FARRINGTON HIGHWAY INTERSECTION IMPROVEMENTS AT HALEAKALA AVENUE AND NANAKULI AVENUE

Waianae, Oahu, Hawaii

Draft Environmental Assessment

APRIL 2010

State of Hawaii
Department of Transportation
Highways Division

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APPENDIX B: Hazardous Materials Technical Memo
APPENDIX C: Cultural Impact Evaluation (Cultural Impact Assessment, April 2005; follow-up letter report, May 2005)
APPENDIX D: Traffic Study
APPENDIX E: Air Quality Technical Report
APPENDIX F: Noise Technical Report
APPENDIX G: Archaeological Literature Review and Field Inspection

LIST OF ACRONYMS

AAQS	Ambient Air Quality Standards
AIAN	American Indian or Alaskan Native
AM	morning
AASHTO	American Association of State Highway Transportation Officials
ACHP	Advisory Council on Historic Preservation
ADA	Americans with Disabilities Act
AG-1	land zoned as restricted agriculture
ALISH	Agricultural Lands of Importance to the State of Hawaii
APE	Area of Potential Effect
ASTM	American Society for Testing and Materials
BMPs	Best Management Practices
BPNAS	Barbers Point Naval Air Station
BRT	Bus Rapid Transit
BWS	Board of Water Supply
CFR	Code of Federal Regulations
CIA	Cultural Impact Assessment
CWA	Clean Water Act
CZM	Hawaii Coastal Zone Management Program
DA	U.S. Department of the Army
DAGS	Hawaii Department of Accounting and General Services
dB	decibel
dBA	A-weighted decibel
DBEDT	Department of Business, Economic Development and Tourism
DEA	Draft Environmental Assessment
DHHL	State of Hawaii, Department of Hawaiian Home Lands
DLNR	State of Hawaii, Department of Land and Natural Resources
DOE	Hawaii Department of Education
DP	Development Plan
DHHS	U.S. Department of Health and Human Services
DPP	City and County of Honolulu, Department of Planning and Permitting
DTS	City and County of Honolulu, Department of Transportation Services
EA	Environmental Assessment
EJ	Environmental Justice
EJC	Estate of James Campbell
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
Ewa DP	Ewa Development Plan
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
FPPA	Farmland Protection Policy Act
HAR	Hawaii Administrative Rules
HC	hydrocarbons

HCDA	Hawaii Community Development Authority
HCDCH	Housing and Community Development Corporation of Hawaii
HCM	Highway Capacity Manual
HDOH	State of Hawaii Department of Health
HDOT	State of Hawaii Department of Transportation
HECO	Hawaiian Electric Company
HEI	Hawaiian Electric, Inc.
HOV	High Occupancy Vehicle
HRS	Hawaii Revised Statutes
HWY-D	HDOT Highways Division, Design Branch
KCDD	Kalaeloa Community Development District
KKHD	Koko Head
L_{eq}	constant energy level equivalent noise level
LOS	level-of-service
LUO	Land Use Ordinance
MOA	Memorandum of Agreement
MPH	miles per hour
n.a.	not available
NAC	Noise Abatement Criteria
NCHRP	National Cooperative Highway Research Program
NEPA	National Environmental Policy Act
NHOPI	Native Hawaiian or Other Pacific Islander
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
OEQC	Office of Environmental Quality Control
OHA	Office of Hawaiian Affairs
OIBC	Oahu Island Burial Council
OMPO	Oahu Metropolitan Planning Organization
OR&L	Oahu Railway & Land Company
ORTP	Oahu Regional Transportation Plan
PB	Parsons Brinckerhoff
PM	afternoon
ROW	Right-of-way
RTP	Regional Transportation Plan
SDWA	Safe Drinking Water Act
SHPD	State Historic Preservation Division
SHPO	State Historic Preservation Officer
SIHP	State Inventory of Historic Properties
SIP	Hawaii State Implementation Plan for air quality
SMA	Special Management Area
SOBA	Southern Oahu Basal Aquifer
STIP	Statewide Transportation Improvement Program
TDM	Travel Demand Management
TMAs	Travel Management Associations
TMK	Tax Map Key

TNM	Traffic Noise Model
TOP 2030	Transportation for Oahu Plan 2030
TSM	Transportation System Management
US DOT	U.S. Department of Transportation
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VPH	vehicles per hour

CHAPTER 1: DESCRIPTION OF THE PROPOSED ACTION

1.1 INTRODUCTION

The State of Hawaii Department of Transportation (HDOT), in cooperation with the U.S. Department of Transportation's Federal Highway Administration (FHWA), is proposing improvements to Farrington Highway between Helelua Street and Nanakuli Stream in Nanakuli on the island of Oahu, a total distance of approximately 0.8 miles (see Figure 1-1). The proposed project would widen Farrington Highway within these project limits from four to five lanes, with the new fifth lane dedicated to left-turn movements only. In addition to the widening, the proposed project would provide a shared use path for pedestrians and cyclists on the makai side of the highway, and would upgrade highway lighting and drainage systems. The existing State-owned right-of-way (ROW) for Farrington Highway, which varies in width between approximately 90 to 100 feet, would be adequate for the new facilities. The ROW is adjacent to tax map key (TMK) plats: 8-9-001, 02, and 8-7-008.

The proposed project is listed in the 2030 Oahu Regional Transportation Plan (ORTP), which is the long-range regional transportation plan prepared by the Oahu Metropolitan Planning Organization (OMPO). The proposed project also encompasses projects S06 and S08 as listed in the Statewide Transportation Improvement Program (STIP) (FY 2008 to FY 2013).

1.1.1 PURPOSE OF THIS DOCUMENT

The project actions proposed by HDOT require environmental review in accordance with Chapter 343 of Hawai'i Revised Statutes (HRS) because of the use of State funds for its construction. Therefore, the proposed project must undergo environmental review in accordance with HRS Chapter 343 and Title 11, Chapter 200 of the Hawai'i Administrative Rules (HAR). Roadway widening to install a fifth lane for localized purposes is typically exempted from environmental review, however, since the proposed project would impact the historic Oahu Railway and Land railroad (OR&L), which is listed on the National Register of Historic Places, an Environmental Assessment is appropriate.

This Draft Environmental Assessment (EA) discloses the environmental and social impacts that could result from the project's implementation, and commits to the employment of specific measures to prevent, minimize or mitigate adverse impacts to the environment. Additionally, this Draft EA contains a record of all comments and consultation activities that have been conducted to date as part of project planning.

Because federal funds administered by the FHWA would be used for construction, the project must also comply with the National Environmental Policy Act (NEPA), a federally-mandated environmental review process. Pursuant to NEPA, a Categorical Exclusion (CatEx) is anticipated for this project. This Draft EA provides supporting documentation for compliance with NEPA and other federal environmental regulations, which are ongoing. Other federal laws that apply to the proposed project include

Section 7 of the Endangered Species Act, Section 106 of the National Historic Preservation Act, and Section 4(f) of the 1966 Department of Transportation Act.

HDOT has determined that the Proposed Action is not likely to have a "significant" impact in accordance with HRS Chapter 343. Therefore, HDOT anticipates issuing a "Finding of No Significant Impact" (FONSI) on the project. After receipt of agency and public comments on this Draft EA, HDOT will determine if its preliminary FONSI determination is still appropriate.

1.1.2 ORGANIZATION OF THIS DOCUMENT

This Draft EA is organized as follows:

- Chapter 1 discusses the Purpose and Need for the proposed project and introduces the alternatives that were considered, as well as the project's anticipated schedule, costs, and permits and approvals that may be required.
- Chapter 2 describes the existing environmental and social conditions in and around the project site, discloses the potential impacts that may result from the project, and proposed mitigation measures for those impacts considered adverse.
- Chapter 3 documents the agency and public coordination conducted to date.
- Chapter 4 provides the rationale for HDOT's anticipated FONSI, pursuant to HRS Chapter 343.
- Chapter 5 consists of a list of references used in the preparation of this EA.
- Appendix A contains records of comments and coordination conducted for the proposed project.
- Appendices B through F are various technical reports prepared for this project.

1.1.3 NAMING CONVENTIONS IN THIS DOCUMENT

This document generally uses the directional terms north, south, east, and west. However, the terms "mauka" and "makai" (towards the mountains and towards the ocean, respectively) are also used, especially where these terms may be the most accurate way to describe a direction or location. For this project area, mauka generally corresponds to a north easterly direction, and makai is a south westerly direction.

In addition, the Ka Waihona o ka Nauao Public Charter School (Ka Waihona PCS) campus, located makai of Farrington Highway, accommodates six educational and childcare facilities including Ka Waihona PCS, Kamehameha Schools Pre-School, Punana Leo, In Peace, Nanakuli Head Start, and the Nanakuli Learning Center (see Figure 1-2). Unless otherwise stated, this document uses Ka Waihona PCS Campus and Ka Waihona PCS to refer to the entire property as a whole, including the other institutions and childcare facilities located therein.

Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
Draft Environmental Assessment

Project Location Map
Figure 1-1

Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
Draft Environmental Assessment

Ka Waihona PCS Campus
Figure 1-2

1.2 PROJECT PURPOSE AND NEED

This project would address the following issues:

- Improve traffic safety;
- Improve traffic operations and relieve congestion;
- Provide facilities for pedestrians and cyclists, which are lacking.

1.2.1 IMPROVE TRAFFIC SAFETY

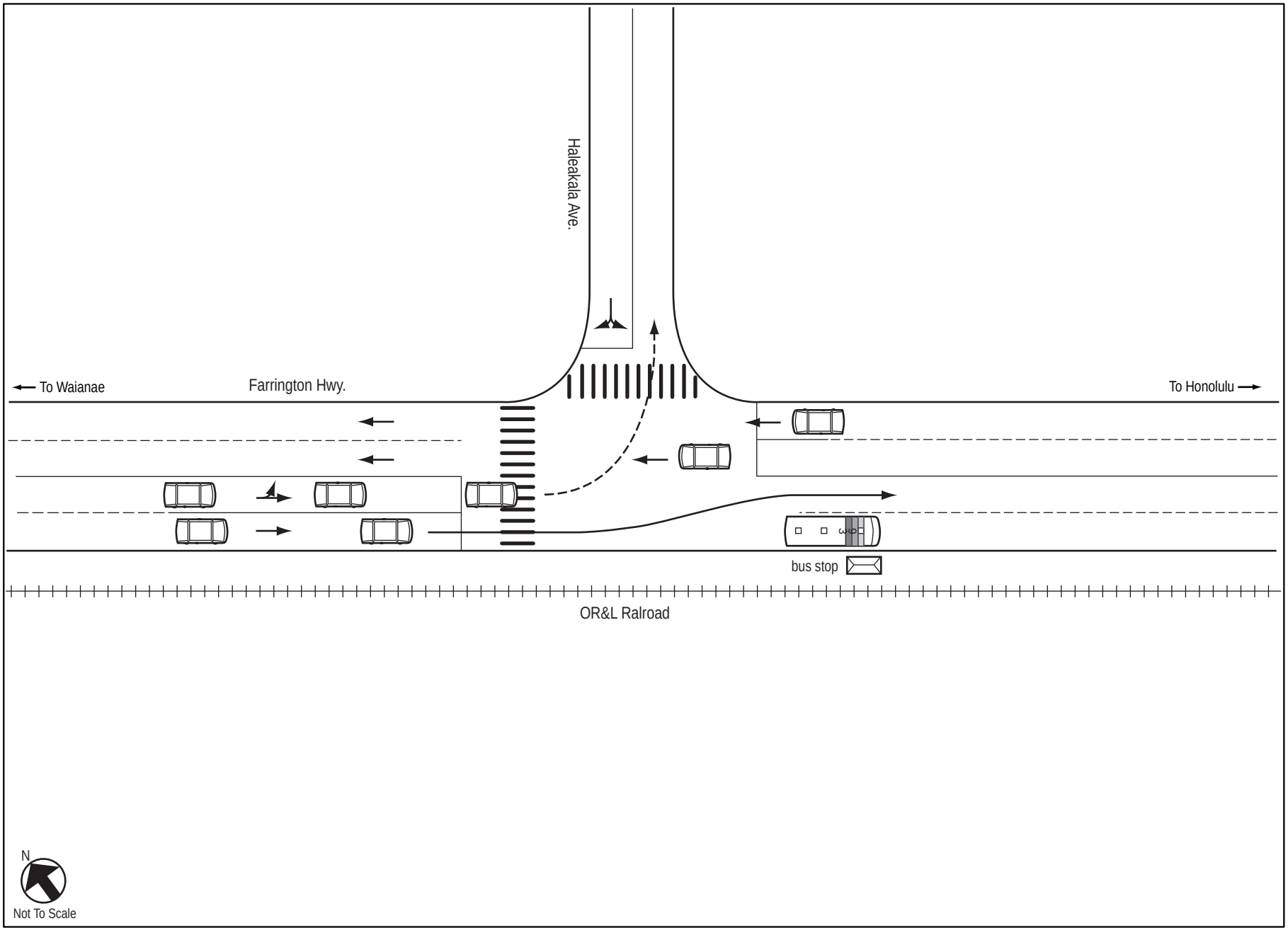
The purpose of the proposed project is to improve safety on Farrington Highway, specifically at the Haleakala Avenue and Nanakuli Avenue intersections.

Haleakala Avenue is a three-legged intersection where the Waianae-bound approach on Farrington Highway has one shared through/right turn lane and one through lane. The Honolulu-bound approach contains one shared through/left turn lane and one through lane. Haleakala Avenue has two lanes, one mauka-bound, and one makai-bound at its intersection with Farrington Highway. Figure 1-3 shows the existing operations and lane configuration at the Farrington Highway / Haleakala Avenue intersection.

The intersection of Nanakuli Avenue and Farrington Highway is a four-legged intersection where the entrance/exit to Nanakuli Beach Park is directly opposite of Nanakuli Avenue. For this portion of Farrington Highway, the Honolulu-bound direction has one shared left-turn/through lane, and one shared right-turn/through lane. The Waianae-bound direction also has a shared left-turn/through lane, and a shared right-turn/through lane. Figure 1-4 shows the existing operations and lane configuration at the Farrington Highway / Nanakuli Avenue intersection.

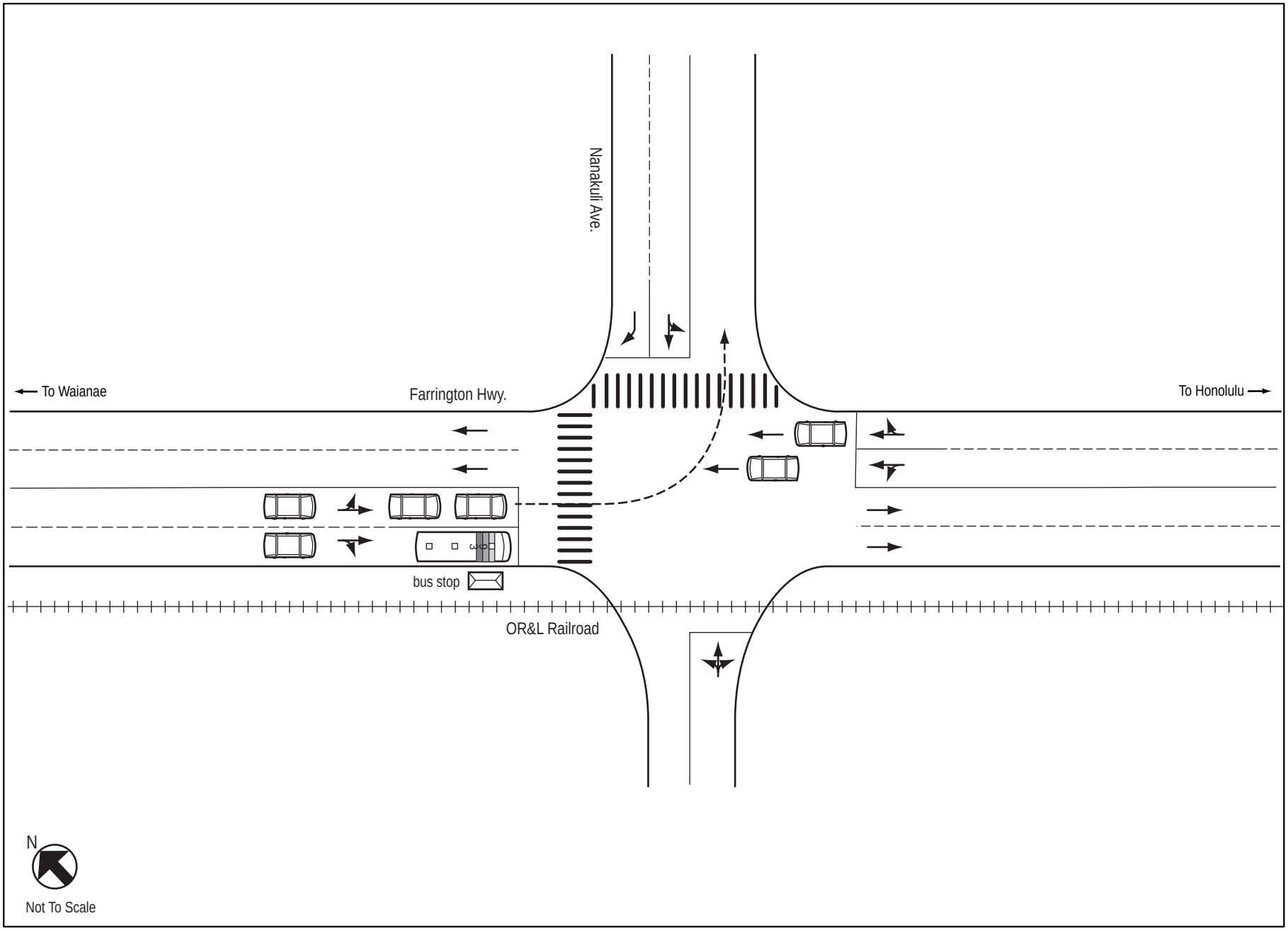
Both Haleakala Avenue and Nanakuli Avenue provide access to hundreds of homes in the Nanakuli Valley as well as Nanaikapono Elementary School, Nanakuli Elementary School, Nanakuli Intermediate and High School, the Nanakuli Fire Station and other community resources. It is estimated that one out of five cars traveling within the project limits in the Honolulu-bound direction will turn at either one of these two intersections.[1] Since Farrington Highway is the principal means to enter and exit Nanakuli and the rest of the Waianae Coast, it is a heavily utilized roadway. Total bi-directional volumes taken in 2007 at Nanakuli Bridge, just south east of the project limits, yielded 42,248 vehicles within a 24-hour time period.

[1] Estimate is based on vehicle counts taken in April 2009 as part of the traffic study included in Appendix B.



Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
Draft Environmental Assessment

Existing Operations at Haleakala Avenue
Figure 1-3



Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
Draft Environmental Assessment

Existing Operations at Nanakuli Avenue
Figure 1-4

Given the high vehicle volumes on Farrington Highway and high number of motorists making left-turns at Haleakala and Nanakuli Avenue, the traffic signals at these intersections provide a 10 second delay to Waianae-bound traffic so that Honolulu-bound left-turning vehicles can make this movement without yielding to Waianae-bound vehicles. Although left-turning motorists may still turn following the 10 second delay, they would have to yield to the high volumes of Waianae-bound traffic. Accidents are typically caused by vehicles attempting the left-turn without properly yielding to oncoming traffic or they are in a rush to clear the intersection before the next light cycle. In addition, Honolulu-bound vehicles would weave in/out of the shared left-turn/through lane in an attempt to avoid the delay caused by left-turning vehicles yielding to oncoming traffic (see Figure 1-3 and Figure 1-4).

