedestrian visibility and reduce exposure**

Specific Guidance: Install marked crosswalk with pedestrian crossing sign (W11-2) and down arrow (W16-7p) plus advance warning signs. Use S1-1 signs for School Crossing locations. In addition, install raised crosswalks, refuge islands, bulb-outs, overhead signs, and/or flashing beacons to increase pedestrian visibility to motorists and shorten the pedestrian crossing distance.

C **Do not install marked crosswalk.**

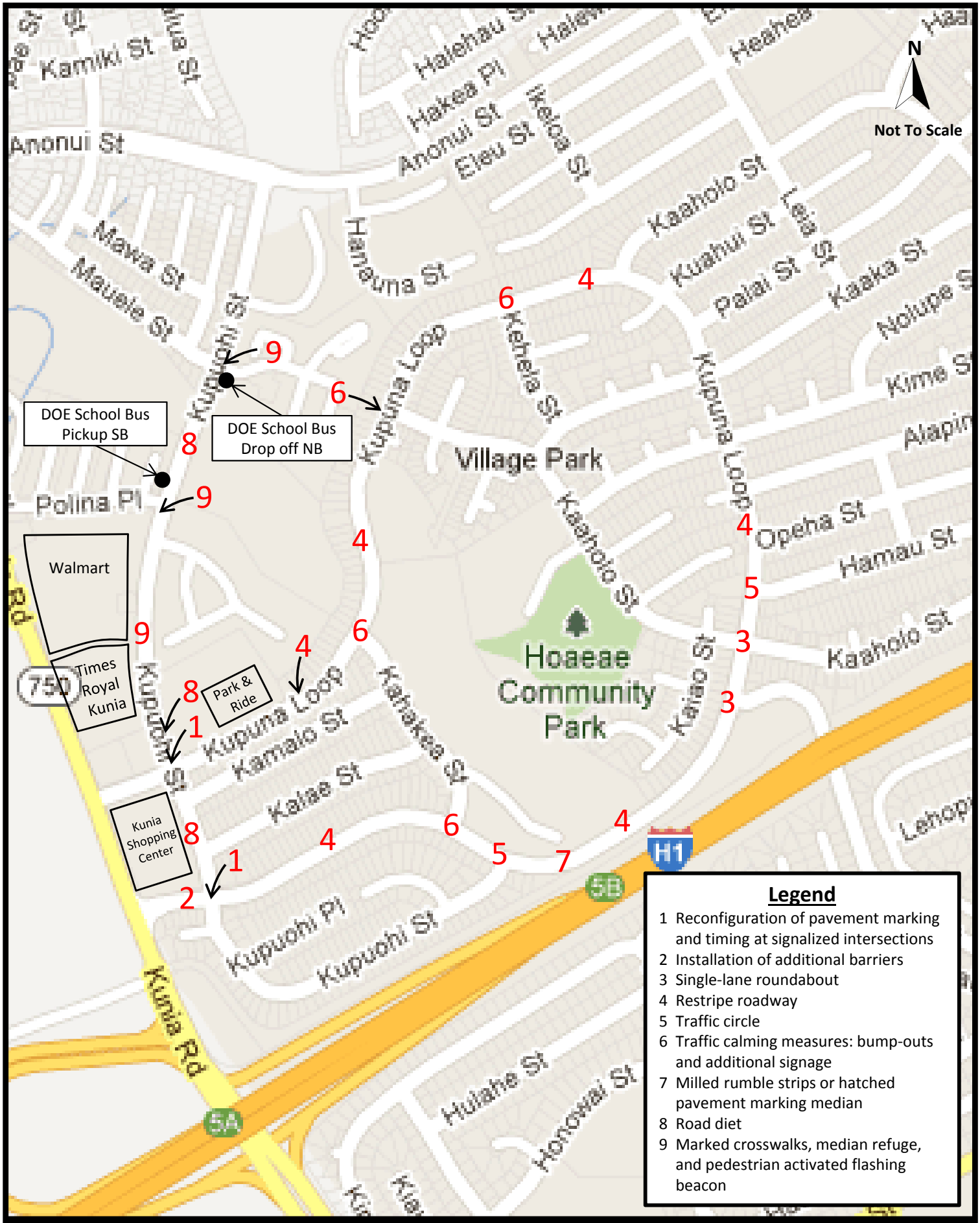
Specific Guidance: Consider traffic signal, grade-separated crossing, or other substantial crossing improvement to improve crossing safety for pedestrians.