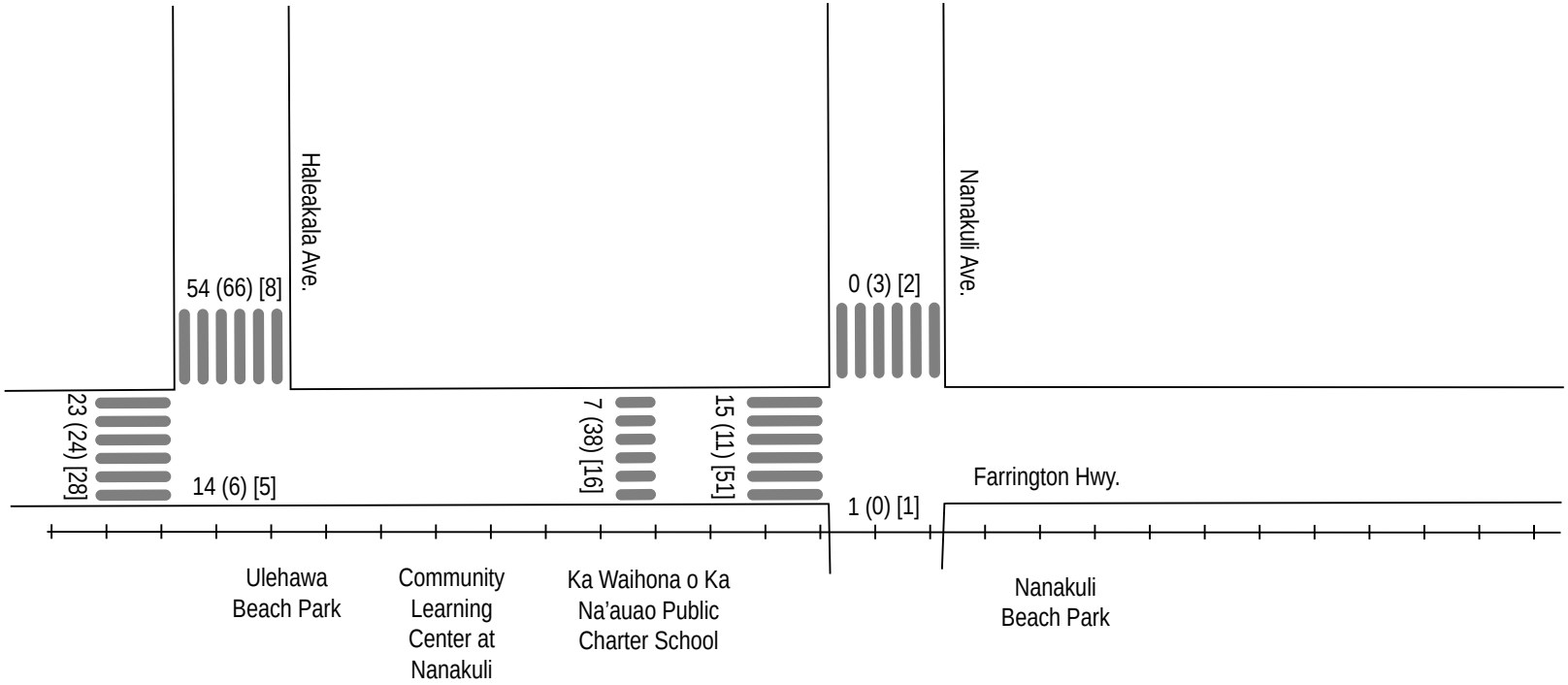
In addition to high volumes of vehicle traffic, the project corridor also experiences a high volume of pedestrian traffic during peak morning (6:45 am to 7:45 am), mid-day (12:30 pm to 1:30 pm), and late afternoon hours (3:15 pm to 4:15 pm) (see Figure 1-5). Pedestrian traffic is generated by the schools and the 6 bus stops (3 on each side) that are located along Farrington Highway within the project limits. Table 1 shows the frequency of Honolulu-bound and Waianae-bound buses during peak-hours. As shown in Figure 1-5, both Haleakala Avenue and Nanakuli Avenue have crosswalks and adjacent bus stops, which contribute to potential conflicts, such as where drivers attempting to avoid the left-turn, weave back to avoid stopping buses.

Table 1:
Bus Frequencies during Peak Periods

Existing	Morning	Mid-Day	Late Afternoon
Honolulu-bound	10/hr	5/hr	6/hr
Waianae-bound	6/hr	5/hr	6/hr

Note: Peak Periods are defined as 6:45am to 7:45am (morning), 12:30pm to 1:30pm (mid-day), 3:15 to 4:15pm (late afternoon).
Source: PB Americas, July 2009

A traffic accident analysis of the project corridor was conducted by HDOT's Traffic Branch under the Highway Safety Improvement Program (HSIP) of Title 23, United States Code, and Section 148. The analysis indicates that providing a left-turn lane with protective traffic signal phases on Farrington Highway at Nanakuli Avenue, Haleakala Avenue, and Nanakuli Beach Park Road should decrease the number and severity of accidents at these intersections from the type of left-turning hazardous actions described above. In addition, the dedicated left turn lanes would likely decrease the number of vehicles weaving in and out of the median through lane to avoid delays caused by left-turning vehicles and buses stopping near the intersections.



Legend

XX (XX) [XX] - AM (Mid-day) [PM] Pedestrian Volumes

Counts taken Wednesday, April 8, and Tuesday, June 2, 2009

AM taken between 6:30AM – 8:30AM and MD/PM counts taken 2:00PM – 5:00PM

- Crosswalk

N

Not To Scale

Existing Pedestrian Volumes and Crosswalks
Figure 1-5

1.2.2 IMPROVE TRAFFIC OPERATIONS AND RELIEVE CONGESTION

In addition to improving safety, the proposed project would provide operational improvements by addressing the existing traffic congestion created by high volumes of motorists occupying the Honolulu-bound median lane that wish to make left turns onto Haleakala Avenue and Nanakuli Avenue during the morning and afternoon peak periods. During the morning peak period, Farrington Highway's Honolulu-bound lane at Haleakala Avenue operates at a level-of-service (LOS) of F, which is the lowest measurement of efficiency for a road's performance (an LOS A represents the highest measurement). The morning Honolulu-bound queue at this intersection has been observed reaching up to 20 vehicles largely because motorists wishing to make left turns onto Haleakala Avenue block through traffic in the median lane, which reduces the through capacity of Farrington Highway at this intersection.

At Nanakuli Avenue, Farrington's Honolulu-bound lane operates at an LOS E, one level better than LOS F, which corresponds to a marginal service state. Similar to the conditions at the Haleakala Avenue intersection, the poor traffic conditions at Nanakuli Avenue is also due to high commuting volumes and the lack of a left turn storage lane, substantially reducing the through capacity on Farrington Highway.

Providing a left-turn lane at each intersection would improve the overall level of service on Farrington Highway both in the short (year 2012) and long (year 2032) term. With the proposed improvements, the level of service by 2012 for morning Honolulu-bound through traffic at Haleakala Avenue would improve from its current LOS F with an average of 93 seconds of delay to LOS B with an average of 10 seconds of delay. At Nanakuli Avenue, the proposed project would not substantially change the level of service in the afternoon and evening peak period, but it would improve the level of service during the morning period from LOS E with an average of 64 seconds of delay to LOS B with an average of 18 seconds of delay.

1.2.3 PROVIDE MULTI-MODAL PEDESTRIAN AND CYCLING FACILITY

The mauka or Waianae-bound side of Farrington Highway has a sidewalk that is intermittently made of concrete and asphalt that ranges in width from six feet to ten feet within the project limits.

The makai or Honolulu-bound side of Farrington Highway does not have a sidewalk despite the relatively high number of pedestrians traveling to and from Nanakuli and Ulehawa beach parks, Ka Waihona PCS Campus and the three makai side bus stops. Many pedestrians have been observed using the highway's wide unpaved shoulder, which sits at a higher elevation than the roadway from Ulehawa Beach Park to Helelua Street. The width of the shoulder within the project limits is approximately 30 feet and is dominated by a mixture of sand and dirt, asphalt remnants, gravel in some areas, and grass in others. The proposed project would provide a shared use path (see Section 1.3.2), improving the safety pedestrians and cyclists traveling along the highway and using the campus and park. A cross-section for the proposed project superimposed over the existing condition is provided in Figure 1-6.

Bike Plan Hawaii (September 2003), the master plan for bicycle facilities in the State of Hawaii, identifies future bicycle facilities for the Farrington Highway corridor between Auyong Homestead Road and Honokai Hale. Within the project limits, the bike plan recommends a signed shared road. However, the more recent Draft Oahu Bike Plan (July 2009) indicates a separated path and as part of the long term regional plan, the project's proposed shared use path should provide a link with other planned pedestrian and bicycling facilities, resulting in pedestrian and bicycling facilities that extend from Makaha to existing facilities at Pearl Harbor and beyond. Figure 1-7 illustrates some of the pedestrian and bicycle facilities assumed within the City and County of Honolulu's Waianae DP area and beyond. The project's proposed shared use path would connect with the phase 3 of the future Leeward Bikeway Project, which is anticipated for construction in 2012.

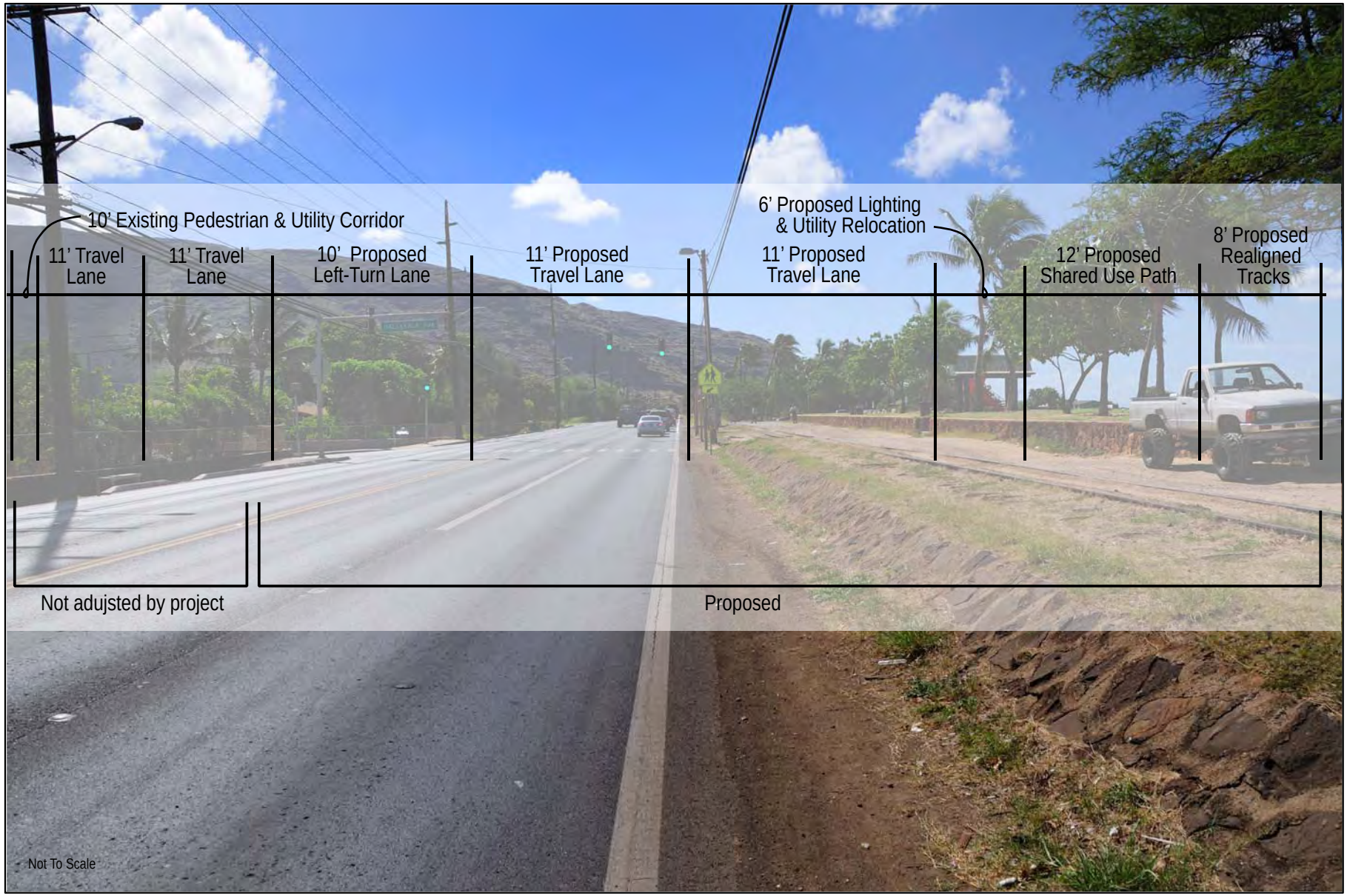
In the evaluation of both the No-Build and Build Alternatives, unless noted, the bicycle and pedestrian facilities assumed in 2032 are consistent with those included in the Bike Plan Hawaii (2003) and the Draft Oahu Bike Plan (2009).

1.3 ALTERNATIVES ADDRESSED IN THIS EA

1.3.1 NO-BUILD ALTERNATIVE

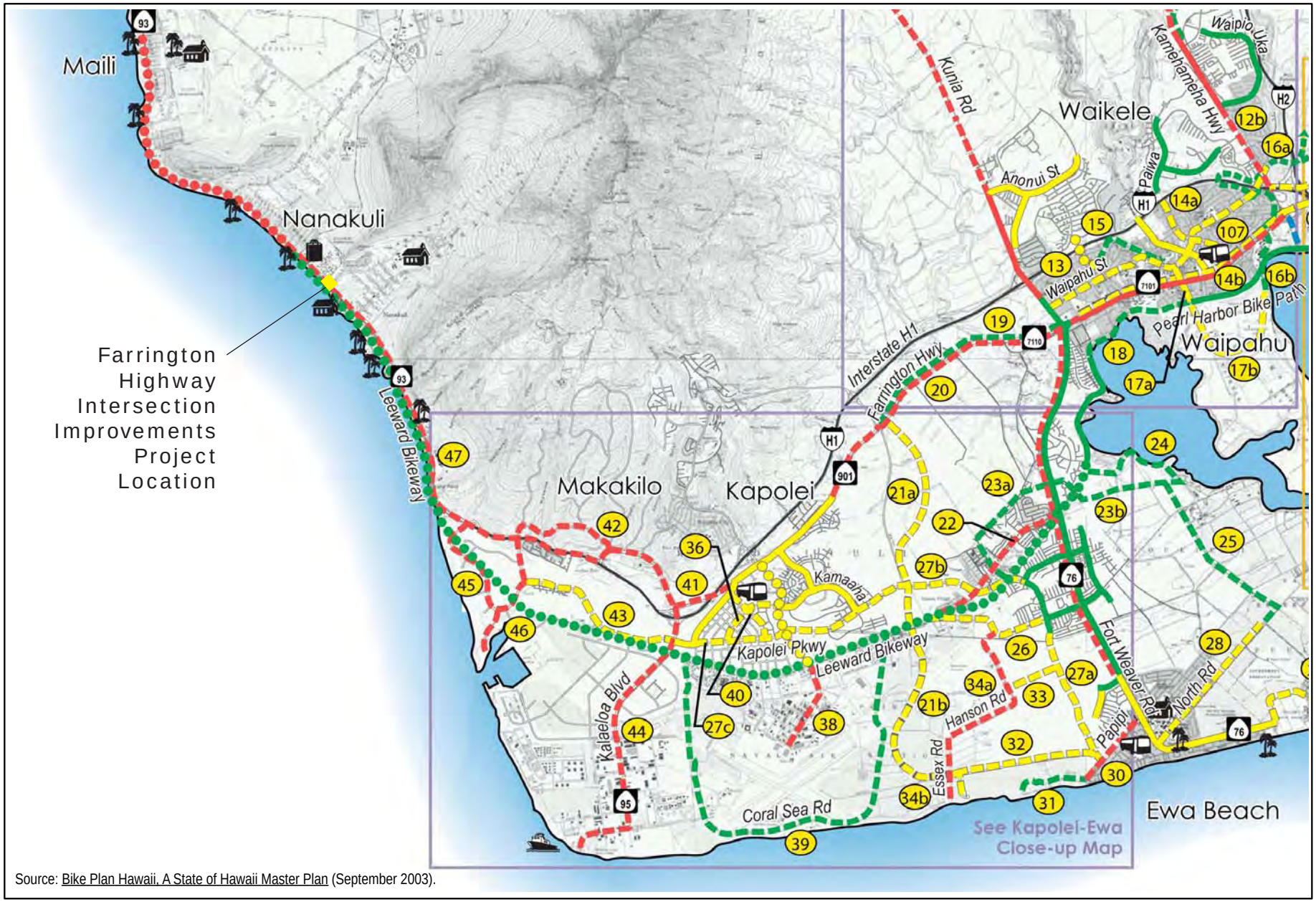
Within the project limits, Farrington Highway is a four-lane (two11 feet wide lanes in each direction), undivided arterial roadway, with 10 feet wide shoulders on the mauka side and 36 feet wide shoulders on the makai side. Three signalized intersections are provided at Helelua Street, Haleakala Avenue and Nanakuli Avenue, and numerous driveways have direct access to the highway. A sidewalk is provided on the mauka side of the highway, but no pedestrian facilities are provided on the makai side. The No-Build Alternative assumes these current conditions at least up to the year 2032.

Future roadway improvement assumptions affect forecasts of travel patterns and traffic volumes. Future (Year 2032) roadway improvements assumed are consistent with those included in the ORTP Mid-Range Plan, which indicates that no major roadway improvements will be constructed in the vicinity of the project site.



Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
Draft Environmental Assessment

Proposed Cross Section
Figure 1-6



Source: Bike Plan Hawaii, A State of Hawaii Master Plan (September 2003).

Future Bicycle and Pedestrian Facilities
Figure 1-7

1.3.2 BUILD ALTERNATIVE

The Build Alternative consists of two primary actions: (1) widen Farrington Highway from its current four lanes to five lanes, with the fifth lane dedicated to left turn movements; and (2) construct a shared use path on the makai side of the highway. Plan views of the proposed project actions are shown in Figures 1-8 and 1-9.

The existing ROW, which varies in width within the project limits from 90 to 101 feet, is wide enough to accommodate the proposed facilities. Typical cross-sections of the proposed widening at Haleakala Avenue and Nanakuli Avenue are shown in Figures 1-10 and 1-11. The proposed improvements would require the removal of rails and ties associated with the historic Oahu Railway and Land Company (OR&L) railroad ROW, which runs parallel with Farrington Highway. Since the existing rails and ties are deteriorating, upon recommendations provided by the Hawaiian Railway Society, new rails, wooden ties, spikes and ballast would be installed along a new alignment located approximately 10 feet makai from their existing location. As shown in Figures 1-10 and 1-11, the relocated rails would be situated makai of the proposed shared use path. Portions of the new railroad alignment would have a vertical handrail and grade separating wall to provide for a safety buffer between the shared use path and the new railroad alignment, which is discussed further in Section 1.3.2.2.

In addition to the primary actions, other actions of the Build Alternative include:

- Upgrade/install street lights and other safety fixtures which comply with National Cooperative Highway Research Program (NCHRP-350) and in accordance with the Roadside Design Guide;
- Re-construct mauka sidewalks, curb and gutters in accordance with the requirements of the Americans with Disabilities Act (ADA);
- Upgrade drainage systems in accordance with the latest versions of the HDOT Criteria for Highway Drainage, and the FHWA Hydraulic Engineers Circulars and Hydraulic Design Series;
- Installation of structural permanent best management practices (permanent BMPs) for water quality treatment at storm drain inlets; and
- Relocate affected utilities as necessary.

1.3.2.1 Left-turn Lane

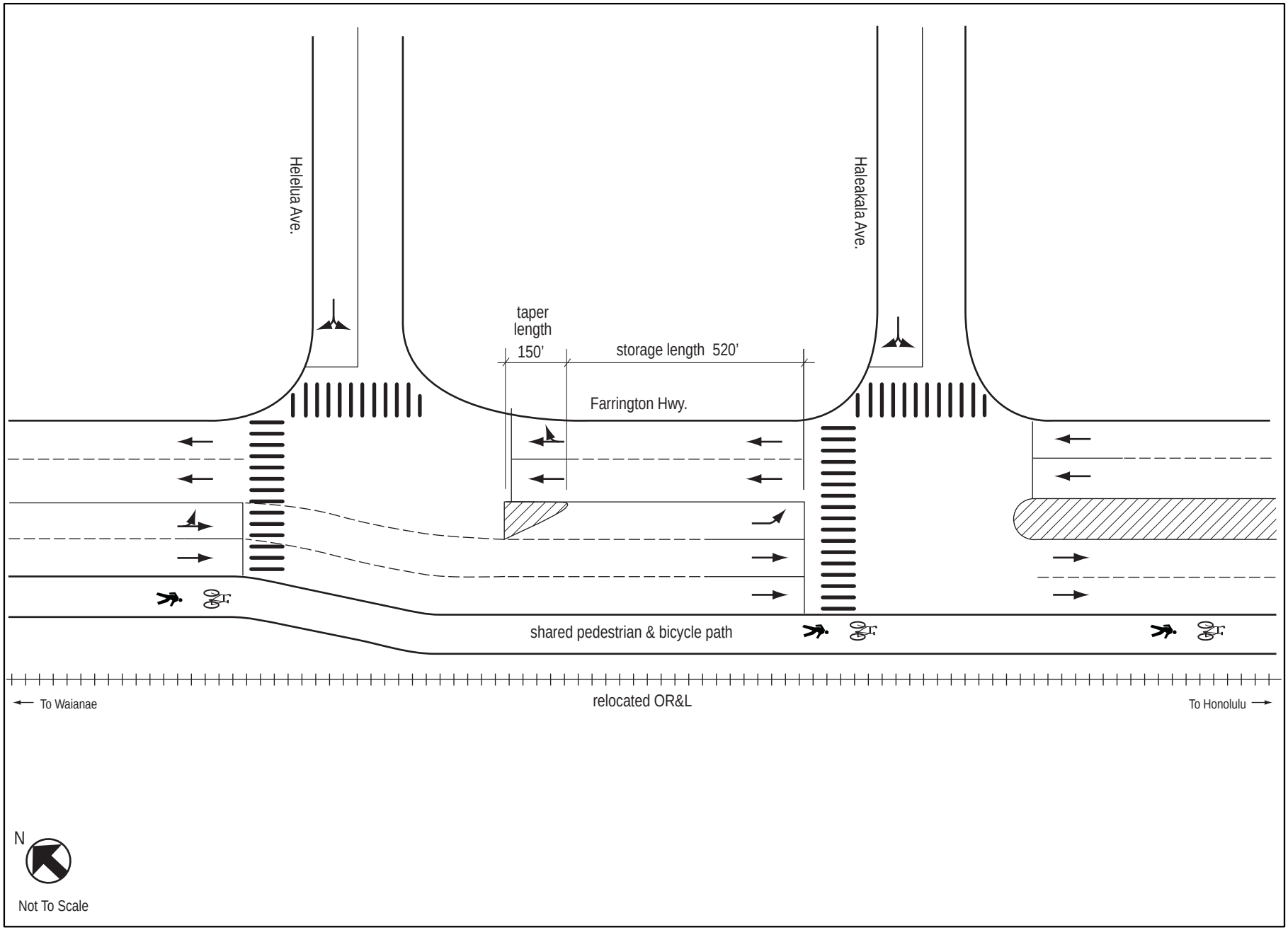
The total length of the new turn lane would run from Helelua Street to the western bank of Nanakuli Stream, a distance of approximately 0.8 miles. The project termini were determined to specifically address the safety issues at the Nanakuli Avenue and Haleakala Avenue intersections, which are largely caused by the lack of storage capacity and protection for left turning vehicles (see Section 1.2.1). The proposed left turn lane would be 10 feet wide, situated between the opposite travel lanes, and be available for left turn movements for both Honolulu- and Waianae-bound traffic with one exception. Waianae-bound left turns into the Ka Waihona PCS driveway would be restricted for safety reasons. Most motorists utilizing the proposed lane would be travelling in the Honolulu-bound direction since Nanakuli Avenue and Haleakala Avenue both provide access to Nanakuli High and Intermediate School, Nanaikapono Elementary School, as well as the Hawaiian Homestead, a large residential community located within Nanakuli Valley. According to the State of Hawaii Department of

Hawaiian Homelands (DHHL), which owns the Hawaiian Homestead, an estimated 1,040 single-family homes are within this residential area (2006, Nanakuli Regional Development Plan). The number of access points on the makai side of Farrington Highway are limited (Ka Waihona PCS, Ulehawa Beach Park, and Nanakuli Beach Park) with far less development and land uses when compared with the mauka side of the highway. The striping and configuration for the proposed left-turn lane would facilitate traffic movements based on those trends as shown in Figure 1-8 and 1-9. Upon completion, the two Honolulu-bound through lanes and the two Waianae-bound through lanes would remain. The configuration of the Waianae-bound lanes would remain the same, whereas the Honolulu-bound lanes would shift by approximately 10 feet due to the provision of the new turn lane.

The new 10-foot wide lane would begin immediately after Farrington Highway intersects with Helelua Street. Continuing towards Honolulu or southeast, the new lane would be striped as a median for approximately 150 feet before the lane transitions to a left-turn only lane for the remaining approach to the Haleakala Avenue intersection. This pocket would create approximately 520 feet of storage for vehicles to queue while waiting to turn left onto Haleakala Avenue.

Immediately southeast of Haleakala Avenue, the new10-foot wide lane would again be striped as a median for approximately 700 feet. Upon the approach to the Nanakuli Avenue intersection, the lane would be striped for left turns. Storage capacity at this intersection would be approximately 200 feet.

Immediately southeast of Nanakuli Avenue, the new10-foot wide lane would then switch in favor of Waianae-bound left turns into the entrance of Nanakuli Beach Park. The Honolulu-bound left turns from Farrington Highway onto Nanakuli Avenue and Waianae-bound left turns into the Nanakuli Beach Park would be signalized and timed to occur separately. The storage capacity for the Nanakuli Beach Park left-turn pocket would be approximately 60 feet. The number of vehicles making the left turn into the beach park is far fewer than the number of vehicles making left-turns into Haleakala and Nanakuli Avenues. Southeast of the left turn into Nanakuli Beach Park, the new lane would be striped as a median only until reaching the western or leeward bank of Nanakuli Stream. At this point, the new lane would taper back to the existing striping.



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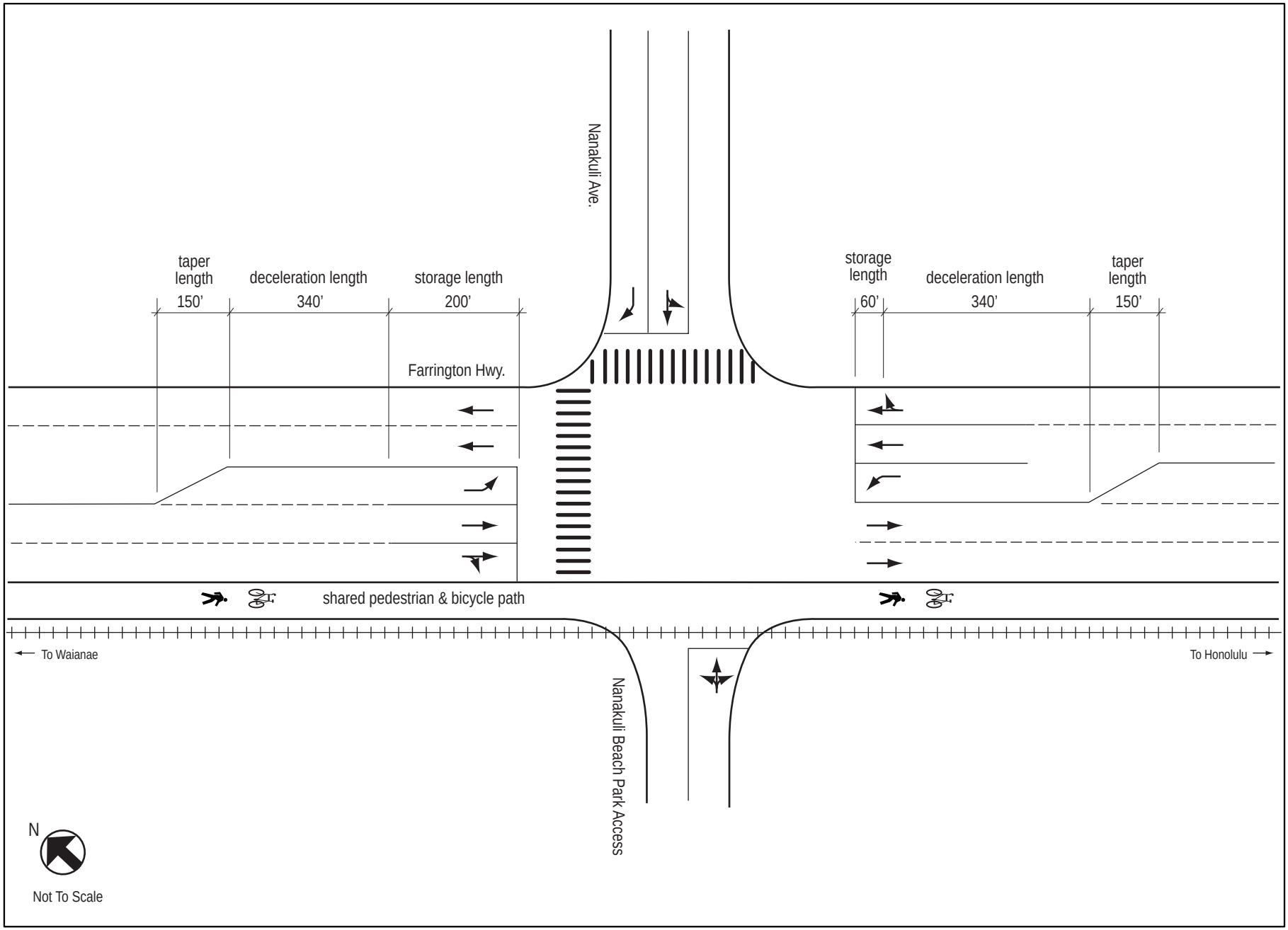
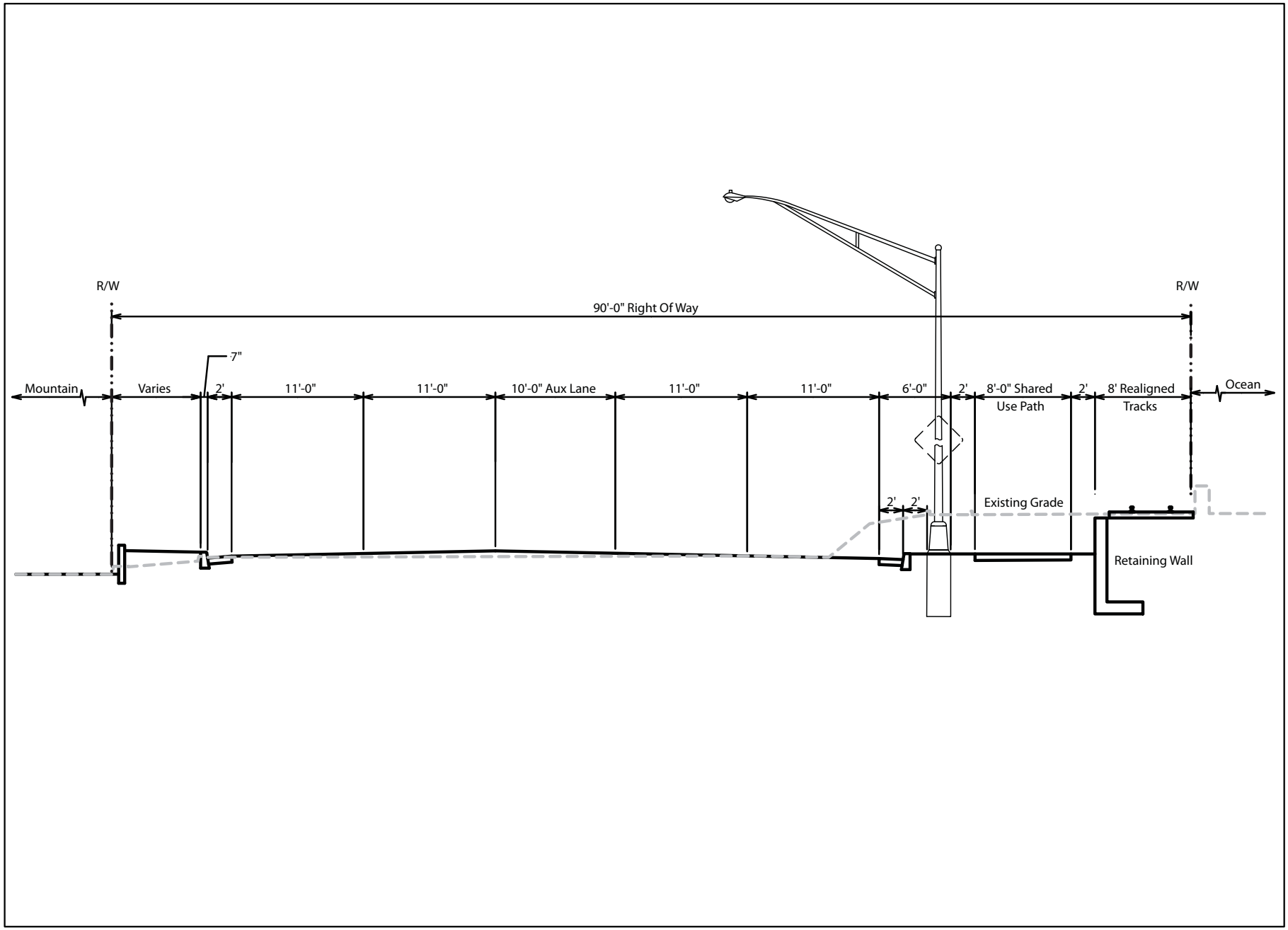
Proposed Improvements at Haleakala Avenue
Figure 1-8



Proposed Improvements at Nanakuli Avenue
Figure 1-9



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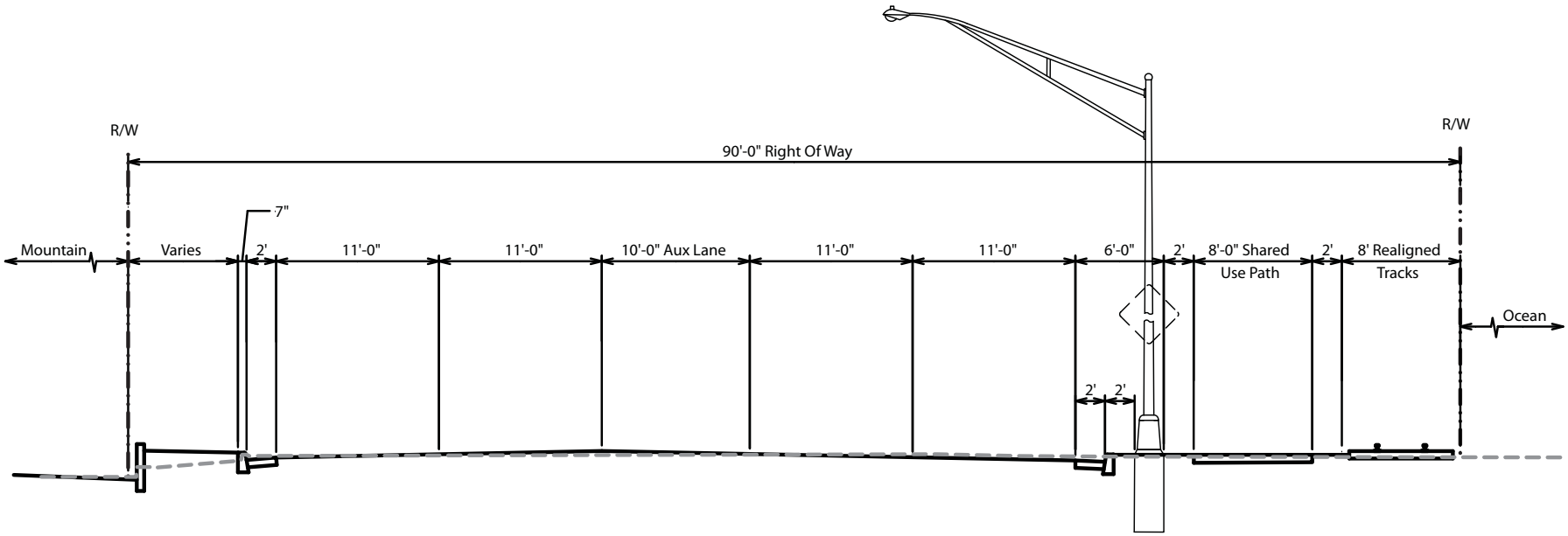
Proposed Detailed Typical Section Near Haleakala Avenue
Figure 1-10



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Proposed Detailed Typical Section Near Nanakuli Avenue
Figure 1-11

1.3.2.2 Shared Use Path

The proposed shared use path would be constructed on the makai side of Farrington Highway within the same project limits as the proposed left-turn lane, running from the leeward bank of Nanakuli Stream and terminating at Helelua Street. Due to the amount of available ROW, and in order to minimize and in some cases avoid impacts to the historic OR&L railroad, Ka Waihona PCS, Nanakuli Beach Park, and Ulehawa Beach Park, the shared use path would be eight feet wide within a twelve feet wide corridor. As shown in Figure 1-6, the proposed shared use path would be paved and physically separate from the roadway. It would be designed and constructed in accordance with the requirements and guidelines of the 1999 AASHTO Guide for the Development of Bicycle Facilities and the Americans with Disabilities Act (ADA). The proposed shared use path would be wide enough to accommodate a variety of uses including bicyclists, pedestrians, skaters, wheelchair users, and other non-motorized users. Since the majority of users are anticipated to be generated by Nanakuli Beach Park, Ka Waihona PCS, Ulehawa Beach Park, and bus stops, the signage for the proposed shared use path would be focused on avoiding conflicts between the various users and facilitating transitions at access points and driveways such as the entrances to the Nanakuli and Ulehawa Beach Parks.

Along Farrington Highway, the existing elevation of the unpaved shoulder fluctuates from at grade at Nanakuli Stream and eventually rises to about a foot above the roadway's gradient at Ulehawa Beach Park. From Ulehawa Beach Park to Helelua Street the difference in elevation between the paved highway and shoulder continues, gradually reaching a difference of three to four feet at Helelua Street partially due to a berm supporting the historic OR&L railroad. Also, Ulehawa Beach Park sits at a higher elevation than the roadway with a four-foot grade adjustment retaining wall that separates the beach park from the Farrington Highway ROW. In order to accommodate the proposed project improvements in this area, the berm or existing grade of the highway shoulder would be excavated an estimated twenty feet from the existing edge of pavement to achieve the needed space and level surface for the proposed improvements. Figure 1-10 illustrates the proposed typical section for this area.

Despite the proposed excavation, a difference in elevation ranging from approximately three to four feet would remain between the proposed shared use path and the proposed new alignment of the OR&L railroad. Along the steeper sections between the path and new railroad alignment, a grade-separating or retaining wall with vertical hand rails would be constructed. Re-using the existing rip rap or rock wall materials from the existing berm was initially considered for the proposed retaining wall. However, a rock wall would require a wider footing at the base for support, which could not be accommodated within the existing ROW. The proposed retaining wall would likely be made of concrete blocks with a texturized finish for an aesthetical appeal.

As shown in Figure 1-7, the proposed shared use path would eventually become linked with future facilities envisioned within the Bike Plan Hawaii (2003) and the Draft Oahu Bike Plan (2009). Phase 3 of the Leeward Bikeway Project, which consists of a shared use bike path that terminates at Lualualei Homestead Road, would connect to the proposed shared use path at the Helelua Street terminus.

1.3.3 ALTERNATIVES CONSIDERED BUT REJECTED

The following alternatives were considered for this project, but were rejected from further consideration:

- Transportation System Management (TSM) alternative;
- Left-turn storage lanes only at the intersection alternative;
- Mauka side widening; and
- Share path alternative alignments.

The first two alternatives listed above specifically address the safety and traffic issues associated with operations at the Haleakala and Nanakuli Avenue intersections. The third alternative would provide facilities and upgrades described in Section 1.3.2, but would avoid the OR&L railroad relocation. The fourth alternative provides two options for the shared use path described in Section 1.3.2.

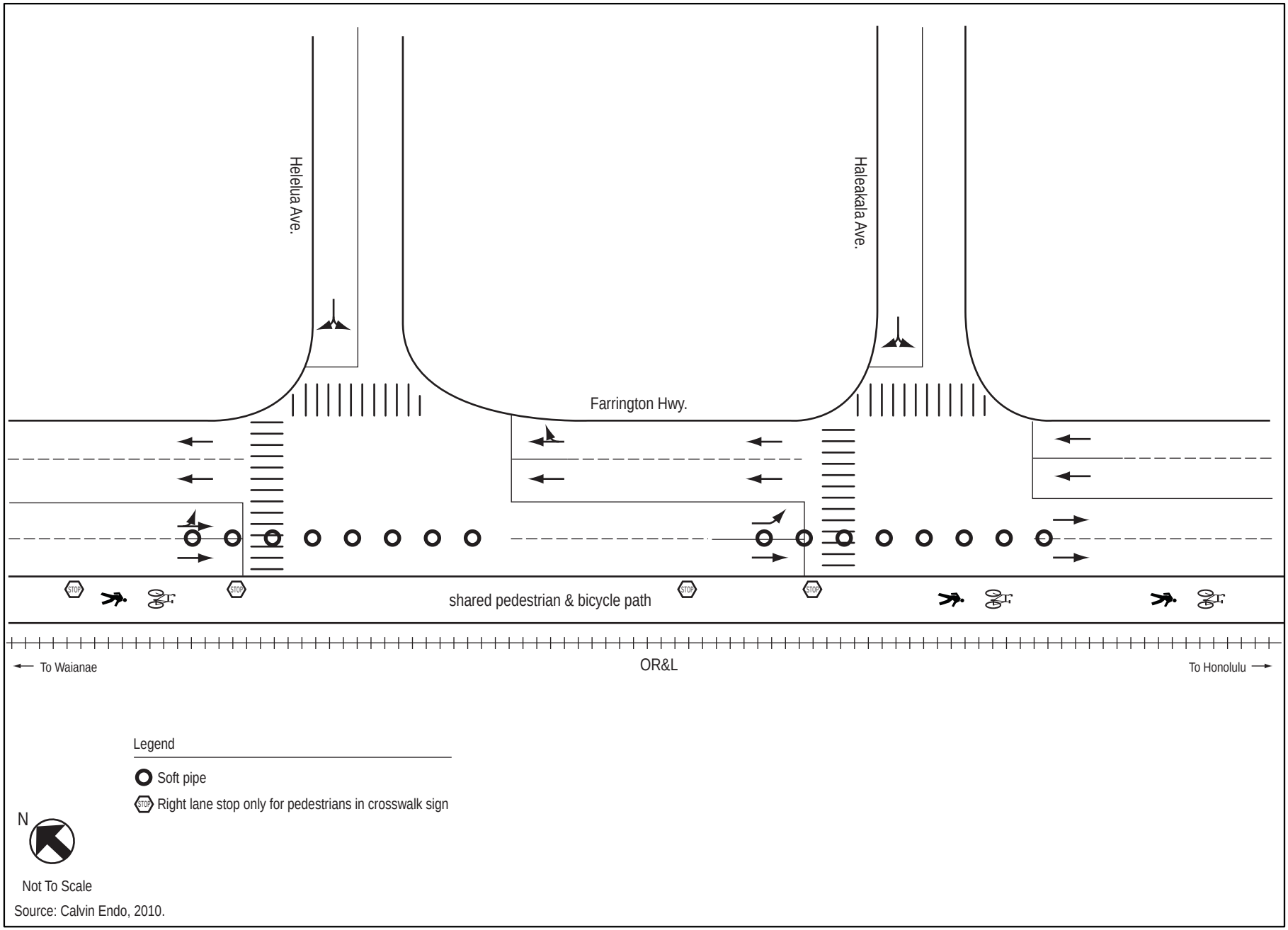
The remainder of this section consists of brief descriptions of each alternative considered and reason(s) for rejection of that alternative.