APPENDIX D
Proposed Mitigation Map and Table

Village Park - Kupuna Loop Sub-Area Corridor Study
Mitigative Measures

ID #	Mitigation	Locations
1	Reconfiguration of pavement marking and timing at signalized intersections	Kupuna Loop (upper) at Kupuohi Street *
		Kupuna Loop (lower) at Kupuohi Street *
2	Installation of additional barriers	Kupuna Loop (lower) between Kunia Road and Kupuohi Street
3	Single-lane roundabout	Kupuna Loop (lower) at Aiki Street *
		Kupuna Loop (lower) at Kaaholo Street *
4	Restripe roadway	Kupuna Loop east of Kupuohi Street
5	Traffic circle	Kupuna Loop (lower) at Kupuohi Street (lower) *
		Kupuna Loop at Hamau Street
6	Traffic calming measures: bumpouts and additional signage	Kupuna Loop (upper) at Kaaholo Street (NW) *
		Kupuna Loop (upper) at Kehela Street
		Kupuna Loop (upper) at Kahakea Street
		Kupuna Loop (lower) at Kahakea Street
7	Milled rumble strips or hatched pavement marking median	Kupuna Loop (lower) between Kupuohi Street (lower) and Aiki Street
8	Road Diet	Kupuohi Street between Anonui Street and Kupuna Loop (upper)
		Kupuohi Street between Kupuna Loop (upper) and Kupuna Loop (lower)
		All throughout Anonui Street
9	Marked crosswalks, median refuge, and pedestrian activated flashing beacon	Kupuohi Street at Polina Place *
		Kupuohi Street at Walmart driveway (makai)/ The Villas at Royal Kunia driveway
		Kupuohi Street at Mauele Street
10	Overflow parking	Anonui Street near Community Park
11	Road block	North end of Anonui Street

* - Conceptual design included in Appendix E.



Legend

1 Reconfiguration of pavement marking and timing at signalized intersections
2 Installation of additional barriers
3 Single-lane roundabout
4 Restripe roadway
5 Traffic circle
6 Traffic calming measures: bump-outs and additional signage
7 Milled rumble strips or hatched pavement marking median
8 Road diet
9 Marked crosswalks, median refuge, and pedestrian activated flashing beacon

Village Park Mitigation Map

Village Park Corridor Study – Kunia, Hawaii

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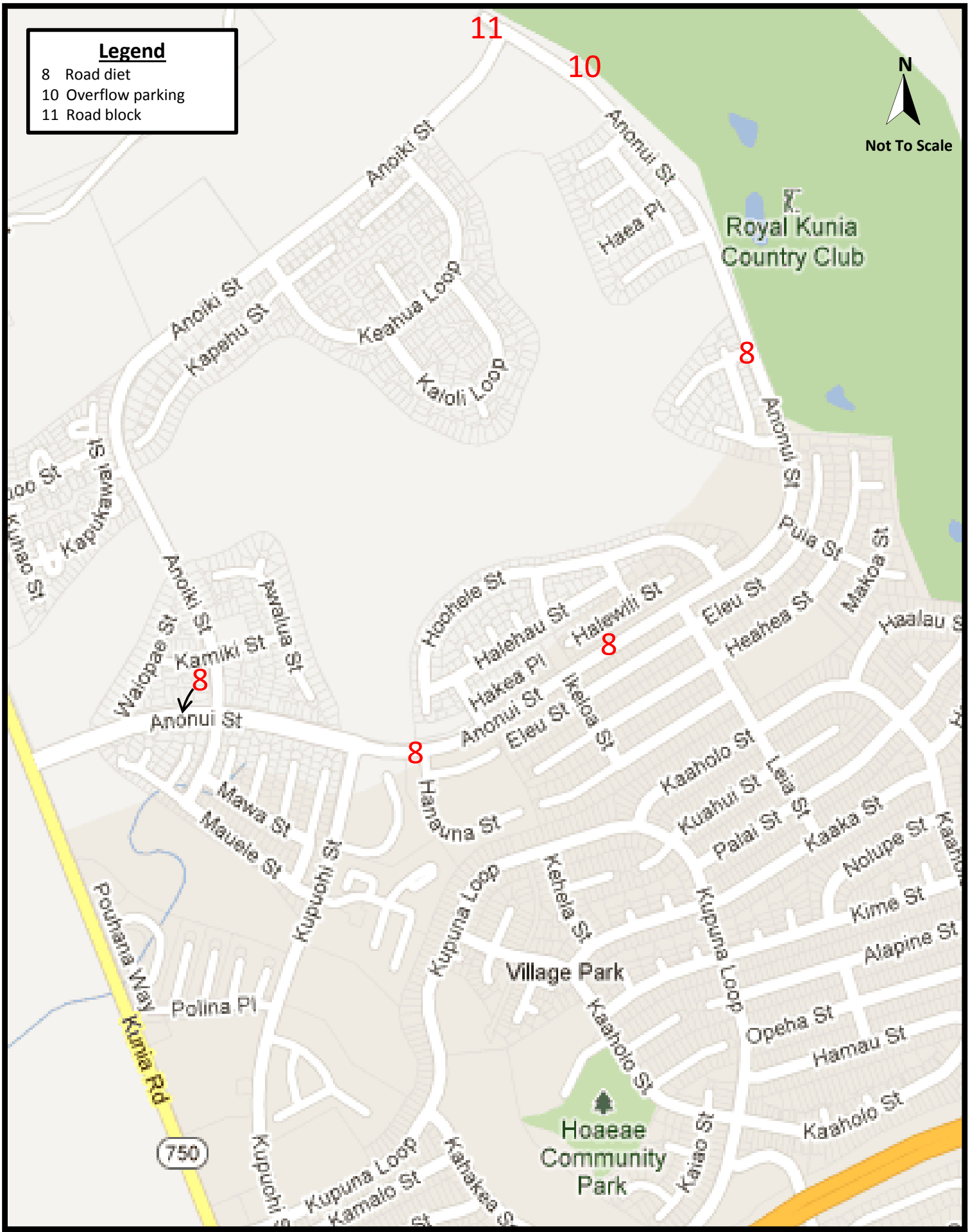

Royal Kunia Mitigation Map

Village Park Corridor Study – Kunia, Hawaii

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APPENDIX E
Civil Conceptual Designs

APPROX. NORTH
SCALE: 1 In. = 40 Ft.

PROPERTY LINE, TYP.

KUPUNA LOOP (LOWER)

EXIST. CROSSWALKS TO REMAIN

NEW PAVEMENT MARKINGS, TYP.

REMOVE EXIST. PAVEMENT MARKING, TYP.

NEW 6" WIDE WHITE STRIPING WITH TYPE "C" RPM AT 20' O.C.

NEW 4" WIDE DOUBLE YELLOW STRIPING WITH TYPE "D" RPM AT 20' O.C.

TO KUPUNA LOOP (LOWER) – KUPUOHI ST. INTERSECTION

KUPUOHI ST.

NEW 6" WIDE WHITE STRIPING WITH TYPE "C" RPM AT 20' O.C.

NEW 4" WIDE DOUBLE YELLOW STRIPING WITH TYPE "D" RPM AT 20' O.C.

NEW 4" WIDE DOUBLE YELLOW STRIPING WITH TYPE "D" RPM AT 20' O.C.

BULB OUT

PARKING LANE

NEW CROSSWALK

NEW 4" WIDE DOUBLE YELLOW STRIPING WITH TYPE "D" RPM AT 20' O.C.

4" WIDE WHITE HASH STRIPE AT 10' O.C.

REMOVAL OF FIVE (5) PARKING STALLS.

PARKING LANE

BIKE LANE PAVEMENT MARKING, TYP.

TO KUPUNA LOOP (UPPER) – KUPUOHI ST INTERSECTION

241° 50' 10"
100.00

KUPUOHI ST AT KUPUNA LOOP (LOWER)
MITIGATION #2

EXISTING SIDEWALK, TYP.

EXISTING CROSSWALK, TYP.

EXISTING PAVEMENT MARKING AND STOP LINE TO REMAIN

EXISTING CURB AND GUTTER, TYP.

EXISTING CURB RAMP, TYP.

SHARROWS, TYP.

ONLY

NEW 4" WIDE WHITE HASH STRIPE AT 10' O.C.

NEW 4" WIDE YELLOW DOTTED GUIDE STRIPING, TYP.

EXISTING PAVEMENT MARKINGS, TYP.

KUPUNA LOOP (UPPER)

KUPUOHI ST AT KUPUNA LOOP (UPPER)
MITIGATION #1

40' 20' 0 40' 80'

SCALE: 1" = 40'

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APPENDIX D–MITIGATION #1 AND #2