1.3.3.1 Transportation System Management Alternative

The TSM Alternative is defined as the application of construction, operational, and institutional actions to increase the effectiveness of the present transportation system without large capital expenditures. Relatively minor modification of existing roadway facilities fall into this category. An example of these actions would be modification of individual intersections along the Farrington Highway corridor while leaving Farrington Highway as a four lane roadway without the fifth left-turn lane.

The TSM alternative for the project involved the temporary coning of the median Honolulu-bound lane during the morning peak period at the Haleakala and Nanakuli Avenue intersections to create dedicated left-turn lanes. Alternatively, soft piping could be installed as a permanent barrier between the median and makai side or through Honolulu-bound lanes starting 20 feet before and after the intersections to create the left-turn only lane (See Figure 1-12). At both intersections, only one through lane would be provided for Honolulu-bound traffic. The TSM alternative, including the soft piping variation, was rejected from further consideration because one lane would not provide sufficient capacity for Honolulu-bound traffic. Both intersections would continue to present traffic bottlenecks. Furthermore, the lane configurations would not provide any deterrence for motorists continuing straight rather than making the left turn, which would create potential conflicts with the Honolulu-bound through traffic.

Signal modification alternatives, which typify a TSM alternative, were implemented within the existing intersections on Farrington Highway at Haleakala Avenue and Nanakuli Avenue to increase the effectiveness of the present transportation system including signal synchronization. However, due to construction activities in the corridor the signals have been modified and are scheduled for re-synchronization in 2010.



Source: Calvin Endo, 2010.

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TSM Coning Alternative
Figure 1-12

1.3.3.2 Intersection Only Left-Turn Lanes Alternative

Instead of a continuous left-turn lane throughout the project limits, this alternative would only provide left-turn storage lanes immediately approaching the Haleakala and Nanakuli Avenue intersections for Honolulu-bound traffic. Similar to the Build Alternative described in Section 1.3.2, this alternative would improve the safety and operations at the Haleakala and Nanakuli Avenue intersections by providing shelter for left turning vehicles, while allowing Honolulu-bound through traffic to continue un-impeded utilizing two lanes. However, this alternative was rejected from further consideration because upon consideration of the storage requirements for both intersections, the cumulative length of this alternative's left-turn lanes was not substantially shorter than the total length of the left turn lane under the Build Alternative. Furthermore, this alternative would result in a zig-zag lane configuration within the project limits.

The community suggested a variation of this alternative. This alternative would create a "dog leg" or exit off of Farrington Highway at Nanakuli Avenue as shown in Figure 1-13, and could be used in conjunction with the TSM alternatives discussed in Section 1.3.3.1 to address safety of the left turns at Haleakala Avenue. This alternative was removed from further consideration because the turning radius required for this alternative could not be accommodated within the existing ROW. Additionally, it would remove the Ka Waihona PCS fire lane access, which is a critical access point for the school.

1.3.3.3 Mauka Side Widening

Widening the mauka side of Farrington Highway rather than the makai side of the Highway was considered in order to avoid relocating portions of the OR&L railroad. This alternative was rejected from consideration because it would cause substantial adverse impact to the surrounding community in comparison to the Build Alternatives which proposes to use the existing ROW. The ROW acquisition would involve residential displacements, including native Hawaiian Homesteaders, as well as the displacement of community stores, a HawaiianTelcom switching station, the future Nanakuli Village Center, and St. Rita's Catholic Church.

1.3.3.4 Shared Path alignment Alternatives

The following alternatives address different conceptual alignments for the shared use path as proposed under the Build Alternative (See Figure 1-14.).

1.3.3.4.1 Meandering Shared Use Path

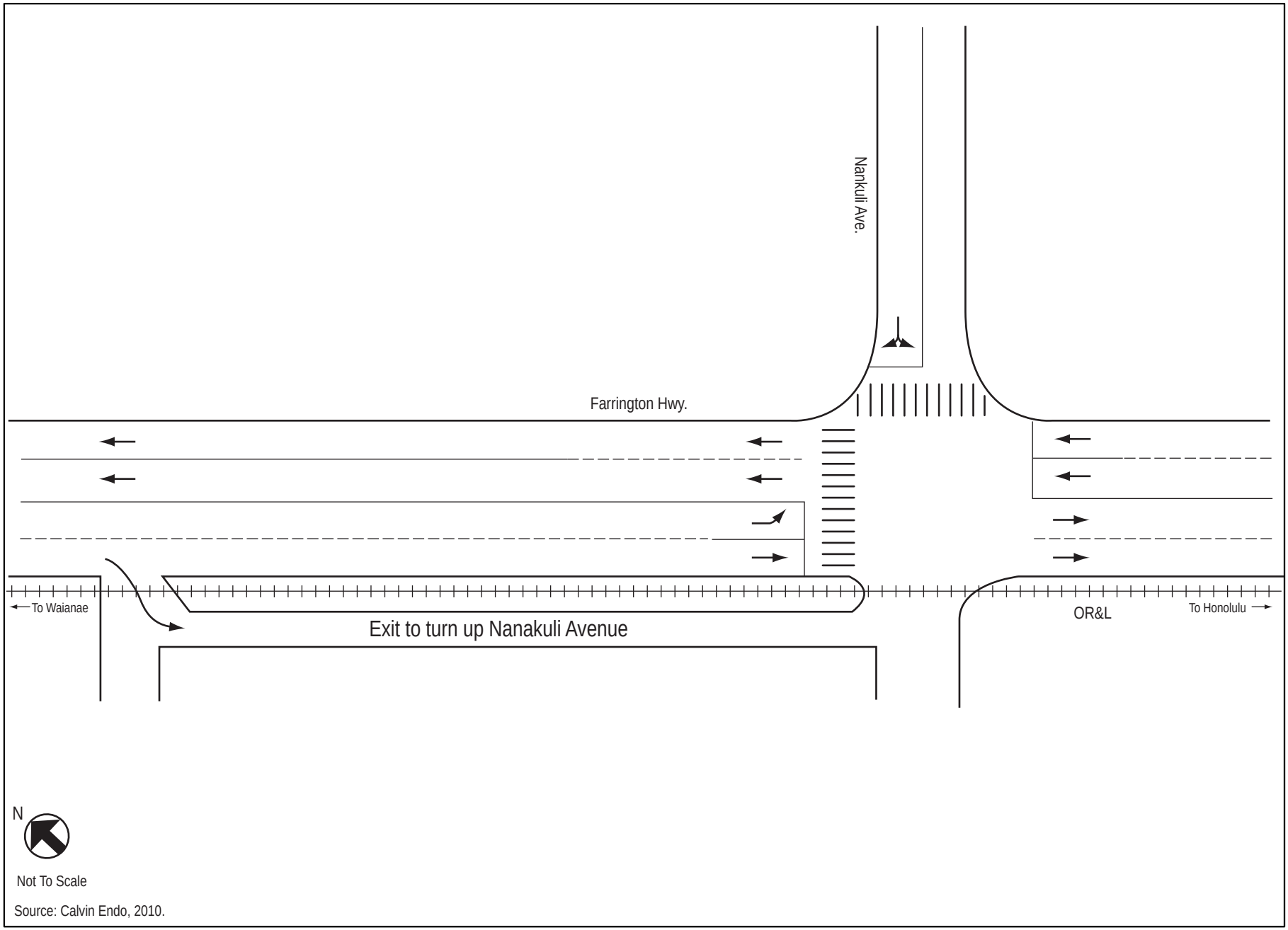
This alternative would have the same roadway cross-section as the proposed path described in Section 1.3.2, but the path alignment would meander through portions of the Nanakuli Beach Park, Ka Waihona o Ka Nauao Public Charter School and other school facilities until running parallel with Farrington Highway as it approaches Ulehawa Beach Park across from Haleakala Avenue. Although this alternative provides additional clearance for the OR&L railroad for potential future operations, it was rejected from further consideration since the pedestrian path would no longer serve pedestrians walking along the roadway, poses security and access concerns associated with a public pedestrian and bicycle facility located within school grounds,

and may require the purchase of additional ROW and/or present maintenance-related issues with the other landowners.

In addition, the community has expressed concern and desire (See Section 3.3 for public involvement activities) to protect adjacent beach parks as a resource. The portion of Ulehawa Beach Park adjacent to Farrington Highway was designed in such a way to restrict vehicular access, and create natural barriers within the facility for the perpetual protection of sand dunes and cultural deposits within the park (City and County of Honolulu, Dept of Design and Construction 1999). Locating the shared use path on the park's grounds would be in direct conflict with the protection and preservation of those sensitive resources.

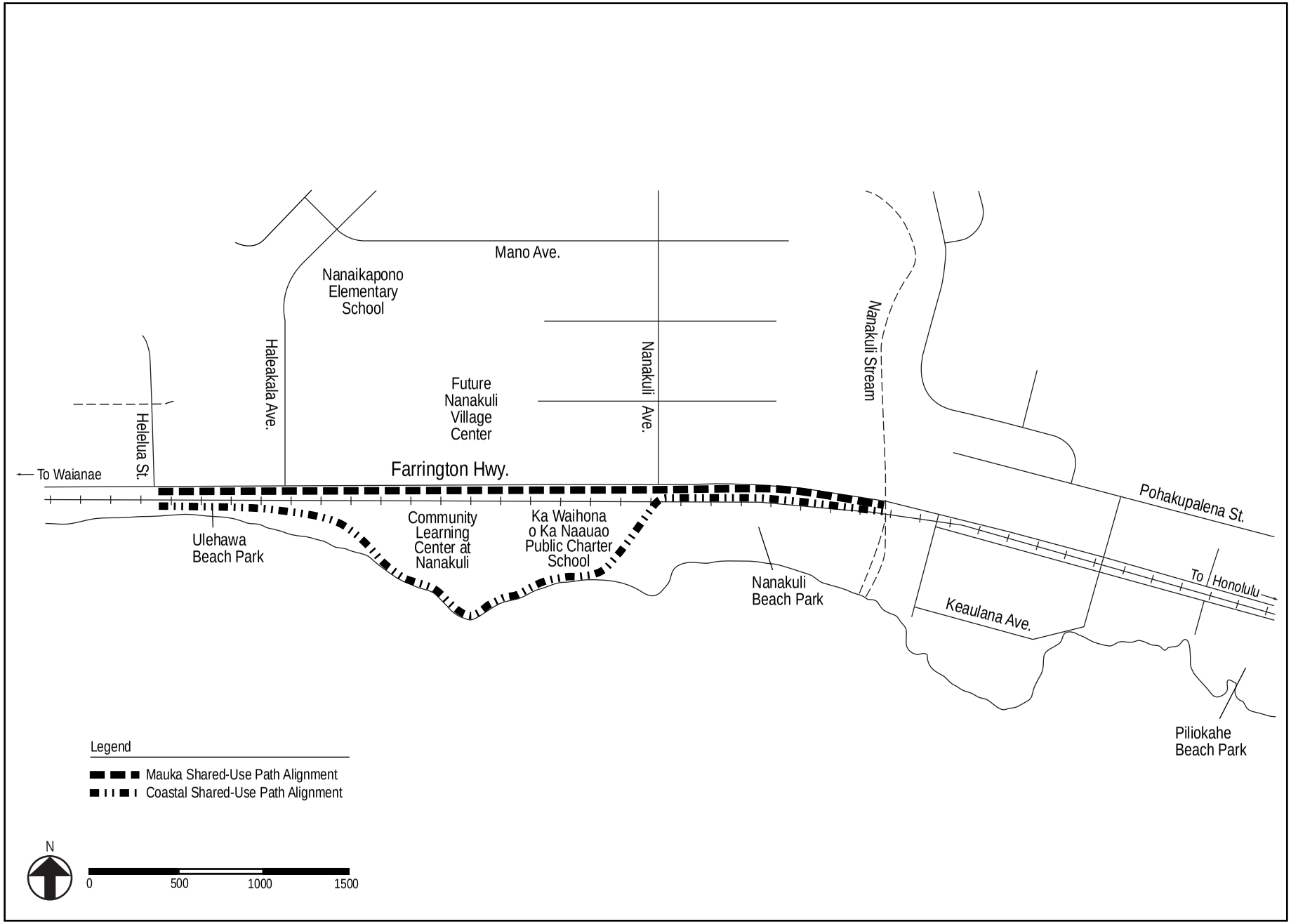
1.3.3.4.2 Makai Shared Use Path with Additional Clearance

The shared use path alignment under this alternative would be the same as the proposed alignment described in Section 1.3.2, but would require an additional 8 feet of ROW from adjacent schools and beach parks in order to provide the clearance required for potential future railroad operations. This alternative was rejected from further consideration because of the needed acquisition of park and school property, some of which would result in the displacement of buildings.



Source: Calvin Endo, 2010.

Nanakuli Avenue Exit Alternative
Figure 1-13



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Shared Use Path Alternatives
Figure 1-14

1.4 PROJECT SCHEDULE AND COST

The tentative project schedule is as follows:

- Environmental Review: completion Spring 2010
- Permitting and Final Design: completion Summer 2010
- Advertise for construction: Fall 2010
- Award and Construction: Winter 2010

The total estimated cost of the Farrington Highway Intersection Improvements at Haleakala and Nanakuli Avenue project is $6.6 million (2009 dollars). The estimate includes landscaping, drainage, highway lighting, traffic control measures, roadway signs and striping, fencing, railroad relocation, paving, and environmental mitigation costs. The funding for the project would be shared between the State and FHWA.

1.5 PERMITS AND APPROVALS

The following environmental permits and approvals may be required prior to the construction of the proposed project. Coordination is currently on-going:

- U.S. Army Corps of Engineers (USACE) – CWA Section 404 permit (Nationwide) (Anticipated);
- Department of Health (SDOH) – CWA Section 401 Water Quality Certification (Anticipated); Noise Permit;
- Department of Business Economic Development and Tourism (DBEDT) – Coastal Zone Management consistency concurrence;
- Department of Land and Natural Resources (DLNR) – Stream Channel Alteration Permit (Anticipated); and
- City and County of Honolulu, Department of Planning and Permitting (DPP) – Grading, Grubbing, Stockpiling and Excavation permit; Special Management Area Permit (SMA).

CHAPTER 2: AFFECTED ENVIRONMENT, POTENTIAL IMPACTS, AND PROPOSED MITIGATION

This chapter describes the existing environmental conditions of the project site, potential impacts of the proposed project, and proposed mitigation. Sections in this chapter address the various environmental or social disciplines analyzed for the proposed action. In general, each section describes any existing regulatory requirements associated with the discipline, existing conditions, potential construction and long-term impacts of the proposed project, and mitigation measures, if any.

2.1 GEOGRAPHIC SETTING

This section addresses the project site's topography, soil conditions, and potential presence of hazardous materials.

2.1.1 EXISTING CONDITIONS

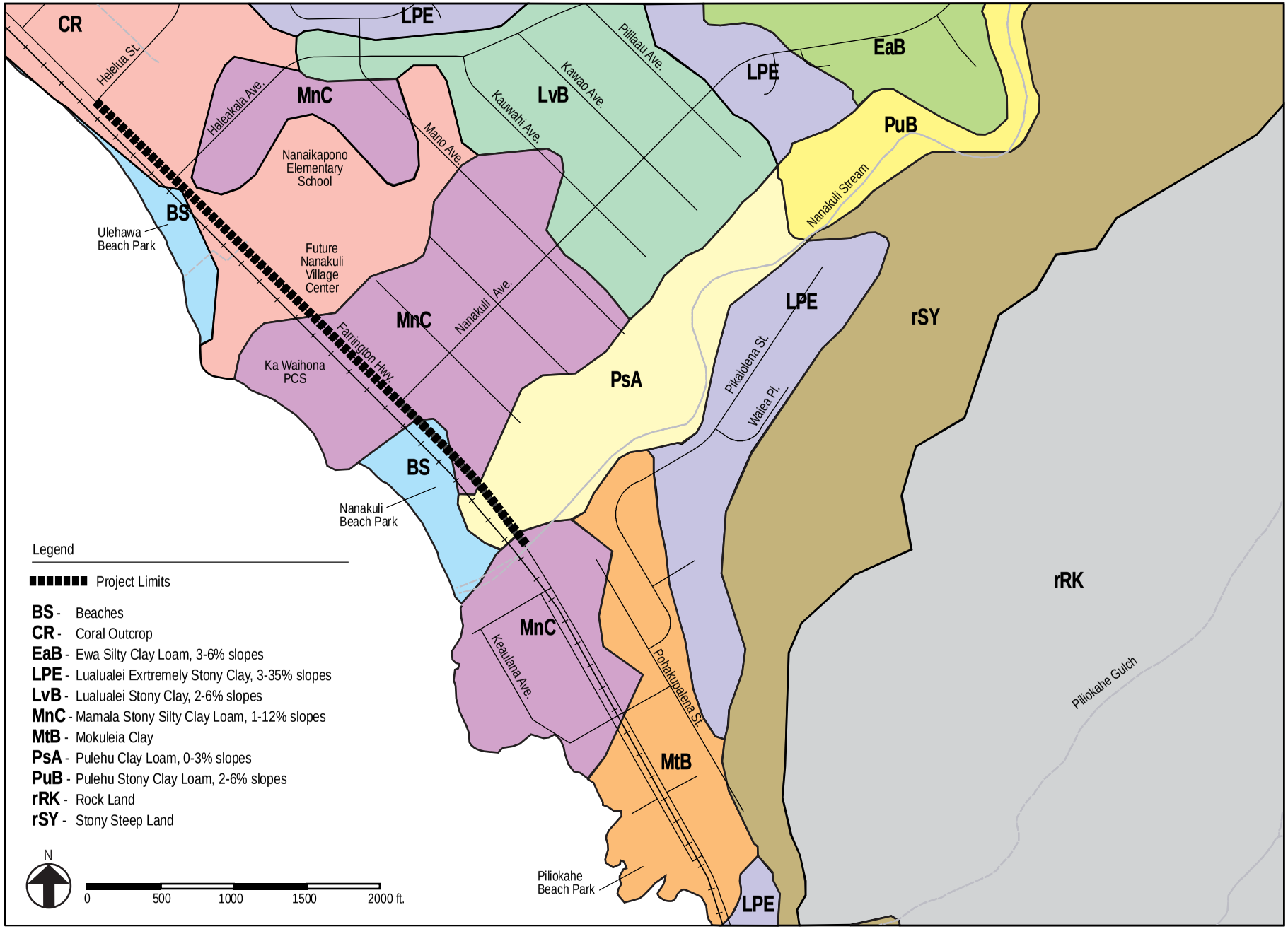
2.1.1.1 Topography and Soils

The proposed project site is nestled at the base of Nanakuli Valley, situated in the Waianae Mountain Range. The Waianae Mountain Range is located on the island's west side and is the result of one of two extinct shield volcanoes responsible for the formation of the Island of Oahu. It is an estimated 22 miles long and characterized by narrow ridges and majestic amphitheater valleys such as the Makua, Makaha, Waianae, Lualualei, and Nanakuli Valleys, which were eroded by rain before the volcano that gave rise to the Ko'olau Mountain Range rose up a million years later on the northeastern side of the island. The Ko'olau Mountain Range now acts as a barrier, shielding the rain brought in by the northeasterly trade winds and creating a drier climate on the westward slopes of the Waianae Mountains.