VILLAGE PARK CORRIDOR STUDY – KUNIA, HAWAII

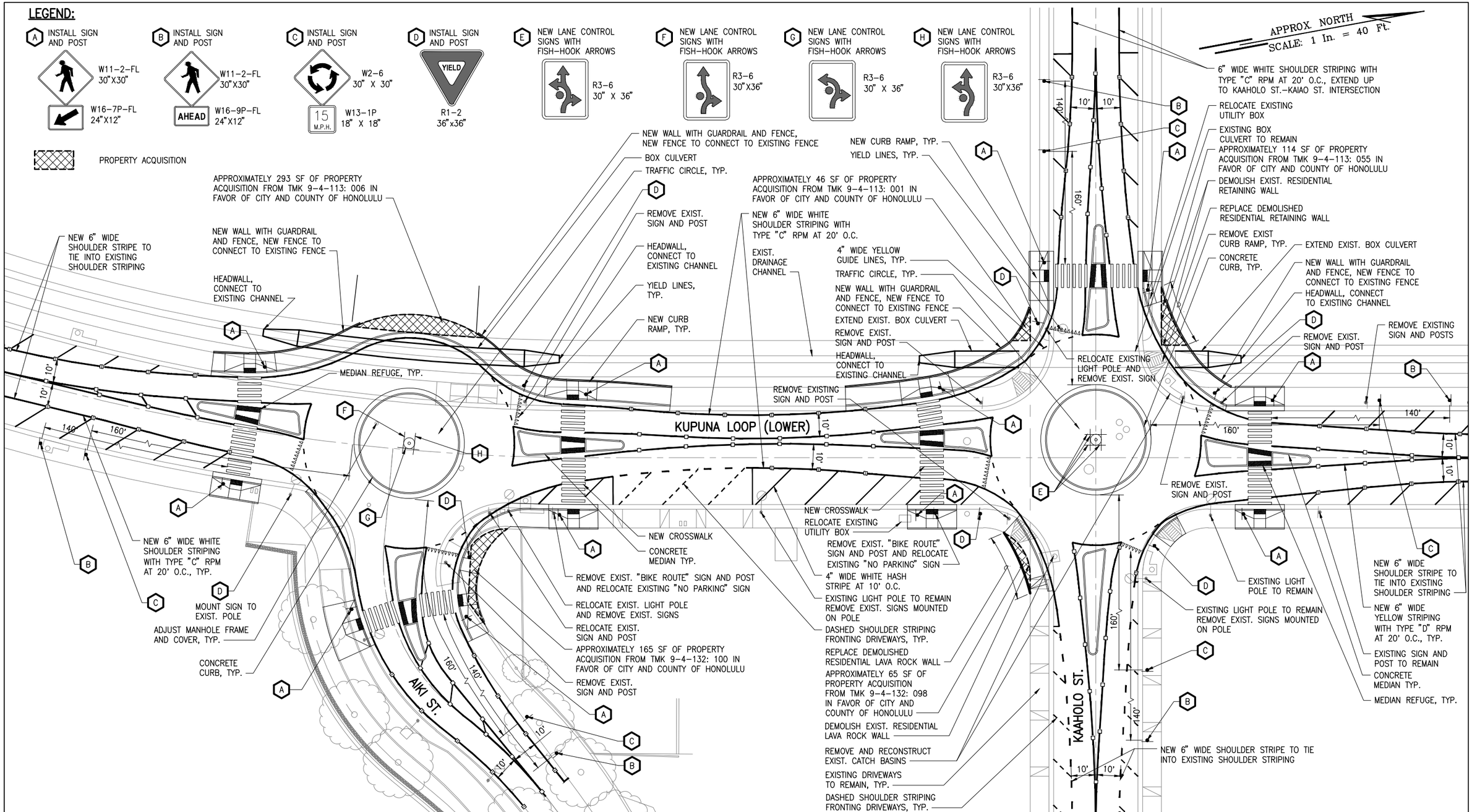
SHEET C–1

LEGEND:

- (A) INSTALL SIGN AND POST — W11-2-FL 30"X30"; W16-7P-FL 24"X12"
- (B) INSTALL SIGN AND POST — W11-2-FL 30"X30"; W16-9P-FL AHEAD 24"X12"
- (C) INSTALL SIGN AND POST — W2-6 30" X 30"; W13-1P 15 M.P.H. 18" X 18"
- (D) INSTALL SIGN AND POST — YIELD R1-2 36"x36"
- (E) NEW LANE CONTROL SIGNS WITH FISH-HOOK ARROWS — R3-6 30" X 36"
- (F) NEW LANE CONTROL SIGNS WITH FISH-HOOK ARROWS — R3-6 30"X36"
- (G) NEW LANE CONTROL SIGNS WITH FISH-HOOK ARROWS — R3-6 30" X 36"
- (H) NEW LANE CONTROL SIGNS WITH FISH-HOOK ARROWS — R3-6 30"X36"

PROPERTY ACQUISITION

APPROX. NORTH
SCALE: 1 In. = 40 Ft.



KUPUNA LOOP AT AIKI ST
(MITIGATION #3)

KUPUNA LOOP AT KAAHOLO ST
(MITIGATION #4)

40' 20' 0 40' 80'
SCALE: 1" = 40'

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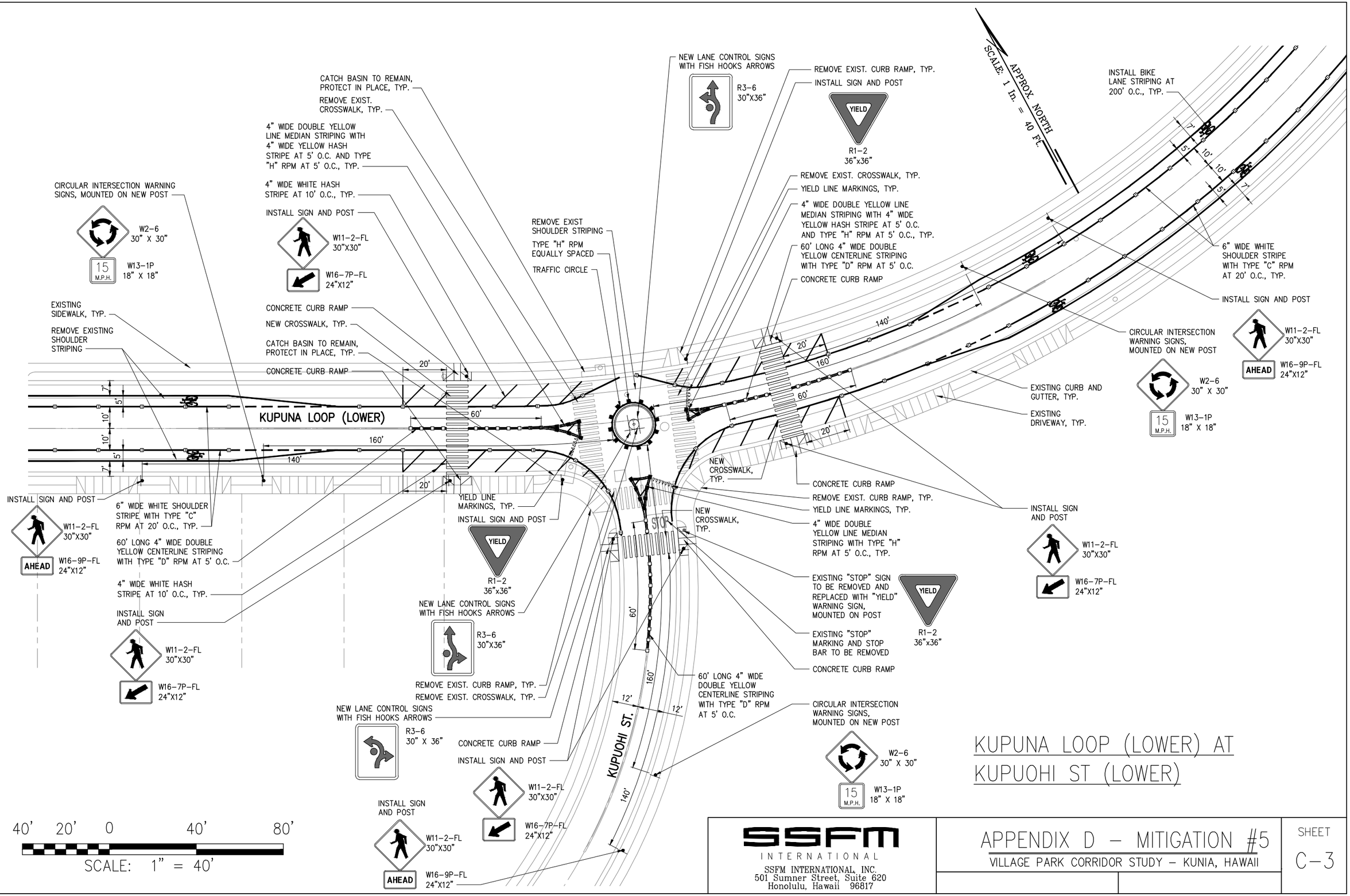
APPENDIX D-MITIGATION #3 AND #4
VILLAGE PARK CORRIDOR STUDY - KUNIA, HAWAII