Within the project limits, Farrington Highway is a coastal roadway that runs parallel to the Waianae coastline. The coastal area adjacent to the roadway is generally at a higher elevation than Farrington Highway. Coastal elevations vary from 14 to 17 feet above mean sea level (MSL) at the highest and lowest points along the project limits. On Farrington Highway, the terrain appears relatively level, but there is a gradual downward slope from the coastline into the valley, eventually reaching a valley low point of about five feet above MSL at an estimated one third of a mile inland from the coast before beginning an upward ascent toward the mountains. Within the project limits, the elevations along Farrington Highway range from a low of 11 feet above MSL near Helelua Street to a high of 16 feet above MSL near Nanakuli Stream.

The coastal plain at the foot of the Waianae Mountain Range is underlain by elevated coral reef formed when the sea level was higher than today. The ancient reef is partially covered by alluvium deposited through erosion of the Waianae Range.

Figure 2-1 illustrates the four underlying soils found along the project corridor, which are coral outcrop (CR), Mamala silty stony clay at zero to 12 percent slopes (MnC), Beach (BS), and Pulehu clay loam at zero to three percent slopes (PSA). According to the Natural Resource Conservation Service, Mamala soils are dark reddish brown, well drained, and occur on coastal plains. The soils are formed from alluvium deposited over coral limestone and consolidated calcareous sand. The Pulehu series is very dark brown.



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Soils Map
Figure 2-1

It is well drained, and formed from alluvium washed from igneous rock. Soils from this series are found on alluvial fans and stream terraces. Both Mamala and Pulehu soils are suitable for irrigated agriculture, dryland vegetation, as well as irrigated and non- irrigated pasture. Under the Agricultural Lands of Importance to the State of Hawaii (ALISH) agricultural classification system, Pulehu soils are considered "prime" soils, having the best physical, chemical, and climatic properties for mechanized crops. Although Pulehu soils in particular are well suited for agricultural purposes, the Pulehu soils within the project area are somewhat isolated along the stream bank of Nanakuli Stream.

One distinct topographical feature within the Farrington right-of-way is an approximately 30 foot-wide berm on the makai side of the roadway that extends from the Ulehawa Beach Park driveway entrance to Helelua Street and beyond the project limits. The berm reaches a maximum elevation of three to four feet higher than the paved roadway and contains a portion of the historic Oahu Railway and Land Company (OR&L) railroad and a dirt roadway shoulder. The berm's rip-rap base provides erosion protection along its mauka face. On the makai side the berm is separated from Ulehawa Beach Park by a coral wall just over a foot thick and varies from two to three feet high.

2.1.1.2 Hazardous Materials

The area surrounding the project site is primarily residential. Other land uses include schools, parks, undeveloped land, and limited commercial property (see Section 2.6). The project area has no signs of large-scale industrial development or contamination resulting from historical land use practices nearby. The OR&L railroad suggests a limited potential existence of hazardous materials. The Waianae extension of the OR&L was completed in July 1898. Operations continued for the next 49 years, transporting freight and passengers until December 12, 1947. Potential contamination may be encountered in the track and railroad ties as well as in local soil and groundwater resulting from past spills. In addition, the wooden railroad ties, remaining ballast, and soil may contain elevated levels of wood preservatives such as creosote, which is a highly toxic substance.

2.1.2 POTENTIAL IMPACTS

2.1.2.1 Topography and Soils

Section 1.3.2.2 describes the roadway shoulder near Ulehawa Beach Park and Helelua Street, where a berm is situated within the project limits. In order to accommodate the improvements, the berm would be excavated about twenty feet from the existing edge of pavement (see Figure 1-10). A grade adjustment wall and vertical rail would be constructed for safety. The impact to topography would be isolated to this area.

In extreme weather events, community members indicate that portions of Farrington Highway near the coast experiences wave inundation. Since the coast near Ulehawa Beach Park sits at an elevation slightly higher than Farrington Highway, it provides the roadway some protection. Changes to topography would not further compromise the area's vulnerability to wave inundation since only a portion on the mauka side of the berm would be excavated.

As discussed in Section 2.1.1.1 and shown in Figure 2-1, a portion of the project site is underlain with Pulehu soils, which are considered prime soils under the ALISH agricultural

classification system. Although an estimated 220 linear feet of the proposed project site intersects with these prime soils, the small area affected by the project was never going to be made available for agricultural production because it is within the roadway right-of-way. The adjacent land use is a beach park with unsuitable conditions for agriculture.

Under the No-Build Alternative and similar to the Build Alternative, the small area of prime soils would not be made available for agricultural production, so their importance would not be affected. The berm would not be excavated under the No-Build Alternative.

2.1.2.2 Hazardous Materials

Potential contamination may be encountered during excavation of the berm containing the OR&L railroad. Contamination in local soil resulting from years of railroad operation and past fuel spills may be encountered during this process. Due to natural attenuation over the decades and the nature of railroad operations occurring at or near the surface, it is unlikely that excavated soils would contain contaminants above regulated levels. The removal of the train ties and rails during railroad relocation could create increased potential for stirring up hazardous materials such as wood preservatives and other industrial materials. Special provisions would be in place prior to project construction in areas within or adjacent to the existing rail line.

Construction planning would include development of spill prevention, control, and countermeasure plans; erosion and sedimentation control plans; and plans for handling and disposal of contaminated materials. Contractors who are likely to encounter contamination would be required to demonstrate their ability to identify these situations and respond quickly to avoid contamination migration to public areas.

The No-Build alternative would not relocate the railroad, and therefore, disturbance of hazardous materials would not occur.

2.2 WATER RESOURCES

2.2.1 EXISTING CONDITIONS

2.2.1.1 Surface Waters

The Waianae coastal plains do not support perennial streams due to the relatively dry climate. Orographic rainfall at higher elevations allow some streams such as the Nanakuli, Lualualei, Waianae, Makaha, and Makua to have small perennial flows at elevations greater than 600 feet MSL. However, these streams, like the others found along the coast, become intermittent in low-lying areas. The two streams that occur within the vicinity of the proposed project are Ulehawa Stream Channel and Nanakuli Stream.

The Ulehawa Stream Channel is an existing trapezoidal concrete lined channel between Ka Waihona PCS and Ulehawa Beach Park. It crosses under Farrington Highway through a culvert. The drainage channel receives storm water runoff from Nanaikapono, Ka Waihona PCS, and Farrington Highway, and discharges directly into the ocean.

Nanakuli Stream is located on the eastern portion of the project. It has a muliwai, or estuary that experiences ponding due to beach deposits blocking the mouth of the stream. Previous studies indicate that the ponding begins about 150 to 200 feet mauka of Farrington Highway, reaching the beach berm at Nanakuli Beach Park. The beach blockage occasionally causes flooding and during heavy rainfall, the blockage can be breached sending stream water into the ocean. Upstream of the muliwai, the stream is predominately dry with very little vegetation in the stream bed. Storm water runoff from Farrington Highway and adjacent property discharges into Nanakuli Stream. Nanakuli Stream and Ulehawa Stream Channel are not listed as impaired streams by the Hawaii State Department of Health (HDOH) in accordance with Section 303(d) of the Clean Water Act.

According to the Flood Insurance Rate Maps (FIRM), and as shown in Figure 2-2, much of the project corridor and vicinity are classified as undetermined flood zones. The zones immediately surrounding Nanakuli Stream are classified as 100-year Flood Zones VE and AE. Zone VE is an area with a 100-year floodplain where the base elevation has been determined; Zone AE is a 100-year floodplain in which flooding occurs where velocity hazard and base flood elevations have been determined. This classification is consistent with community reports that this area of Farrington Highway has been subject to wave inundation during severe hurricanes. The entire project site is within the Tsunami Inundation Zone.

2.2.1.2 Groundwater

Groundwater in Oahu occurs in perched water tables, deep basalt aquifers, and shallow aquifers within the caprock. The Southern Oahu Basal Aquifer (SOBA) is a Sole Source Aquifer designated by the United States Environmental Protection Agency (EPA) due to its importance as a main source in providing potable, artesian groundwater and is afforded special regulatory protections. The proposed project area does not overly the Southern Oahu Basal Aquifer.

Groundwater within the project area is characterized as a thin, buoyant, unconfined lens of brackish water floating on salt water due to its proximity to the coastline. The basal lens can be affected by drought, ocean tides, and groundwater withdrawal from wells.

Recharge to the Waianae region's groundwater occurs via rainfall in the mountains that percolates down into perched water tables, deep basalt aquifers, and shallow aquifers within the caprock, becoming part of the groundwater resource. Ulehawa Stream channel and the lower reaches of Nanakuli Stream do not contribute to groundwater recharge.

2.2.2 POTENTIAL IMPACTS

The proposed project would cover an estimated 2.25 acres of soil with new impervious surfaces (i.e. asphalt and concrete). This conversion of permeable surfaces to impervious surfaces reduces the ability of the ground to absorb water when it rains, typically resulting in the increase of storm water runoff and potential ponding on the roadway, which creates hazardous conditions for motorists. As noted in Section 2.1.1.1, the soils within the project site are well drained, providing relatively porous conditions in the surrounding environment. Generally, except under extreme storm conditions, most rainwater would percolate into the ground where it falls. The drainage infrastructure of Farrington Highway would be upgraded to accommodate the additional impervious area, facilitating the removal of the additional storm water runoff. Details on proposed drainage improvements are provided in the Drainage Report

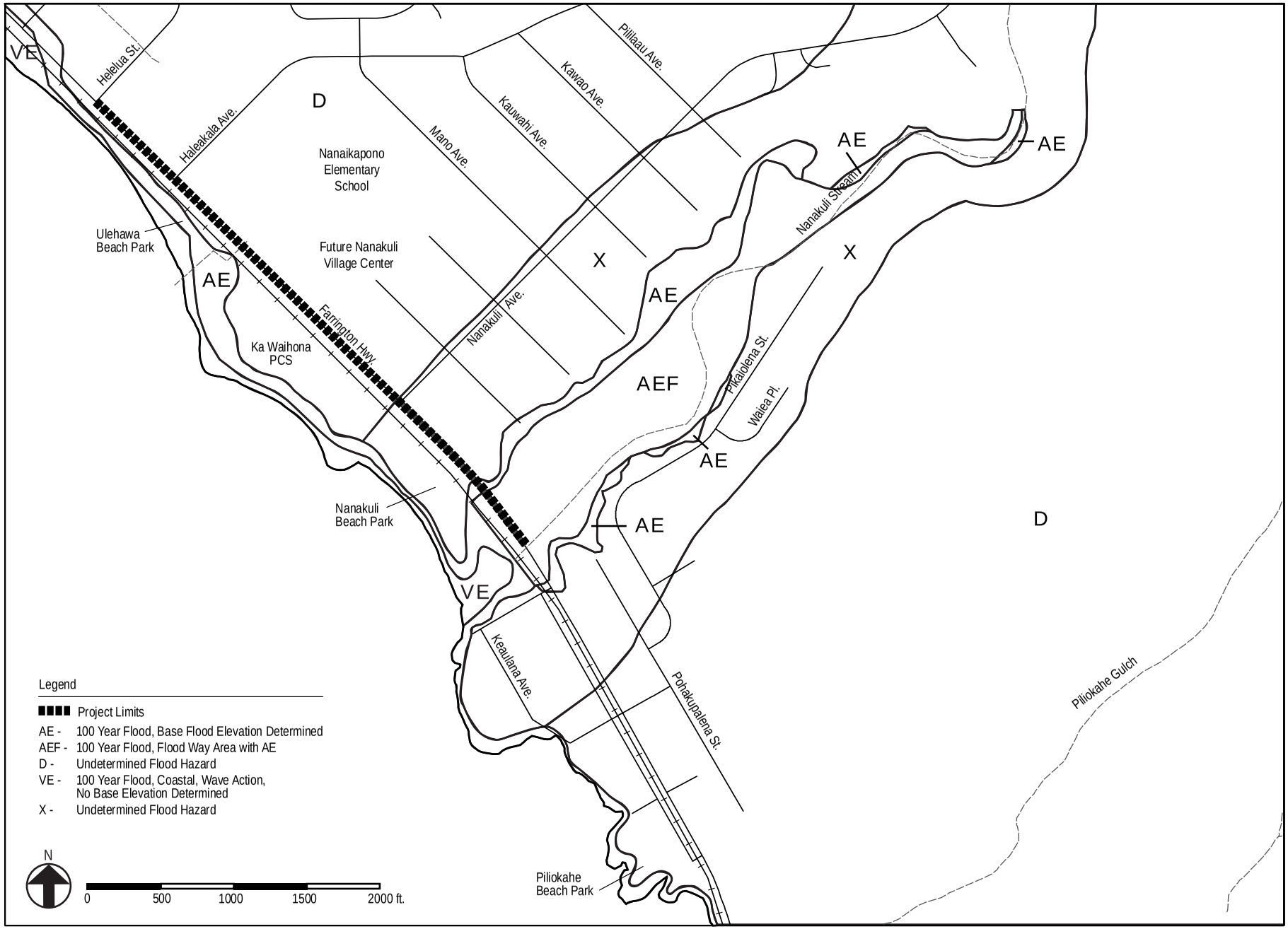
in Appendix C. An additional outfall and drainage system would be tied into the existing highway drainage system at Ulehawa Stream Channel and Nanakuli Stream. Given the elevations within the project limits, in order to achieve the needed drainage slope or invert so that water flows away from the roadway, the outfalls may be placed relatively low in relationship to the stream bed or drainage channel. Before the Final EA is completed, HDOT would coordinate with the U.S. Army Corps of Engineers to determine whether a Department of the Army, Section 404 permit would apply to the project.

In addition to improving storm water removal from the roadway, the proposed project would provide some water quality treatment prior to discharge into the streams. By installing filter devices or structural permanent best management practices (permanent BMPs) at storm drain inlets, as storm water passes through these devices carrying trash and debris, the debris becomes caught in the filter devices rather than being discharged into the stream with the storm water.

The excavation of the berm near Ulehawa Beach Park and Helelua Street would not be deep enough to encounter groundwater resources. However, if groundwater is encountered during excavation and dewatering is required, the contractor will be directed to remove the groundwater from the project site (using tanker trucks) and dispose through a sanitary sewer system.

Since the proposed project disturbs an area greater than one acre, a National Pollutant Discharge Elimination System (NPDES) Permit for Construction Activities would be required for construction. Best management practices (BMPs) for dust control, erosion control, and sediment control would be incorporated into the project's site specific BMP plan to manage and control storm water run-off during construction. Although the proposed project does not anticipate any direct impact to protected species or critical habitat, best management practices (BMPs) would minimize potential impacts to water quality as well as impacts to fish and wildlife resources. Nearby stream beds and coastal resources beyond the project footprint would then be afforded additional protection from impacts during construction.

Under the No-Build Alternative, the level of storm water runoff and ground water recharge would remain the same as existing conditions. Farrington Highway's drainage system would remain unchanged.



Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
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Flood Map
Figure 2-2

2.3 BIOLOGICAL RESOURCES

2.3.1 REGULATORY REQUIREMENTS

Section 7 of the Endangered Species Act of 1973 requires federal agencies to consider impacts on endangered or threatened species and critical habitat of such species. For terrestrial species, it requires that federal agencies consult with the U.S. Fish and Wildlife Service (USFWS, or the Service) about the effects of any major construction activity on a listed species or species proposed as endangered, or those effects which could result in the destruction or adverse modification of designated critical habitat (40 Code of Federal Regulations 402). The State's counterpart law is Chapter 195D, Hawaii Revised Statutes (HRS), as amended, under which species are similarly protected. The remainder of this section discusses the impact to biological resources in this regulatory context.

2.3.2 EXISTING CONDITIONS

The Farrington Highway ROW within the project limits supports very little vegetation. Residences in the project area line the majority of the mauka side of the highway, therefore there is little to no space available for highway-associated landscaping. On the makai side, vehicles and pedestrians traveling on the roadway shoulder to access the adjacent Ulehawa Beach Park and Nanakuli Beach Park have compressed the soil to such an extent that vegetation, other than weeds, is generally unable to establish itself.

Previous studies indicate that a wetland (a brackish marsh) or muliwai at one time existed on the makai side of the roadway near Nanakuli Beach and Nanakuli Stream just southeast of the project site. Nanakuli Stream's intermittent flooding and the ocean's high tides fed the brackish marsh. However, sand movement deposited by the ocean currents and fill from the City and County of Honolulu's bridge that crosses the stream may have filled the wetland complex. The area is now proliferated with pickleweed (*Batis maritima*).

Due to the project site's urban setting, faunal species found at or near the site include domesticated species, such as cats and dogs. Other predominate or typical species found in the study area include common bird species, such as the mynah (*Acridotheres tristis*), pigeons and doves (*Geopelia maugeus*) (*Streptopelia chinensis*), sparrows (*Passer domesticus*), house finches (*Carpodacus mexicanus*), and the invasive red-vented bulbuls (*Pycnonotus cafer*). All of these species were introduced to the Hawaiian Islands and none of them are classified as federally or State-listed rare, threatened or endangered species.

Consultation with the U.S. Fish and Wildlife Service (USFWS) was initiated per requirements of the Section 7 of the Endangered Species Act of 1973 (16 U.S.C. 1531-1543). The State of Hawai'i Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) was also contacted for information on the possible presence of threatened and endangered species. Correspondence with USFWS and DOFAW is summarized in Section 3.2, and copies of correspondence are located in Appendix A.

In a letter dated October 16, 2009, the USFWS stated that their records including data compiled by the Hawaii Biodiversity and Mapping Program indicate no known federally listed species or designated critical habitat for protected species within the project footprint. In a

letter dated September 24, 2009, DOFAW indicated that they have no objections to the proposed project.

2.3.3 POTENTIAL IMPACTS

Since there is very little existing vegetation, it is anticipated that impacts would be minimal. Vegetation would be restored to pre-project condition upon project completion.

Due to the information provided by USFWS, the FHWA is more than likely to render a "no effect" determination in accordance with Section 7 of the Endangered Species Act for the proposed project.

2.4 AIR QUALITY

2.4.1 REGULATORY REQUIREMENTS

The 1977 Clean Air Act (CAA), amended in 1990, provided for the establishment of National Ambient Air Quality Standards (NAAQS) by the U.S. EPA. The State of Hawaii has also established its own standards. Both federal and State standards have been set to maintain ambient air quality. At the present time, six parameters are regulated including the following: particulate matter, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, carbon monoxide, ozone, and lead. State of Hawaii air quality standards are comparable to national standards except those for nitrogen dioxide and carbon monoxide, which are more stringent than the national standards. Localities in which pollution levels persistently exceed the NAAQS are considered non-attainment areas. National and State Ambient Air Quality Standards are provided in Table 2-1.

Table 2-1
National and State Ambient Air Quality Standards

Pollutant	Standards		
	Hawai'i State	Federal Primary[a] (Health)	Federal Secondary[b] (Welfare)
Carbon Monoxide (CO)			
1 Hour[1]	9 ppm	35 ppm	----
8 Hour[1]	4.4 ppm	9 ppm	----
Nitrogen Dioxide (NO_2)			
Annual (Arithmetic)	0.04 ppm	0.05 ppm	0.05 ppm
PM10[c]			
24 Hour[3]	150 ug/m^3	150 ug/m^3	150 ug/m^3
Annual (Arithmetic)[2]	50 ug/m^3	---	---
PM2.5[d]			
24 Hour[5]	----	35 ug/m^3	35 ug/m^3
Annual (Arithmetic)[4]	----	15 ug/m^3	15 ug/m^3
Ozone (O_3)			
8 Hour[6]	0.08 ppm	0.08 ppm	0.08 ppm
Sulfur Dioxide (SO_2)			
3 Hour[1]	0.5 ppm	----	0.5 ppm
24 Hour[1]	0.14 ppm	0.14 ppm	----
Annual (Arithmetic)	0.03 ppm	0.03 ppm	----
Lead (Pb)			
3 Months (Arithmetic)	1.5 ug/m^3	0.15 ug/m^3	0.15 ug/m^3
Hydrogen Sulfide (H_2S)			
1 Hour	0.025ppm	----	----

Source: State of Hawai'i, Department of Health, Clean Air Branch – State of Hawaii Annual Summary 2008, Air Quality Data

Note: [a]Designated to prevent against adverse effects on public health
[b]Designated to prevent against adverse effects on public welfare, including protection against visibility, damage to animals, crops, vegetation, and buildings.
[c]Particulate matter 10 microns or less in diameter
[d]Particulate matter 2.5 microns or less in diameter.
(1)Not to be exceeded more than once per year.
(2)Due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution, the agency revoked the annual PM_{10} standard in 2006 (effective December 17, 2006).
(3)Not to be exceeded more than once per year on average over 3 years.
(4)To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m^3.
(5)To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).
(6)To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

2.4.2 EXISTING CONDITIONS

Air quality throughout Oahu, including the project site, is generally good due to prevalent trade winds and on-shore breezes that help disperse most urban air pollutants. All of Oahu is an

attainment area. Air quality data from the nearest monitoring stations operated by the State of Hawaii Department of Health (HDOH) indicate that all national air quality standards are currently being met, although occasional exceedances of the more stringent State standards for carbon monoxide may occur near congested roadway intersections.

2.4.3 POTENTIAL IMPACTS

The pollutants relevant to evaluating the air quality impacts of a roadway project are those contained in motor vehicle emissions. Vehicles emit carbon monoxide (CO), volatile organic compounds (VOCs), the six priority mobile source air toxics (MSAT), nitrogen oxide (NOx), and lead (lead levels have decreased substantially and will continue to do so due to the mandated elimination of lead in gasoline). Those pollutants can react in the atmosphere to generate PM_{10} and $PM_{2.5}$ on a regional basis. CO air pollution is generally considered to be a microscale problem that can be addressed locally to some extent. The other pollutants degrade air quality at a regional scale.

Regional air quality impacts related to VOC, the six priority MSAT, NOx, PM_{10}, and $PM_{2.5}$ are primarily dependent on changes in vehicle miles traveled (VMT), vehicle hours traveled (VHT), and vehicle mix (gasoline-fueled cars vs. diesel-fueled trucks and buses). None of these factors are predicted to change due to the proposed project or the under the No-Build alternative.

Vehicle speed is the primary factor governing potential microscale CO impacts. An analysis of the expected travel patterns and level of service (LOS) for intersections within the project limits indicate whether the project is expected to cause the LOS to deteriorate and therefore have an adverse impact on air quality. Section 2.9 provides the existing, Build and No-Build level of service information anticipated for the Haleakala and Nanakuli Avenue intersections. Since the proposed project would improve the LOS, reducing congestion and the release of CO, the project is not anticipated to adversely impact air quality. In addition, the project does not meet the State or Federal guidelines requiring a detailed microscale analysis.

During construction a site-specific BMP plan will be developed to minimize fugitive dust emissions. Best management practices such as dust screens, and covering stockpiles will be utilized to reduce these emissions during construction.

2.5 NOISE

2.5.1 BACKGROUND

Noise is defined as any sound that is undesirable or interferes with normal human activities. The decibel (dB) scale is used to quantify sound intensity and represents the ratio between a given sound and the faintest sound detectable by human hearing. Because sound pressure levels vary widely within the range of human hearing, the dB scale is logarithmic. The human ear is not equally sensitive to all frequencies within the entire sound spectrum. Accordingly, noise measurements are made using an A-weighting (dBA) scale to correspond to human perceptions of noise. A-scale sound levels are in current use in many community and city noise ordinances, and many state and city highway or traffic noise codes.

Time variations in noise exposure are typically described as constant energy level equivalent (L_{eq}) for a given time period. L_{eq} is the constant noise level over some specified period of time that is equivalent in energy to a fluctuating (or brief) noise "averaged" over that period of time. L_{eq} is also a function of time and is expressed as L_{eq} (time period). For example, Leq(h), expressed in A-weighted decibels (dBA), is the calculated constant noise over one hour which is equivalent in total energy to the combination of noise levels which were actually measured during that one hour.

2.5.2 NOISE REGULATIONS AND IMPACT CRITERIA

HDOT's Highway Traffic Noise Analysis and Abatement Guidelines (HDOT Noise Policy) implements the requirements of the FHWA regulations on noise impacts (23 CFR 772). The policy requires that a noise analysis be performed whenever potentially affected receivers, that are noise sensitive, exist in the study area, either as developed lands or lands that are planned, designed, or programmed for future use.

Under HDOT Noise Policy, a noise impact occurs when the predicted traffic noise levels approach or exceed FHWA's Noise Abatement Criteria (NAC) (see Table 2-2), or when the predicted traffic noise levels substantially exceed the existing noise levels.

Under the HDOT Noise Policy, "approach" is defined as at least 1 dBA less than the NAC, and "substantially exceed the existing noise levels" is defined as an increase of at least 15 dBA. As indicated in Table 2-2, the NAC categorizes different types of exterior and interior land use activities. Depending on the activity category, a different NAC would be applied.

Table 2-2:
Noise Abatement Criteria (NAC)

Activity Category	L_{eq} (h) for Noisiest Traffic Hour (dBA)	Description of Activity Category
A	57 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.
C	72 (Exterior)	Developed lands, properties, or activities not included in Categories A or B.
D	----	Undeveloped lands.
E	52 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

Source: U.S. Department of Transportation, 1982

2.5.3 EXISTING NOISE CONDITIONS

Existing and future noise sensitive land uses and activities adjacent to the proposed corridor and nearby major roadways were identified from site inspections and existing mapping. These land use activities include residences, recreation and park areas such as the Nanakuli Beach Park, Ulehawa Beach Park, and schools such as Ka Waihona PCS. All of these activities would be considered Category B, and have a NAC of 67 dBA. A noise study was conducted to determine the proposed projects impact and is provided in Appendix D. Table 2-3 shows the modeled existing noise condition within the vicinity of the project.

2.5.4 METHODOLOGY OF IMPACT ANALYSIS

Ambient noise levels were measured for 15-minute periods at four locations near the project area to describe the existing noise environment, identify major noise sources in the project area, validate the noise prediction model, and characterize the background environmental noise levels. Measurements were taken October 14th and 15th, 2009 and represent larger clusters of noise-sensitive receptors near the proposed project. Table 2-3 describes the measurement locations.

Table 2-3
Noise Measurement Data and TNM® Model Calibration Check

Location No.	Description	Measured Noise Level (dBA L_{eq})	Modeled Noise Level For Calibration (dBA L_{eq})	Difference between Modeled and Measured Noise Level (dBA L_{eq})
A	Saint Rita's Church Parking Lot	69	69	0
B	Nanaikapono Elementary School Driveway	68	68	0
C	Ulehawa Beach Park Frontage to Farrington Hwy	69	69	0
D	Ka Waihona o Ka Naauao Public Charter School Frontage to Farrington Hwy	67	67	0

Source: PB Americas, Inc., March 2010.

Existing noise levels were subsequently modeled at 29 locations that represent noise sensitive uses in the study area and shown in Figure 2-3. The noise measurement locations listed in Table 2-3 were only used to calibrate the noise model and not used for predicting noise levels at noise sensitive locations because noise measurements were not representative of noise sensitive locations.

For noise model validation, measured noise levels, traffic counts, and average traffic speeds taken during the measurements were used to validate the TNM® traffic noise model. Each of the four measured sites was found to model within +/-1 dBA of the measured levels. Because a 3 dBA change in noise levels is barely perceptible to the average human ear, an agreement of +/-1 dBA is considered acceptable for noise model validation purposes.

The close verification of the modeled and measured noise levels indicates that the model is accurately representing the traffic noise levels in this area. Thus, the model can be relied upon to accurately predict the traffic noise levels for future peak vehicle hour traffic conditions. The measured sites were taken at locations near Farrington Highway that did not represent sensitive use areas. Because of their location, the measured sites were only used to calibrate the noise model and are not carried forward into the analysis.

A match between measurement and modeled sound levels this close indicates that no calibration adjustment of the model is necessary in accordance with FHWA policy.

Predicted noise levels were compared with the FHWA NAC to determine if a noise impact would occur. For each noise impact, mitigation measures would be evaluated using criteria contained in the HDOT Noise Polity. An approved noise mitigation measure must be feasible and reasonable.

2.5.5 EXISTING CONDITIONS

The existing modeled noise conditions at the 29 noise locations are shown in Table 2-4. : The high noise levels are largely due to the proximity of noise sensitive receptors to Farrington Highway and its high traffic volumes.

Table 2-4
Predicted Noise Levels for the Existing Condition (Worst Traffic Noise Condition)

Modeled Site Number	No. of Units Represented by the Receptor[1]	NAC Criteria	Existing Traffic Noise Level L_{eq}(h) dBA	L_{eq} dBA at or Above NAC (Yes/No)
1	6	B	62	No
2	6	B	**71**	Yes
3	4 + Church	B	62	No
4	4	B	**71**	Yes
5	4	B	61	No
6	4	B	**71**	Yes
7	4	B	61	No
8	4	B	57	No
9	4	B	**71**	Yes
10	4	B	57	No
11	Park	B	65	No
12	3	B	61	No
13	3	B	56	No

Modeled Site Number	No. of Units Represented by the Receptor[1]	NAC Criteria	Existing Traffic Noise Level L_{eq}(h) dBA	L_{eq} dBA at or Above NAC (Yes/No)
14	4	B	53	No
15	2	B	**69**	Yes
16	School	B	48	No
17	School	B	59	No
18	Playfield	B	48	No
19	School	B	58	No
20	4	B	**69**	Yes
21	4	B	58	No
22	Athletic Court	B	64	No
23	4	B	**69**	Yes
24	4	B	59	No
25	4	B	**69**	Yes
26	4	B	58	No
27	Park	B	64	No
28	4	B	58	No
29	4 + Church	B	**69**	Yes

Source: PB Americas, Inc., March 2010
Notes: Bold indicates an impacted receptor according to the NAC
1 Unless otherwise indicated, the numbers provided in this column are the number of residential units associated with the noise location

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Noise Measurements and Model Receptors
Figure 2-3

2.5.5.1 Potential Impacts

Table 2-5 shows the predicted traffic noise levels and impact conditions under the proposed project's Build Alternative and No-Build Alternative by the year 2032.

Table 2-5
Predicted Traffic Noise Levels and Impact Conditions

Site Number	No. of Dwelling Units Represented by the Receptor	NAC Criteria	Existing Traffic Noise Level Leq dBA	No-Build Traffic Noise Level Leq/dBA 2030	Difference from Existing	Build Traffic Noise Level Leq/dBA 2030	Difference from Existing
1	6	B/66	62	62	0	62	0
2	6	B/66	**71**	**71**	0	**71**	0
3	4 + Church	B/66	62	62	0	62	0
4	4	B/66	**71**	**71**	0	**71**	0
5	4	B/66	61	62	1	61	0
6	4	B/66	**71**	**71**	0	**71**	0
7	4	B/66	61	61	0	61	0
8	4	B/66	57	57	0	57	0
9	4	B/66	**71**	**71**	0	**71**	0
10	4	B/66	57	57	0	57	0
11	Park	B/66	65	65	0	65	0
12	3	B/66	61	62	1	62	1
13	3	B/66	56	56	0	57	1
14	4	B/66	53	53	0	53	0
15	2	B/66	**69**	**70**	1	**70**	1
16	School	B/66	48	49	1	49	1
17	School	B/66	59	60	1	61	2
18	Playfield	B/66	48	49	1	49	1
19	School	B/66	58	59	1	59	1
20	4	B/66	**69**	**70**	1	**70**	1
21	4	B/66	58	59	1	59	1
22	Athletic Court	B/66	64	65	1	66	2
23	4	B/66	**69**	**70**	1	**70**	1
24	4	B/66	59	60	1	60	1
25	4	B/66	**69**	**70**	1	**70**	1
26	4	B/66	58	59	1	59	1
27	Park	B/66	64	65	1	65	1
28	4	B/66	58	59	1	59	1
29	4 + Church	B/66	**69**	**70**	1	**70**	1

Source: PB Americas, Inc., March 2010

Bold indicates an impacted receptor according to the NAC

By 2032 under the Build Alternative, the same 29 noise locations, which represents 36 residences and one church, would experience a noise impact in accordance with the HDOT Noise Policy. These are the same sites that already approach or exceed the NAC under the existing condition, nevertheless it is still considered an impact. No new noise sensitive sites are expected to experience noise levels above the NAC under the Build Alternative.

2.5.6 NOISE ABATEMENT MEASURES

Because predicted traffic noise levels are expected to exceed FHWA/HDOT noise criteria limits for some receivers, mitigation measures are warranted for consideration under the Build Alternative. Noise abatement is to be considered only where frequent human use occurs and where a lower noise level would provide benefits (U.S. DOT, 1982).

Several different traffic noise abatement measures are evaluated whenever traffic noise impacts are expected. For example, noise generated from long-term operation of the project can be reduced by implementing traffic management measures, acquiring land as buffer zones, realigning the roadway, soundproofing public use or nonprofit institutional structures, and constructing noise barriers or berms. These measures were evaluated for their potential to reduce noise impacts from the proposed project.

Any specific mitigation measure recommended as part of the project must be feasible and reasonable. In this context feasible means the physical ability to implement the noise mitigation measure in such a manner as to provide an acceptable noise reduction benefit, while reasonable means being able to implement the mitigation measure at an acceptable cost.

The 36 residences and one church currently impacted by traffic noise under the existing conditions were evaluated for potential mitigation measures because they exceed FHWA/HDOT noise criteria limits. Upon evaluation, it was determined that mitigation options are not feasible to effectively reduce traffic noise at these locations.

2.5.7 CONSTRUCTION NOISE

During construction, areas adjacent to the project would be exposed to noise from construction activities. Although of a temporary nature, the additional noise can be annoying to the public.

Estimates of maximum noise levels at a distance of 50 feet for various pieces of construction equipment are provided in Table 2-6. While actual noise levels will vary due to particular equipment, phase of construction, and the influence of the person using the equipment, every effort would be made to minimize the adverse affects of construction noise whenever possible.

Construction would normally occur during daylight hours when occasional loud noises are more tolerable. Ka Waihona PCS, the nearest noise sensitive receptor is air conditioned as well as the nearby Nanaikapono Elementary School. Therefore, extended noise disruptions to normal activities are not anticipated.

Since HDOH maintains community noise control standards (HAR Section 11-46) that apply to construction noise, these specifications would be followed. Additional details are provided in the Noise Technical Report in Appendix D.

Table 2-6
Construction Equipment Noise Levels

Equipment Description	Ground Impact Device ?	Specified Limit L_{max} @ 50 feet (dBA, Slow)	Actual Measured L_{max} @ 50 feet (dBA, Slow)
Backhoe	No	80	78
Flat Bed Truck	No	84	74
Front End Loader	No	80	79
Generator	No	82	81
Generator (<25 KVA, VMS signs)	No	70	73
Gradall	No	85	83
Grader	No	85	83
Impact Pile Driver	Yes	95	101
Jackhammer	Yes	85	89
Mounted Impact Hammer (hoe ram)	Yes	90	90
Paver	No	85	77
Pickup Truck	No	55	75
Pneumatic Tools	No	85	85
Pumps	No	77	81
Roller	No	85	80
Scraper	No	85	84
Slurry Plant	No	78	78
Soil Mix Drill Rig	No	80	N/A
Welder/Torch	No	73	74

Source: USDOT, FHWA 2006

2.6 LAND USE

2.6.1 EXISTING CONDITIONS

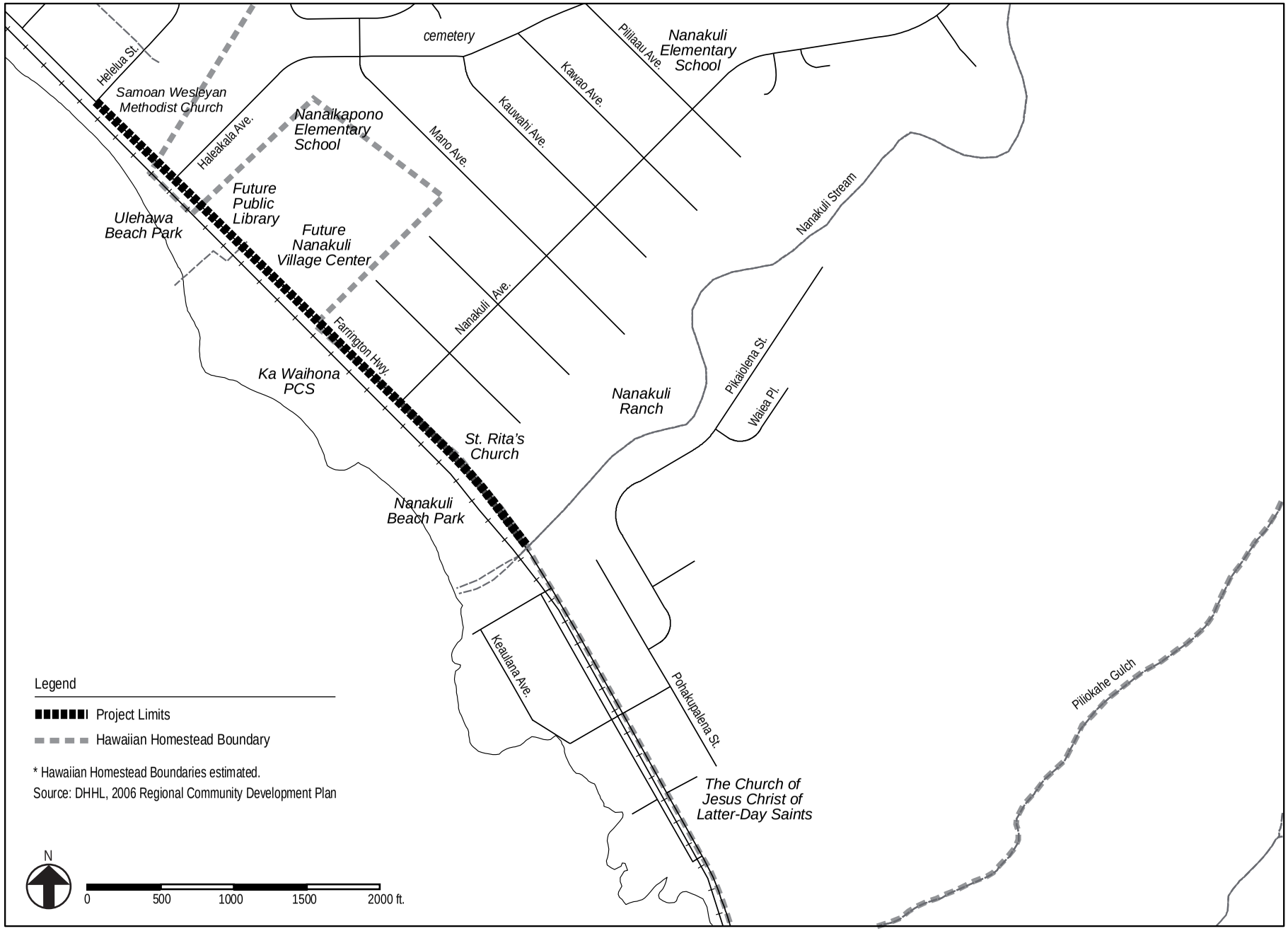
Figure 2-4 illustrates the existing and future land uses within the vicinity of the proposed project. Land use makai of Farrington Highway is dominated by beach parks and school facilities. Nanakuli Beach Park and Ulehawa Beach Park are located immediately makai of Farrington Highway. Nanakuli Beach Park provides grounds and facilities for swimming and water recreation, as well as large basketball courts and a baseball field. Ka Waihona PCS, located between Nanakuli Beach and Ulehawa Beach Parks, hosts five educational facilities that includes Ka Waihona PCS, Kamehameha School, Punana Leo, In Peace, and Nanakuli Head Start.

The area mauka of the project site is largely residential, primarily consisting of single family homes situated on Hawaiian Homestead Lands. Figure 2-5 shows the area considered part of the Nanakuli Hawaiian Homestead. The 2006 Nanakuli Hawaiian Homelands Regional Development Plan indicates that there are 1,040 single-family residences within this region. As shown in Figure 2-5, the Department of Hawaiian Homelands (DHHL) and other State of Hawaii agencies own a majority of the property in this area.

There are three schools mauka of Farrington. Nanaikapono Elementary School is adjacent to the project corridor, and further in the valley are Nanakuli High School and Intermediate School. The NFL YET center for the youth of Nanakuli, and the Boys and Girls Club Teen Center are also located within the project vicinity.

2.6.2 POTENTIAL IMPACTS

Since the proposed project would be constructed within the Farrington ROW, no displacements of existing land uses would be required, nor would the proposed project preclude the development of any future land use, such as the future Nanakuli Village Center, which will be located adjacent to the highway. The proposed project would, however, provide additional roadway capacity to support the adjacent planned development. Ka Waihona PCS noted that a portion of the Farrington Highway ROW fronting the education facility is used as a bus pull-out and drop-off facility; Ka Waihona PCS has decided to reconstruct their bus pull-out facility on school property. During construction, a traffic management plan will be developed to provide access to surrounding driveways and land use.



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Existing and Future Land Uses Map
Figure 2-4

Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
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Major Land Owners
Figure 2-5

2.7 CONSISTENCY WITH GOVERNMENT PLANS, POLICIES, AND CONTROLS

This section describes whether the Build Alternative would be consistent with government plans, policies, and/or controls. The No-Build Alternative would not propose any changes that would require consistency reviews; therefore, the focus of this discussion is largely limited to the Build Alternative.

2.7.1.1 State of Hawaii Plans and Controls

2.7.1.1.1 Hawaii State Plan

The Hawaii State Plan (June 1991), as codified in HRS Chapter 226, consists of comprehensive goals, objectives, policies and priorities for all areas of government functions, including the protection of the physical environment, the provision of public facilities systems, and the promotion and assistance of socio-cultural advancement.