SHEET
C-2



KUPUNA LOOP (LOWER) AT KUPUOHI ST (LOWER)

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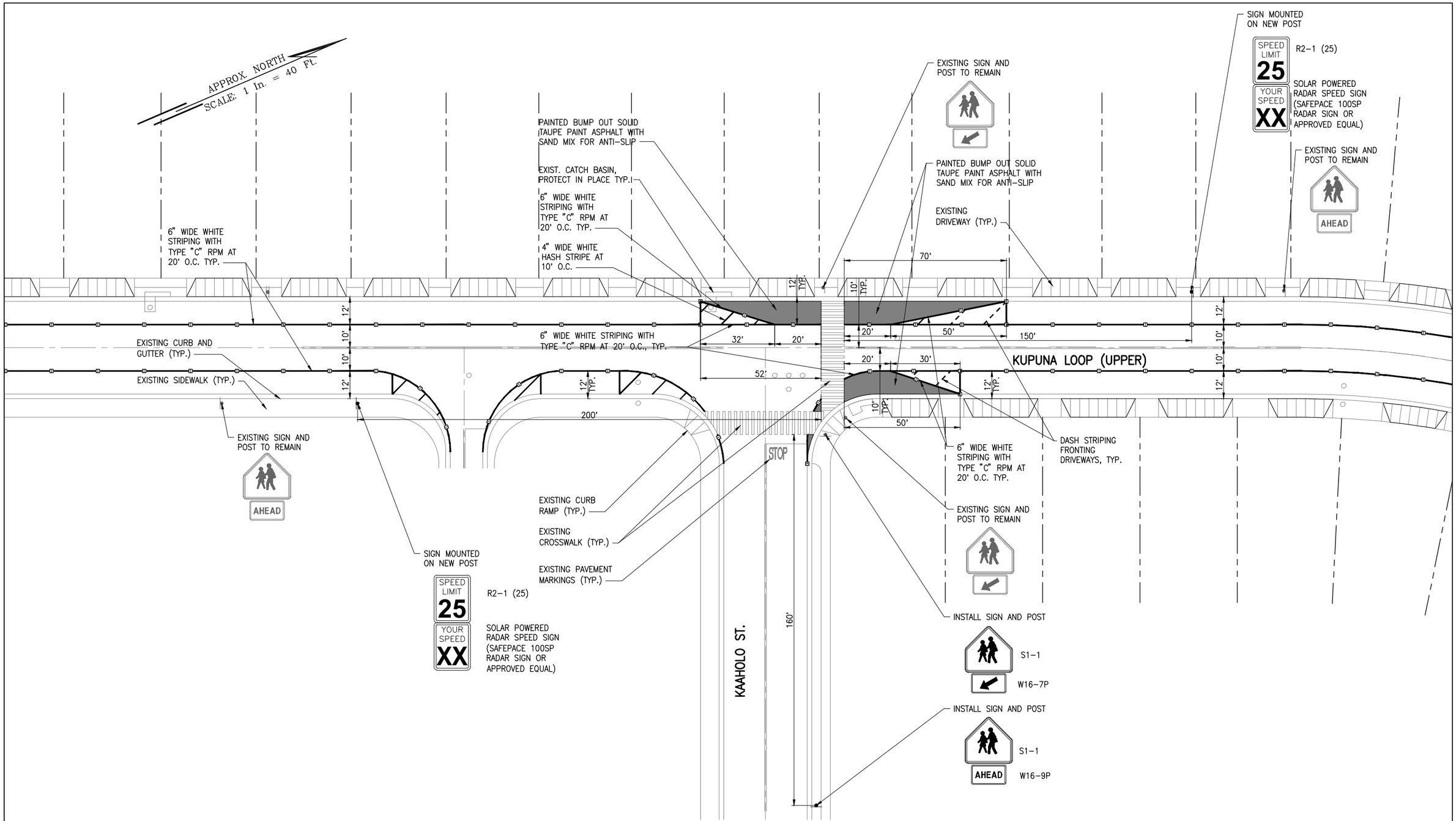
APPENDIX D – MITIGATION #5

VILLAGE PARK CORRIDOR STUDY – KUNIA, HAWAII

SHEET C-3



KUPUNA LOOP (UPPER) AT KAAHOLO ST

40' 20' 0 40' 80'

SCALE: 1" = 40'