The Hawaii State Plan also promotes multi-modal system conformance with desired growth patterns and physical development; encourages coordination of transportation activities and programs among governmental and private parties; and encourages systems that accommodate present and future community development needs. Similarly, the proposed project seeks to improve pedestrian and bicycling facilities; working toward the objective of an integrated multi-modal transportation system that promotes the needs of moving people and goods.

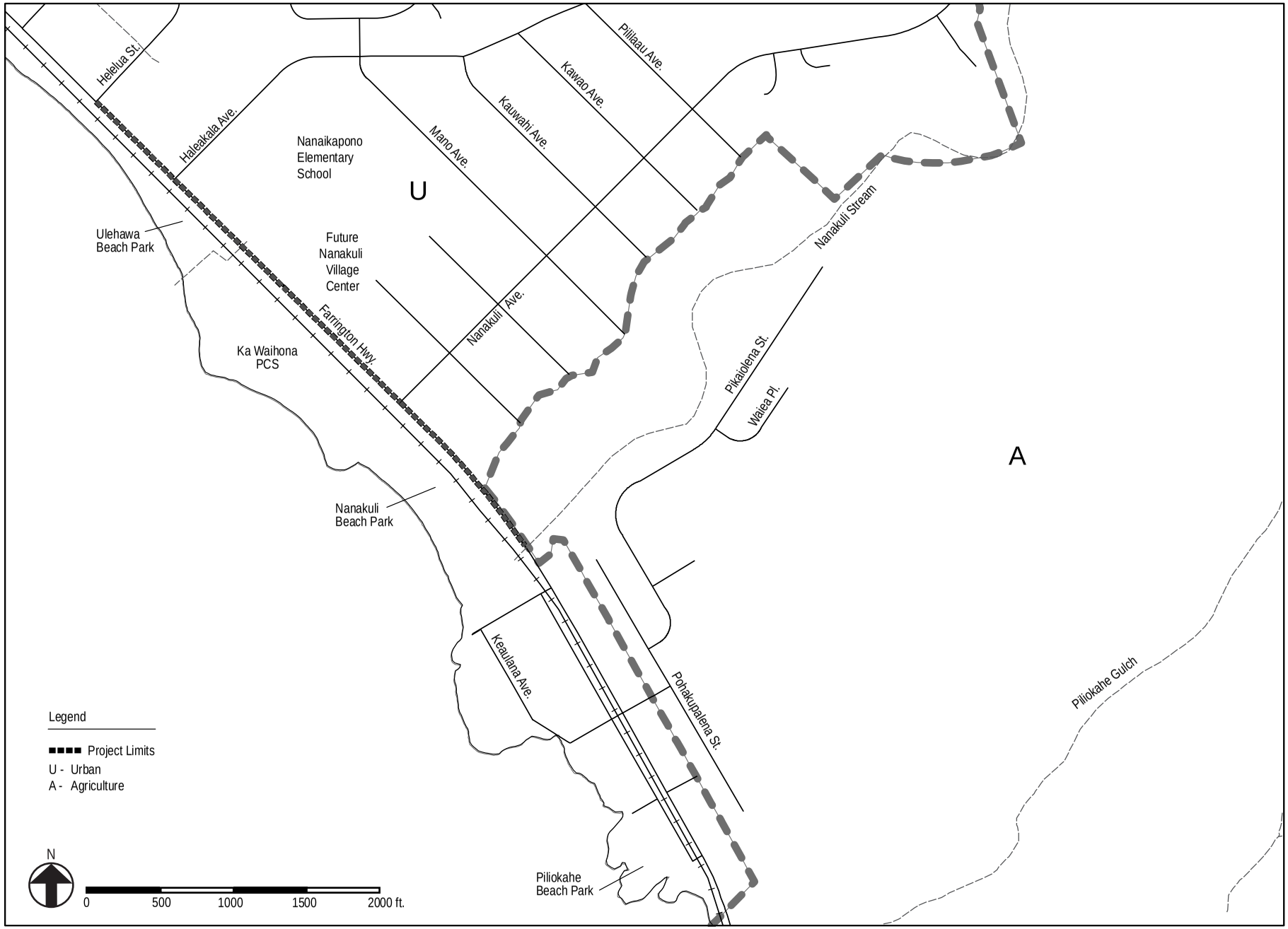
2.7.1.1.2 Hawaii State Land Use Controls

Lands in the State are divided into four classifications: Urban, Agriculture, Rural, and Conservation. Each classification has specific land use objectives, development constraints, and administrative control. Figure 2-6 provides a map of the classified state land use in the project vicinity. The proposed project would occur on land designated as Urban, with which transportation infrastructure is compatible. It should be noted that the southern tip of the project borders land classified for agriculture, but the Farrington Highway ROW is designated as Urban.

2.7.1.1.3 Coastal Zone Management

The objectives and policies of the Hawaii Coastal Zone Management (CZM) Program are designed to protect and manage Hawaii's valuable coastal areas and resources. The proposed action is located within the State's CZM area, which covers the entire State. Pursuant to 15 CFR 930.32, federally-permitted, licensed or assisted activities undertaken in or affecting Hawaii's coastal zone must be consistent with the CZM objectives and policies.

The following brief discussion describes the project's consistency with the objectives and policies of the State's CZM Program. This assessment will be reviewed by the Department of Business, Economic Development and Tourism (DBEDT), Office of Planning, the agency administering the State's CZM program.



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State Land Use Map
Figure 2-6

Recreation Resources. The Build alternative would not adversely affect parks and recreational resources in the project area. The shared use path provides an enhancement to recreational facilities since it provides for an additional recreational activity that previously did not exist.

Historic Resources. The Build alternative would relocate the historic OR&L, however, the relocation would remain within the historic corridor.

Scenic and Open Space Resources. The Build alternative would not obstruct the coastal views or mountain views.

Coastal Ecosystems. The Build alternative would not disrupt coastal ecosystems. The additional impervious surfaces added as a result of the proposed widening would increase the amount of storm water runoff from Farrington Highway. Due to the potential increase of pollutants entering the highway drainage system, which may affect water quality in the Ulehawa Stream Channel and Nanakuli Stream and nearby coastal waters, permanent BMPs would be installed as part of the proposed project.

Economic Uses. The Build alternative would benefit residents, workers and visitors to Nanakuli and the Waianae Coast by alleviating roadway congestion on Farrington Highway, thereby improving the transportation network and improving access to community resources. Project construction would also contribute to the local economy by providing construction related employment.

Coastal Hazards. Farrington Highway is an infrastructure element for evacuation in the event of a coastal hazard, such as a hurricane or tsunami. The Build Alternative would increase evacuation capabilities, allowing traffic to flow freely to higher ground in the Nanakuli Valley or Honolulu-bound when evacuating the coast. No changes to evacuation capacity would result under the No-Build alternative.

Managing Development. The Build alternative would support planned local development, such as the future Nanakuli Village Center, the future Public Library, and continued expansion of Ka Waihona PCS. The majority of the area surrounding the project is owned by DHHL, and other Hawaii State agencies. Future development in this area is limited by available land.

Public Participation. To date, project planning has included one public information meeting, and a presentation before the Waianae Coast Neighborhood Board No. 24, Nanakuli-Maili Neighborhood Board No. 36. Consultations with federal, State and County agencies have also been conducted. For more information see Chapter 3. Additional opportunities for public participation would be afforded following public release of this Draft EA.

Beach Protection. The Build Alternative would not cause or exacerbate coastal erosion because the project site is not adjacent to or abutting the shoreline.

Marine Resources. The Build Alternative would not have an impact on marine or coastal resources because the project site is not adjacent to or abutting the shoreline. Also see Coastal Ecosystems above.

2.7.1.2 City and County of Honolulu Plans and Controls

2.7.1.2.1 General Plan of the City and County of Honolulu

The General Plan (revised 2002) provides broad statements on the objectives and policies of the City and County of Honolulu with regard to the overall physical and economic development of the island, as well as to the health and safety of the island's residents. The proposed project would support the following policies of the General Plan:

- Providing a system of roadways for the safe, and efficient movement of people and goods, and offer a variety of convenient and attractive modes of travel.
- Bike-ways for recreational activities and trips to work, schools, shopping centers, and community facilities; and
- Improve roads in existing communities to reduce congestion and eliminate unsafe conditions.

2.7.1.2.2 Waianae Sustainable Community Plan

The Waianae Sustainable Community Plan addresses one of eight geographic regions on Oahu along with other development or sustainable community plans prepared for the Primary Urban Center (PUC), East Honolulu, Central Oahu, Ewa, Waianae, North Shore, Koolau Loa and Koolau Poko. The PUC and Ewa regions are "development plans" since these regions are slated for population and job growth. However, Waianae and the remaining five regional plans are called "Sustainable community plans" for consistency with the regions' modest growth policies. Sustainable community plans focus on maintaining and improving the existing communities and special qualities of the region.

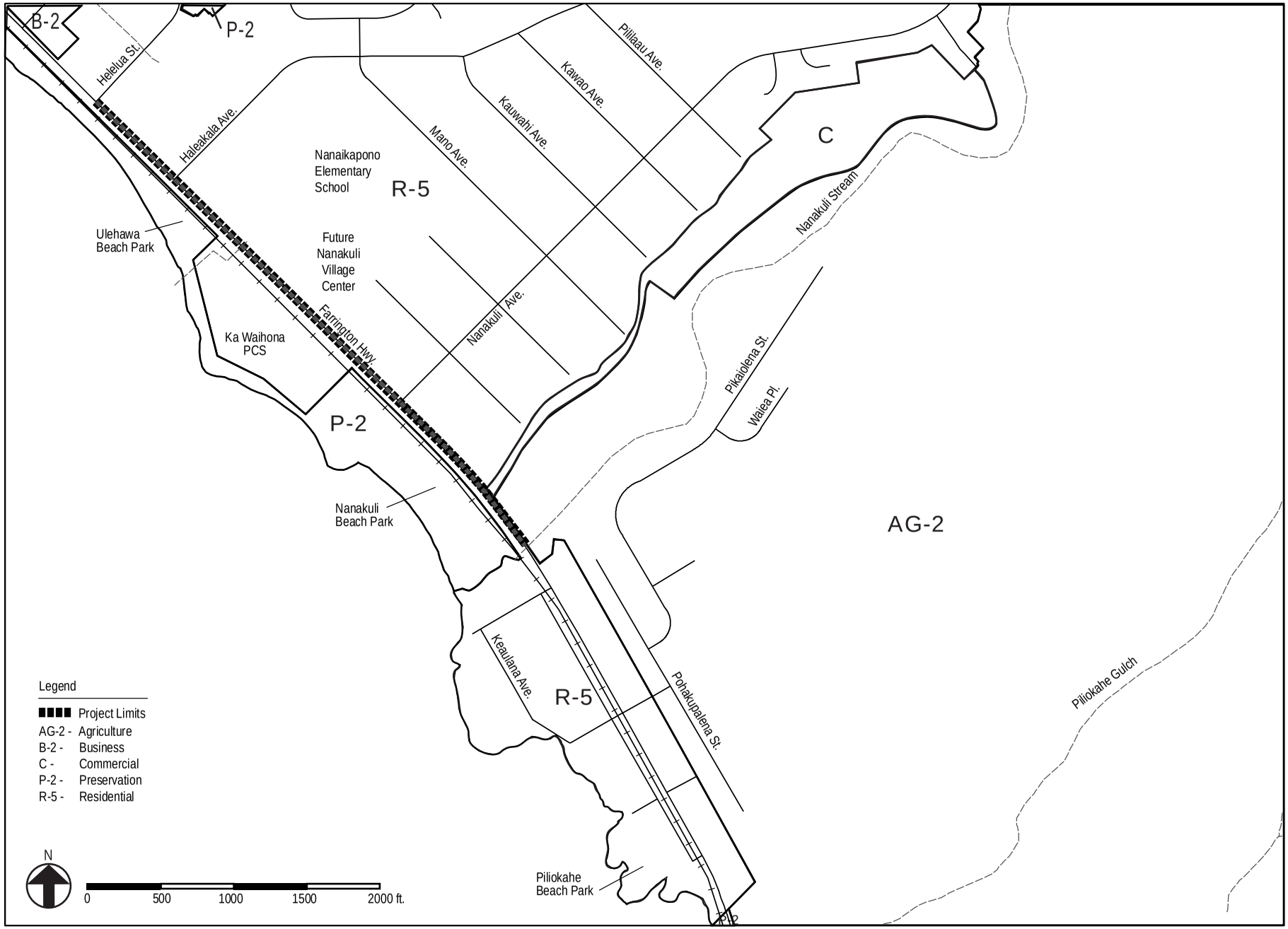
The Waianae Sustainable Communities Plan was adopted on May 10, 2000 by the City Council. The plan contains an overall twenty year vision for the Waianae coast. The proposed project would support the following transportation policies of the community plan:

- Design and implement a safety improvements program for Farrington Highway.
- Encourage plans and programs for other methods of transportation, specifically bikeways and walkways.

2.7.1.2.3 Zoning

City and County of Honolulu zoning is required to be in conformance with Development Plan designations of the Department of Planning and Permitting (DPP) and Land Use Ordinance (LUO). The LUO provides a list of zoning districts and precincts and the permitted uses and structures for each district and precinct. The purpose of the LUO is to regulate land use to encourage orderly development in accordance with adopted land use policies, including the Oahu General Plan and the Waianae Sustainable Communities Plan, and to promote and protect the public health, safety and welfare.

As shown in Figure 2-7, the area surrounding the project vicinity is zoned mostly for agricultural, residential, and preservation purposes. The Farrington Highway ROW lies within the R-5, Residential zone. In accordance with Section 21-3.70 of the LUO, the intent of residential districts is to provide areas for urban residential development.



Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
Draft Environmental Assessment

Zoning Map
Figure 2-7

2.7.1.2.4 Special Management Area (SMA)

HRS Chapter 205A outlines special controls, policies and guidelines for development within an area along the shoreline referred to as the Special Management Area (SMA), as designated by the 1975 Shoreline Protection Act. Under this Act, the City's DPP administers the SMA use permit program for Oahu with authority to issue permits for development activities proposed within the SMA.

The project site is within the SMA and the proposed project would require an SMA permit. Because the cost of the proposed project exceeds the valuation threshold for a minor permit, a major permit would be required.

2.7.1.2.5 Oahu Regional Transportation Plan (ORTP 2030)

ORTP 2030 is the regional transportation plan (RTP) adopted by the Oahu Metropolitan Planning Organization (OMPO) in April of 2006. It replaced the previous Oahu RTP (TOP 2025), adopted in April 2001. The ORTP 2030 responds to the changing needs of Oahu and extends the planning horizon year to 2030. The purpose of ORTP 2030 is to identify facilities and programs to meet increased future travel demands through the Year 2030.

The proposed project was identified in the ORTP 2030 as project number 37-S, which was named "Farrington Highway, Safety Improvements, Makua Valley Road to Aliinui Drive." It was listed as a safety and operational improvements project within the time frame of 2016 to 2030 or the "Mid-Range Plan". The No-Build alternative would not fulfill the directives of ORTP 2030 for the project site.

2.8 SOCIAL, ECONOMIC, AND CULTURAL CONDITIONS

2.8.1 NON-DISCRIMINATION GUIDANCE

HDOT's Title VI Plan (2009) is designed to fulfill its responsibilities under Title VI of the Civil Rights Act of 1964, as amended, Executive Order 12898 on Environmental Justice, US DOT Order 5610.2 on Environmental Justice, and other related non-discrimination regulations and directives. Because Title VI of the Civil Rights Act of 1964 prohibits discrimination based on race, color, or national origin, HDOT uses detailed race categories to attempt to treat people of different national origins equitably in its highway planning, programs, and activities.

Executive Order (EO) 12898, called "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," was signed by the President on February 11, 1994. It directs Federal agencies to take appropriate and necessary steps to identify and address disproportionately high and adverse effects of Federal projects on the health or environment of minority or low-income populations. If minority or low-income populations are found in the project vicinity, good faith effort must be made to ensure that disproportionate and adverse impacts on low-income and minority populations are prevented, minimized, or mitigated. An example of good faith effort is additional public notification or outreach to these groups.

Pursuant to the EO, "low-income" means households with incomes at or below the U.S. Department of Health and Human Services (DHHS) poverty guidelines. For 2009 in Hawaii, an income at or below $25,360 per year for a family of four was considered low-income.

The federal definition of "minority" includes the following groups:

- Black: a person having origins in any of the black racial groups of Africa.
- Hispanic: a person of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture or origin, regardless of race.
- Asian: a person having origins in any of the original peoples of the Far East, Southeast Asia or the Indian subcontinent or the Pacific Islands.
- American Indian or Alaskan Native (AIAN): a person having origins in any of the original people of North America and who maintains cultural identification through tribal affiliation or community recognition.
- Native Hawaiian or Other Pacific Islander (NHOPI): a person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.

HDOT's Title VI Plan states that income and demographic data is to be used to identify applicable populations; the methodology for data collection, maintenance, and analysis follows the Title VI Plan. The following discussion relies on 2000 census data. The project corridor lies wholly within census tract 96.01.

2.8.2 EXISTING CONDITIONS

2.8.2.1 General Socio-Economic Conditions

The following discussion is based on selected census data, which are summarized in Tables 2-7 and 2-8.

2.8.2.1.1 Population and Ethnicity

The State of Hawaii is an unusual, but increasingly common case, where traditionally-defined "minority" populations make up the majority of the population. In Hawaii, no single ethnic group exceeded 24 percent of the overall State population in 2000, and those who classify themselves as "two or more races" made up 21 percent of the State population.

Table 2-7 exhibits demographic characteristics for the State of Hawaii, Oahu, the Waianae DP Area, and Nanakuli Sub Area. As the name implies, the Nanakuli Sub Area is a subset of the Waianae DP Area. Data for the State of Hawaii, island of Oahu, Waianae DP Area, and Nanakuli Sub Area are provided individually for comparative purposes in order to characterize the demographic and socio-economic data of the area surrounding the project site.

Table 2-7:
Year 2000 Demographic Characteristics

	State of Hawaii	Oahu	Waianae DP Area	Nanakuli SubArea
Population	1,211,537	876,156	42,259	11,866
Ethnicity				
White	24%	21%	11%	6%
African American	2%	2%	1%	1%
American Indian/Alaskan Native	0.3%	0.2%	0.3%	0.3%
Asian	42%	46%	17%	11.5%
Native Hawaiian/Other Pacific Islander	9%	9%	30%	41%
Other	1%	1%	1%	2%
Two or More Races	21%	20%	41%	40%
Age				
Less Than 5 Years	7%	7%	9%	9%
5 to 17 Years	18%	17%	26%	23%
18 to 64 Years	62%	63%	57%	61%
65 or More Years	13%	13%	1%	7%
Median Age (Years)	36.2	35.7	28.5	31.2

Sources: City and County of Honolulu, Department of Planning and Permitting. Community Profiles by Development Plan Area: 2000, May 2003.; and Community Profiles by Development Plan Subarea: 2000. U.S Census Bureau 2000.

Table 2-8:
Year 2000 Income and Employment Characteristics

	State of Hawaii	Oahu	Waianae DP Area	Nanakuli Sub Area
Number of Households	403,572	286,731	10,535	2,554
Income by Household				
Median Income[1]	$49,820	$51,914	$42,921	$43,811
Lower Than $15,000	13%	11%	18%	17%
Higher Than $75,000	29%	32%	22%	21%
Persons Below Poverty Level	10%	10%	20%	19%
Selected Income Source by Household				
Social Security Income	28%	27%	26%	26%
Retirement Income	21%	22%	21%	24%
Public Assistance Income	7%	7%	26%	25%
Employment Status of Population 16 years and over	950,055	691,015	29,444	8,575
Civilian Labor Force:	60%	59%	58%	56%
Employed	57%	55%	50%	48%
Unemployed	4%	4%	8%	8%

Source: City and County of Honolulu, Department of Planning and Permitting. Community Profiles by Development Plan Area: 2000, May 2003. and Community Profiles by Development Plan Subarea: 2000. U.S Census Bureau, Census 2000.
Notes: 1 In 1999 dollars.

The population of the City's designated Waianae DP area, which includes Nanakuli, was 42,259 in 2000, or 4 percent of the total Oahu population. According to the Waianae Sustainable Community Plan, this coastal region is anticipated to grow at a very modest rate.

As indicated in Table 2-7, the demographic characteristics of Waianae and Nanakuli residents are for the most part similar to that of the general population of Oahu and the State, except for a few variations. A higher portion (30%) of the population in Waianae is of Native Hawaii or

Pacific Islander descent, as well as a higher population (40%) of people reporting two or more ethnicities than that of the State and island. The other difference is a smaller Asian population in comparison to the island and State. The Nanakuli Sub Area is similar to the Waianae DP, with just a slightly higher proportion of Native Hawaiian of Pacific Islanders. This is likely due to the Native Hawaiian Homestead Lands.

2.8.2.1.2 Income and Employment

In terms of income, the proportion of persons living below the poverty level in the DP Area and Sub Area is much higher than that Oahu and the rest of the State, as shown in Table 2-8. Twenty and 19 percent of Waianae (overall) and Nanakuli residents are considered below the poverty level, respectively. In comparison, the rates for Oahu and the State were the same at ten percent.