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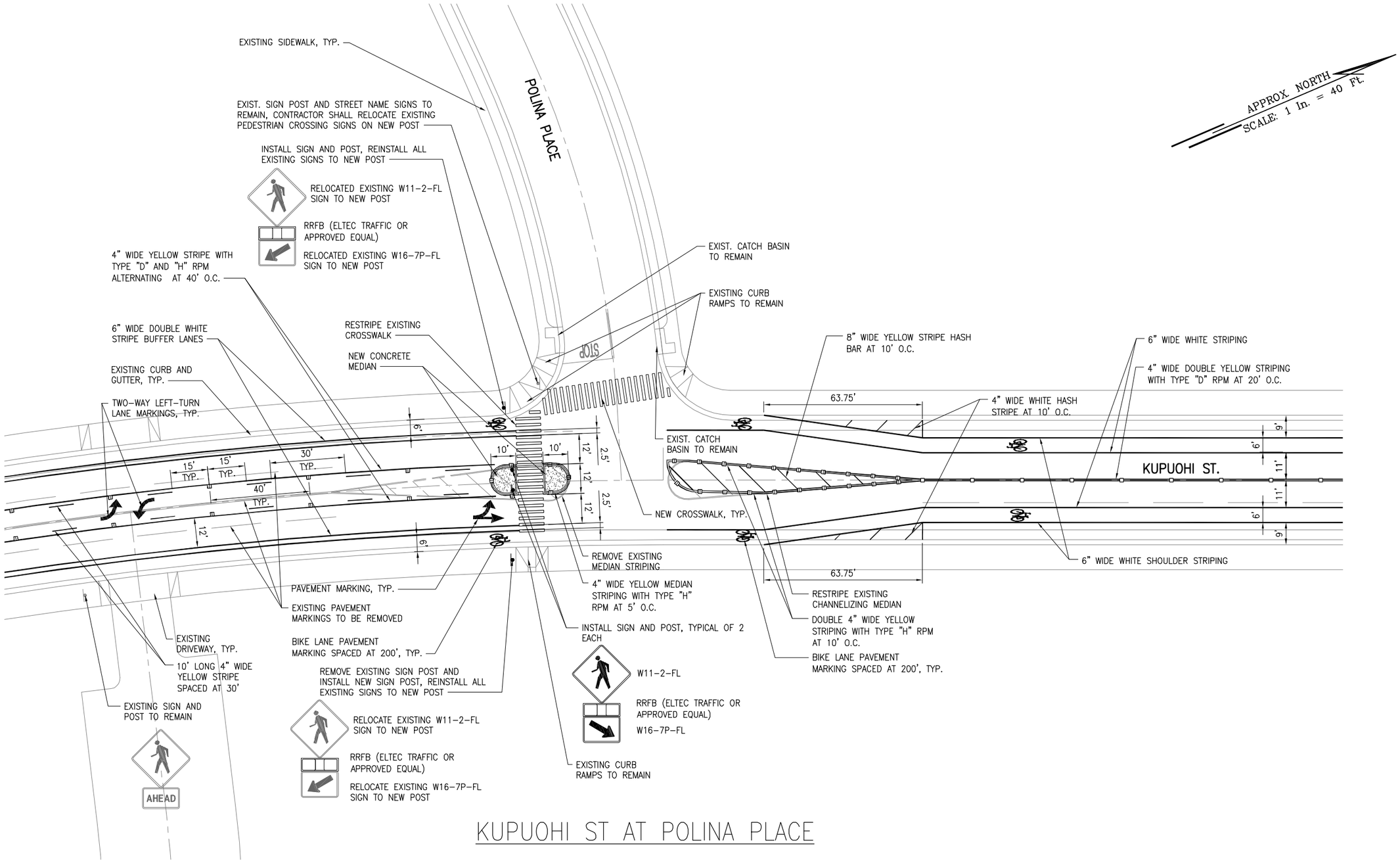
APPENDIX D – MITIGATION #6

VILLAGE PARK CORRIDOR STUDY – KUNIA, HAWAII

SHEET C-4



KUPUOHI ST AT POLINA PLACE

40' 20' 0 40' 80'

SCALE: 1" = 40'

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APPENDIX D – MITIGATION #9

VILLAGE PARK CORRIDOR STUDY – KUNIA, HAWAII

SHEET C–5

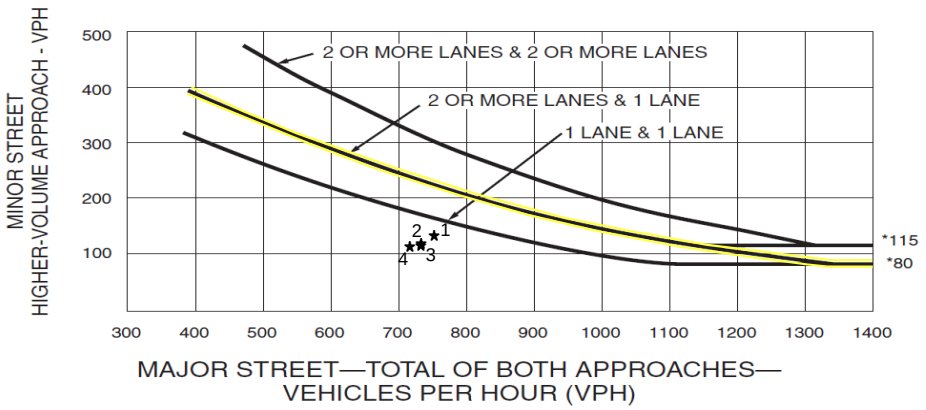
APPENDIX F
Traffic Signal Warrants

Traffic Signal Warrants
Kupuohi Street and Walmart driveway Intersection

4-Hour Warrant - Figure 4C-2

Major/Minor Roads	Approach Type	# of Lanes	1		2		3		4		Pass?
Kupuohi Street /	Major	2	748	No	731	No	731	No	708	No	**No**
Walmart driveway	Minor	1	131		116		111		111		

Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume

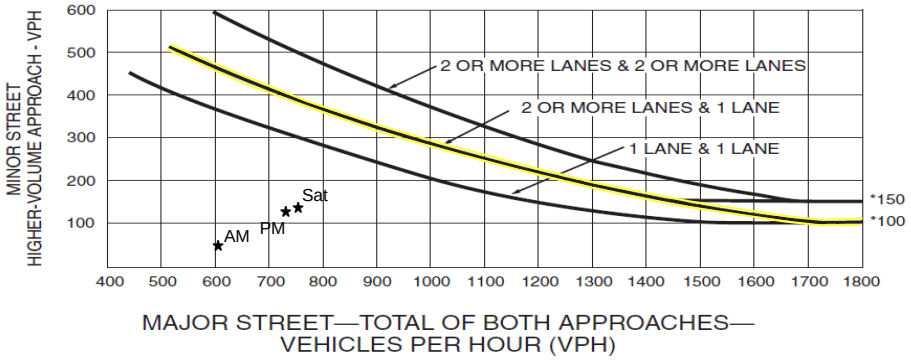


*Note: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.

Peak Hour Warrant - Figure 4C-3

Major/Minor Roads	Approach Type	# of Lanes	Sat Volume	Pass?	AM Volume	Pass?	PM Volume	Pass?	Pass?
Kupuohi Street /	Major	2	758	No	607	No	731	No	No
Walmart driveway	Minor	1	125		44		116		

Figure 4C-3. Warrant 3, Peak Hour



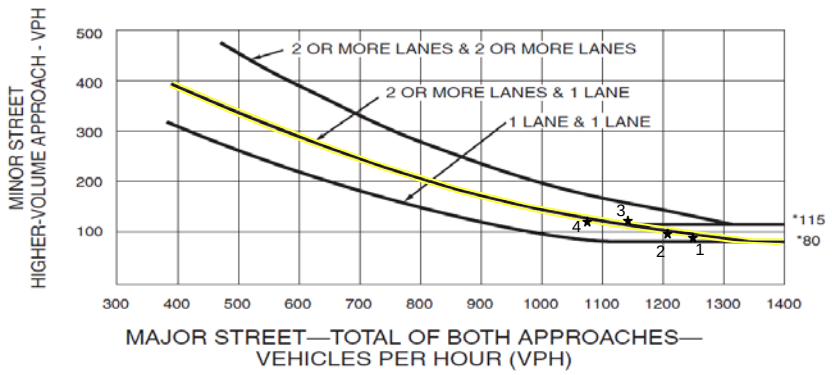
*Note: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.

Source: *MUTCD, 2009.*

4-Hour Warrant - Figure 4C-2

Major/Minor Roads	Approach Type	# of Lanes	1		2		3		4		Pass?
Kupuohi Street /	Major	2	1255	No	1208	No	1149	Pass	1088	No	**No**
Times driveway	Minor	1	92		97		120		118		

Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume

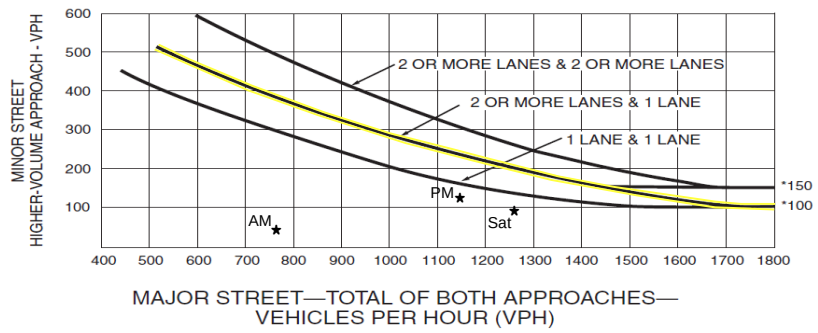


*Note: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.

Peak Hour Warrant - Figure 4C-3

Major/Minor Roads	Approach Type	# of Lanes	Sat Volume	Pass?	AM Volume	Pass?	PM Volume	Pass?	Pass?
Kupuohi Street /	Major	2	1263	No	777	No	1149	No	No
Times driveway	Minor	1	96		36		120		

Figure 4C-3. Warrant 3, Peak Hour



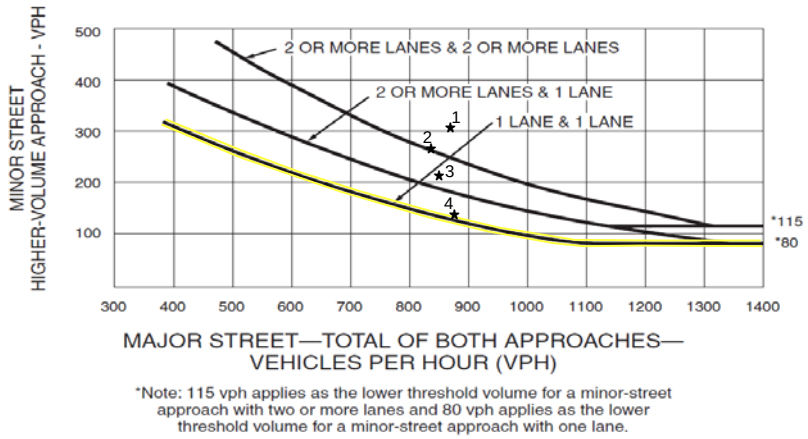
*Note: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.

Source: *MUTCD, 2009.*

4-Hour Warrant - Figure 4C-2

Major/Minor Roads	Approach Type	# of Lanes	1		2		3		4		Pass?
Kupuna Loop (lower) /	Major	1	874	Pass	836	Pass	853	Pass	884	Pass	**Pass**
Aiki Street	Minor	1	303		267		212		132		

Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume

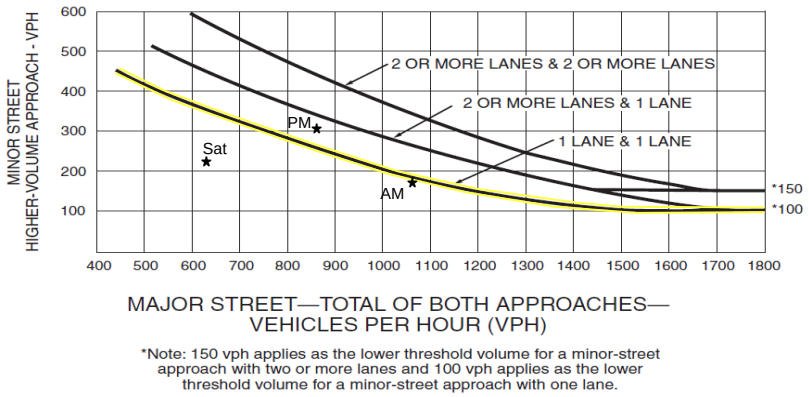


*Note: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.

Peak Hour Warrant - Figure 4C-3

Major/Minor Roads	Approach Type	# of Lanes	Sat Volume	Pass?	AM Volume	Pass?	PM Volume	Pass?	Pass?
Kupuna Loop (lower) /	Major	1	623	No	1074	No	874	Pass	Pass
Aiki Street	Minor	1	213		174		303		

Figure 4C-3. Warrant 3, Peak Hour



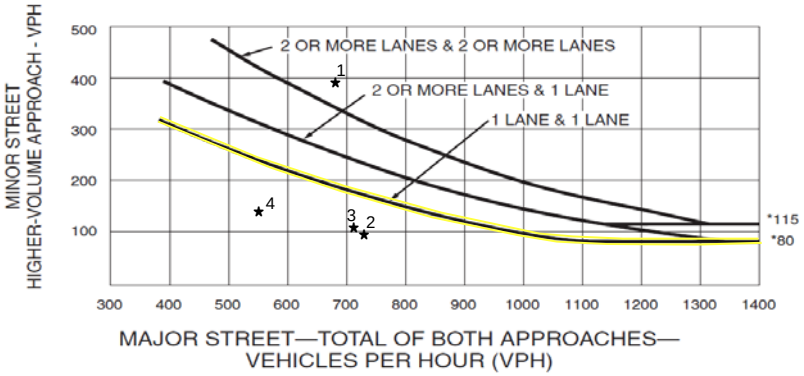
*Note: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.

Source: *MUTCD, 2009.*

4-Hour Warrant - Figure 4C-2

Major/Minor Roads	Approach Type	# of Lanes	1		2		3		4		Pass?
Kupuna Loop (lower) / Kaaholo Street (south)	Major	1	690	Pass	726	No	708	No	566	No	**No**
	Minor	1	394		99		103		136		

Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume

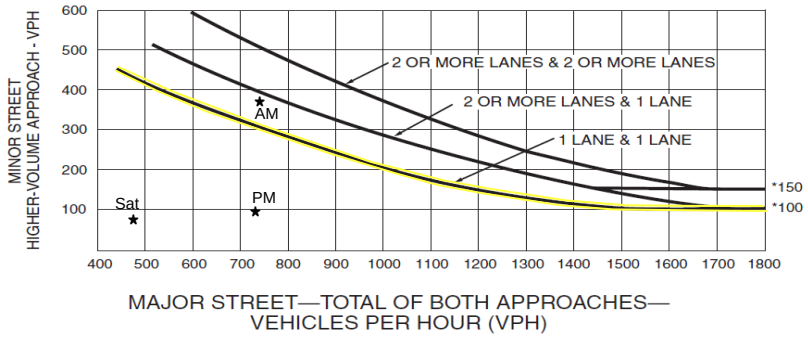


*Note: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.

Peak Hour Warrant - Figure 4C-3

Major/Minor Roads	Approach Type	# of Lanes	Sat Volume	Pass?	AM Volume	Pass?	PM Volume	Pass?	Pass?
Kupuna Loop (lower) / Kaaholo Street (south)	Major	1	483	No	731	Pass	726	No	Pass
	Minor	1	89		377		99		

Figure 4C-3. Warrant 3, Peak Hour



*Note: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.

Source: *MUTCD, 2009.*