Table 2-8 shows the median household incomes and employment characteristics. Median incomes in the Waianae DP Area and Nanakuli were lower than the median household incomes for Oahu and the State. The same percentage of households in Nanakuli live on social security, and retirement, in comparison to Oahu overall, but a higher percentage of households receive public assistance. Table 2-8 also shows that unemployment in the study area was higher than Oahu overall, despite a smaller labor force.

2.8.2.1.3 Housing

In 2000, 65 percent of the housing units were owner-occupied in the Nanakuli Sub area. The owner-occupancy rate for Oahu was 49 percent. The higher owner-occupancy rate in the Nanakuli Sub area is attributable to the large Nanakuli Hawaiian Homestead. Also as indicated in Table 2-9, the vast majority of homes in Nanakuli were single-family dwellings. The region also has a higher percentage of newer homes than the State and Oahu trends.

Table 2-9:
Year 2000 Housing Characteristics

	State of Hawaii	Oahu	Waianae DP Area	Nanakuli Sub Area
Number of Housing Units	460,542	315,988	12,356	2,745
Tenure[1]				
Owner-Occupied	49%	49%	49%	65%
Renter-Occupied	38%	41%	36%	28%
Year Structure Built (in number of years before 2000)				
1 to 10 Years	19%	15%	18%	24%
11 Years or more	81%	85%	82%	77%
Units in Structure				
1 Unit	60%	55%	73%	85%
2 to 4 Units	7%	7%	6%	4%
5 or More Units	33%	38%	21%	11%

Source: City and County of Honolulu, Department of Planning and Permitting. Community Profiles by Development Plan Area: 2000, May 2003. and Community Profiles by Development Plan Subarea: 2000. U.S Census Bureau, Census 2000.

Notes: [1] Tenure does not add to 100% because some properties are vacant.

2.8.2.2 Cultural Resources and Practices

A cultural impact assessment (CIA) was prepared for the proposed project; and is included in Appendix E. The study included efforts to contact multiple cultural informants who might have knowledge and/or concerns about potential project impacts to traditional cultural practices. Thirty one organizations, agencies, and individuals were contacted. For the CIA, more formal, in-person data gathering sessions were held with seven individuals. All of these individuals have lived near or are thoroughly familiar with the Nanakuli area.

Located within the Nanakuli Ahupua'a, there are many mo'olelo and olelo no'eau (proverbs or poetical sayings) that place the project site within a cultural context. Stories of the demigod Maui were originated in the Waianae district. Pu'u Haleakala is where Hina, Maui's mother lived in a cave and made her kappa (cloth). McAllister's Site 148, the Maui pohaku (rock), is located in the Garden Grove complex along Farrington Highway, which is beyond the project limits. It was on this rock that Maui reposed and sunned himself.

Nanakuli kama'aina consider the beaches an important part of their lifestyle. Beaches are used for various activities such as collecting freshwater, fishing, diving, surfing, canoe paddling, and swimming. Participants discussed fishing for *menpachi*, *uhu*, *akule*; *limu* (seaweed, algae) gathering' and salt collection.

One informant also spoke of potential burials in the vicinity of Farrington Highway on the makai side, including *iwi* (ancestral bones). The respondent recommended cultural monitoring of any construction activity that disturbs the sand on the makai side of Farrington Highway. Another respondent commented that the OR&L train tracks be preserved. Pedestrian safety was also a concern documented by the study.

2.8.3 POTENTIAL IMPACTS

General Socio-Economic Conditions

In accordance with the federal definition of "minority" (See Section 2.8.1) which includes those of Native Hawaiian and Pacific Island ancestry, the proposed project improvements would affect minority populations. Socio-economic trends illustrate a population where the household median income is lower than the median income for Oahu. Despite the lower income trend, Nanakuli experiences a higher percentage of owner-occupied homes than the island trend.

While the project is located within a "minority" community, it would not disproportionately affect the community in an adverse manner. Impacts such as noise and air would not worsen as a result of the Build Alternative. Benefits would include a safer roadway, ease of mobility, creation of a more walkable community and thus enhancing the quality of life.

Cultural Resources and Practices

The cultural resource most directly impacted by the proposed project would be the effect on the historic OR&L railroad, in which a portion lies within the Farrington Highway ROW. Under the Build Alternative, the proposed improvements would require that the railroad be removed and relocated, which is discussed in Section 2.11. The proposed project would preserve the OR&L train tracks, and would not change its standing on the National Register of Historic Places.

Since the proposed project would excavate a portion of the berm near Ulehawa Beach Park, the ROW shoulder could no longer safely accommodate the vehicles that currently drive and park when using the Ulehawa Beach Park. This area would still be accessible to pedestrians for beach access, while vehicles would be restricted to accessing the beach park via the parking lot, which is currently under-utilized. During construction, a traffic management plan will be developed to minimize impacts to beach access during construction

2.9 TRANSPORTATION INFRASTRUCTURE

2.9.1 EXISTING TRANSPORTATION CONDITIONS

2.9.1.1 Existing Roadways and Intersections

2.9.1.1.1 Existing Roadway Network

Farrington Highway is a principal arterial four-lane roadway with a posted speed limit of 35 miles per hour within the study area. The highway continues along the entire Waianae coast until terminating at Kaena State Park. In the Honolulu-bound direction, Farrington Highway turns inland near Ko Olina Golf Club and becomes H-1 Freeway near Kamokila Community Park.

Within the project limits, a number of parcels, mostly containing residences, have direct driveway access to the highway. The two major streets are Nanakuli Avenue and Haleakala Avenue. Figure 2-8 shows the existing lane configurations, intersections, pedestrian cross-walks and bus stops within the project limits.

Haleakala Avenue is a three-legged intersection where the Waianae-bound approach on Farrington Highway has one shared through/right turn lane and one through lane. The Honolulu-bound approach contains one shared through/left turn lane and one through lane. Haleakala Avenue itself has two lanes, one mauka-bound, and one makai-bound at its intersection with Farrington Highway.

The intersection of Nanakuli Avenue and Farrington Highway is a four-legged intersection where the entrance/exit to Nanakuli Beach Park is directly opposite of Nanakuli Avenue. For this portion of Farrington Highway, the Honolulu-bound direction has one shared left-turn/through lane, and one shared right-turn/through lane. The Waianae-bound direction also has a shared left-turn/through lane, and a shared right-turn/through lane.

2.9.1.1.2 Existing Traffic Conditions

Both Haleakala Avenue and Nanakuli Avenue provide access to hundreds of homes in the Nanakuli Valley, as well as Nanaikapono Elementary School, Nanakuli Elementary School, Nanakuli Intermediate and High School, the Nanakuli Fire Station and other community resources. A traffic study of the corridor is provided in Appendix B. Farrington Highway is the only publicly accessible way to enter and exit Nanakuli and the rest of the Waianae Coast, and is, therefore, a heavily utilized roadway. A total bi-directional volume taken in 2007 at Nanakuli Bridge, just south east of the project limits, yielded 42,248 vehicles within a 24-hour time period. Figure 2-9 illustrates the existing peak and midday hour traffic volumes along the project limits, including the number of vehicles that turn left on Haleakala Avenue and Nanakuli Avenue. Figure 1-10 and Figure 1-11 depict the existing operations at Haleakala Avenue and Nanakuli Avenue.

During the morning (AM) and evening (PM) peak-hours, the Honolulu-bound queue at the Haleakala Avenue intersection can reach up to 20 vehicles. The queuing in the Waianae-bound direction during the morning (AM) peak-hour is not nearly as long. During the evening (PM) peak-hour, the queuing in the Waianae-bound direction is extremely pronounced, with vehicle queues reaching as far as Kahe Power Plant, almost 3.5 miles away.

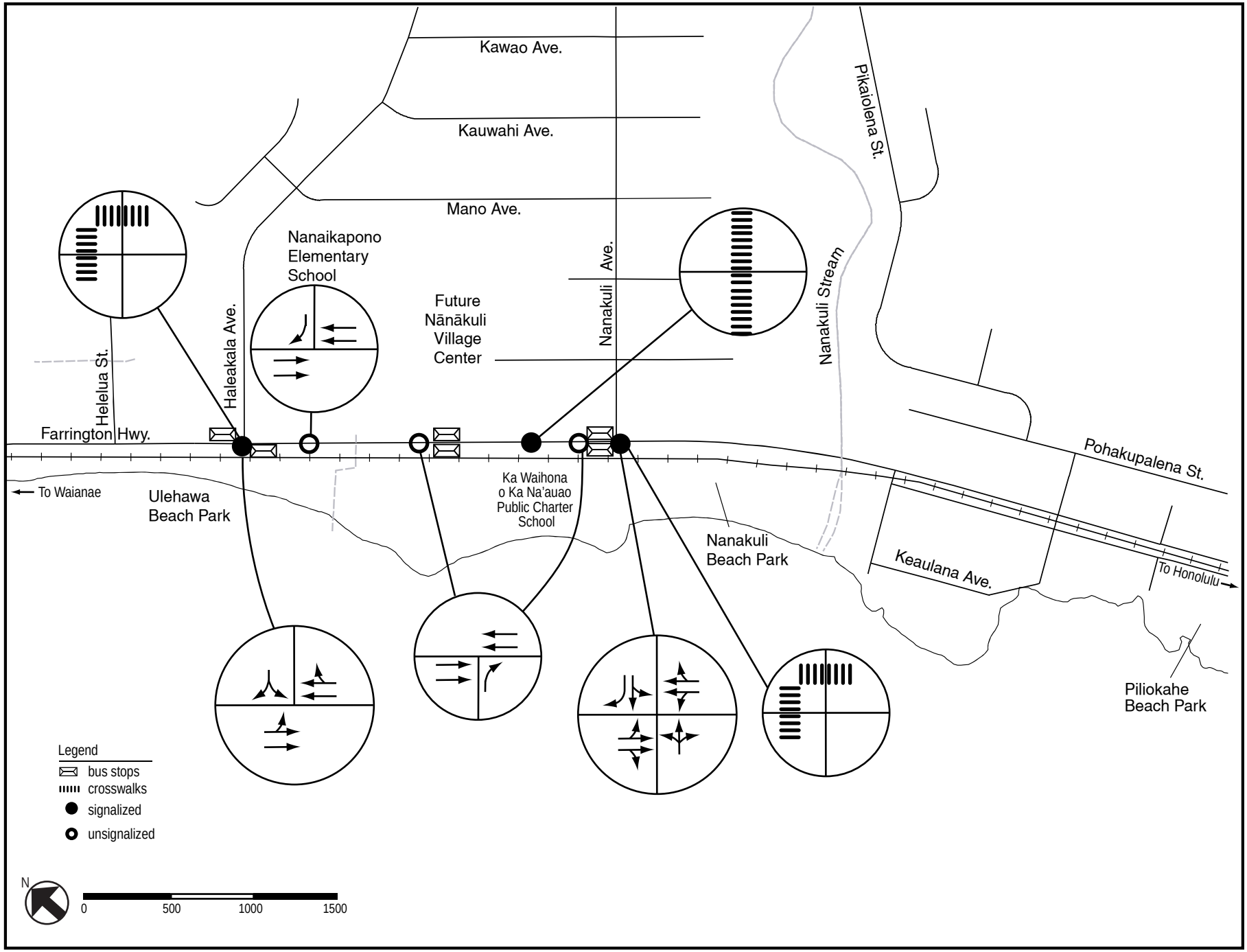
The *2000 Highway Capacity Manual* was used to evaluate the existing intersection operations at the Haleakala and Nanakuli Avenue intersections. Table 2-10 summarizes the results, as indicated by using level of service (LOS) scoring. Levels of service describe six levels of intersection operations from A to F where A is free flowing and F reflects congested conditions.

Table 2-10:
Farrington Highway Existing LOS Summary

Intersection	AM		Midday		PM	
	LOS	Delay	LOS	Delay	LOS	Delay
Farrington Hwy/Haleakala Ave	**E**	**64**	**A**	**8**	**E**	**76**
Farrington Hwy Honolulu-bound left/through	F	92	A	5	A	8
Farrington Hwy Waianae-bound through/right	A	5	A	3	F	117
Haleakala Ave makai left/right	E	77	C	30	F	123
Farrington Hwy/Nanakuli Ave	**C**	**26**	**A**	**7**	**F**	**152**
Farrington Hwy Honolulu- bound left/through/right	C	25	A	7	B	11
Farrington Hwy Waianae-bound left/through/right	A	10	A	5	F	237
Nanakuli Ave mauka left/through/right	D	50	B	16	F	90
Nanakuli Ave makai left/through	F	96	B	20	F	143
Nanakuli Ave makai right	D	50	B	15	F	90

Source: PB Americas, Inc, February 2010.
Note: Delay is in seconds per vehicle.

The Haleakala Avenue intersection operates at an overall LOS E during the morning (AM) peak hour, LOS A during the mid-day peak hour, and LOS E during the evening (PM) peak hour. Due to the heavy left turning volumes, the Honolulu-bound direction operates at LOS F during



Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
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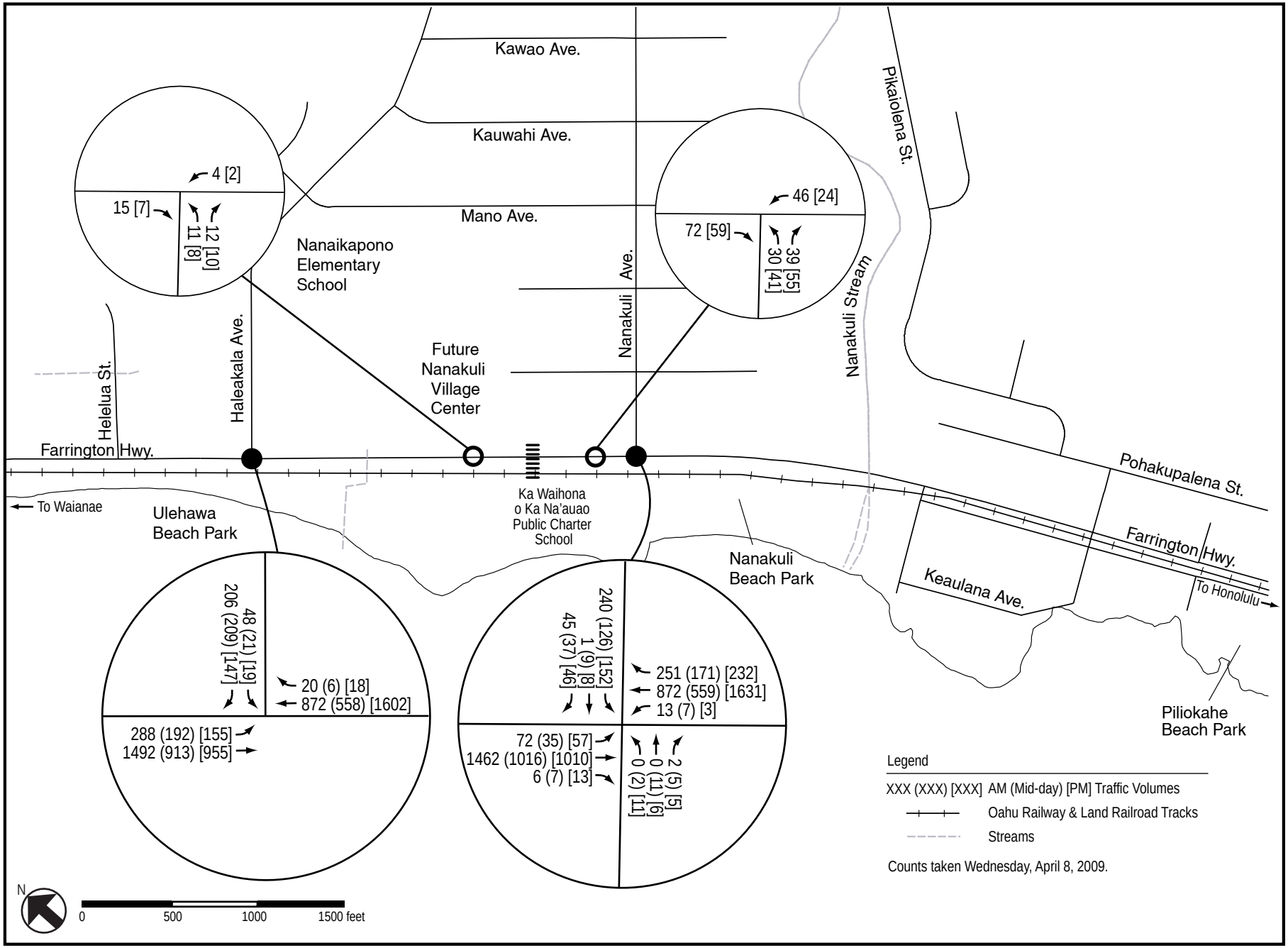
Existing Intersection Lane Configurations
Figure 2-8



Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
Draft Environmental Assessment

Existing Peak Hour Traffic Counts
Figure 2-9

the morning (AM) peak hour even though the movement is provided with a leading left turn green followed by a permissive left turn phase (i.e., vehicles may turn left after yielding to oncoming vehicles). The high left turn volumes are probably because of the three schools located mauka of Farrington Highway. . In addition, through capacity is at times affected by the presence of a stopped City bus at the bus stop located just southeast of the intersection, which along with left-turning vehicles, could essentially block both Honolulu-bound travel lanes.

The Nanakuli Avenue intersection operates at LOS C during the morning (AM) peak hour, LOS A during the afternoon or mid-day peak-hour, and LOS F during the evening (PM) peak hour. The high Honolulu-bound commuting volumes and lack of left-turn storage create delays for the morning operations. Similar to Haleakala Avenue, the presence of a stopped bus at the bus stop near the intersection, along with a waiting left turning vehicle could essentially block both Honolulu-bound travel lanes

2.9.1.2 Existing Public Transit

The City and County of Honolulu's Department of Transportation Services - Public Transit Division (DTS) currently provides an island-wide public bus transit system called TheBus. DTS's Handi-Van provides para-transit service for semi-ambulatory and non-ambulatory persons with disabilities. DTS contracts Oahu Transit Services (OTS) to operate both systems. With a fleet of 531 buses, TheBus provides 100 numbered bus routes, and carries over 238,000 passengers weekly.

Passengers utilizing the public regional transportation services contribute greatly to the pedestrian traffic along the project corridor. Figure 2-8 shows the existing bus stops within the project limits. The six bus routes servicing the project limits are listed on Table 2-11. Honolulu-bound frequencies during the morning peak-, midday- and evening-hours is ten buses per hour, five buses per hour, and six buses per hour, respectively. Waianae-bound bus frequencies during the same time periods are six buses per hour, five buses per hour, and six buses per hour, respectively.

Table 2-11
Existing Bus Routes Servicing the Project Corridor

No.	Name	Type/Area of Service
C	Country Express	Express Route
93/93A	Makaha/Pearl Harbor Express	Express Route
40/40A	Makaha/Honolulu - Ala Moana Route	Trunk Route
403	Waianae Transit Center/Waianae Town/Maili/Nanakuli	Trunk Route

Source: http://Thebus.org - 2009 routes and timetables

2.9.1.3 Cycling and Pedestrian Facilities

The makai side of Farrington Highway within the project limits do not have sidewalks nor any other facility specifically for pedestrians and non-motorized users. However, pedestrians, non-motorized users (e.g., cyclists), as well as vehicles do use the unpaved railway embankment or right-of-way. The mauka side of Farrington Highway contains a raised sidewalk from the intersection of Nanakuli Avenue to a point approximately 75 feet northwest of the

intersection. From this point, the sidewalk converts to an intermittent asphalt-concrete walkway.

Existing crosswalks within the project limits are shown in Figure 2-8. Haleakala Avenue and Nanakuli Avenue both have marked crosswalks to accommodate the considerable volume of pedestrian traffic stemming from bus passengers as well as students. A signalized pedestrian-cross walk is located mid-block between Haleakala and Nanakuli Avenues, directly across from one of the entrances to Ka Waihona, and is used by Ka Waihona students and staff Pedestrian volumes are provided in Figure 1-5

Three basic types of bikeways exist: a “bike route” is a signed, shared roadway specifically designated as a preferred route for bicycling; a “bike lane” refers to a section of roadway designated for bicycling use by striping, signing, and/or pavement markings and a “bike path” is a bikeway physically separated from motorized vehicular traffic by an open space or barrier.

Figure 1-7 show existing and cycling facilities or bikeways (*i.e.*, bike paths, lanes, or routes) in the general vicinity of the project site. Within the project limits, no bikeways are provided, and the highway shoulders are relatively narrow, providing no separation between cyclists and motorized vehicles. As noted above, cyclists may and do use the railway embankment, which is within the highway ROW, to traverse through the project limits.

2.9.2 POTENTIAL TRAFFIC IMPACTS

2.9.2.1 Year 2030 Traffic Conditions

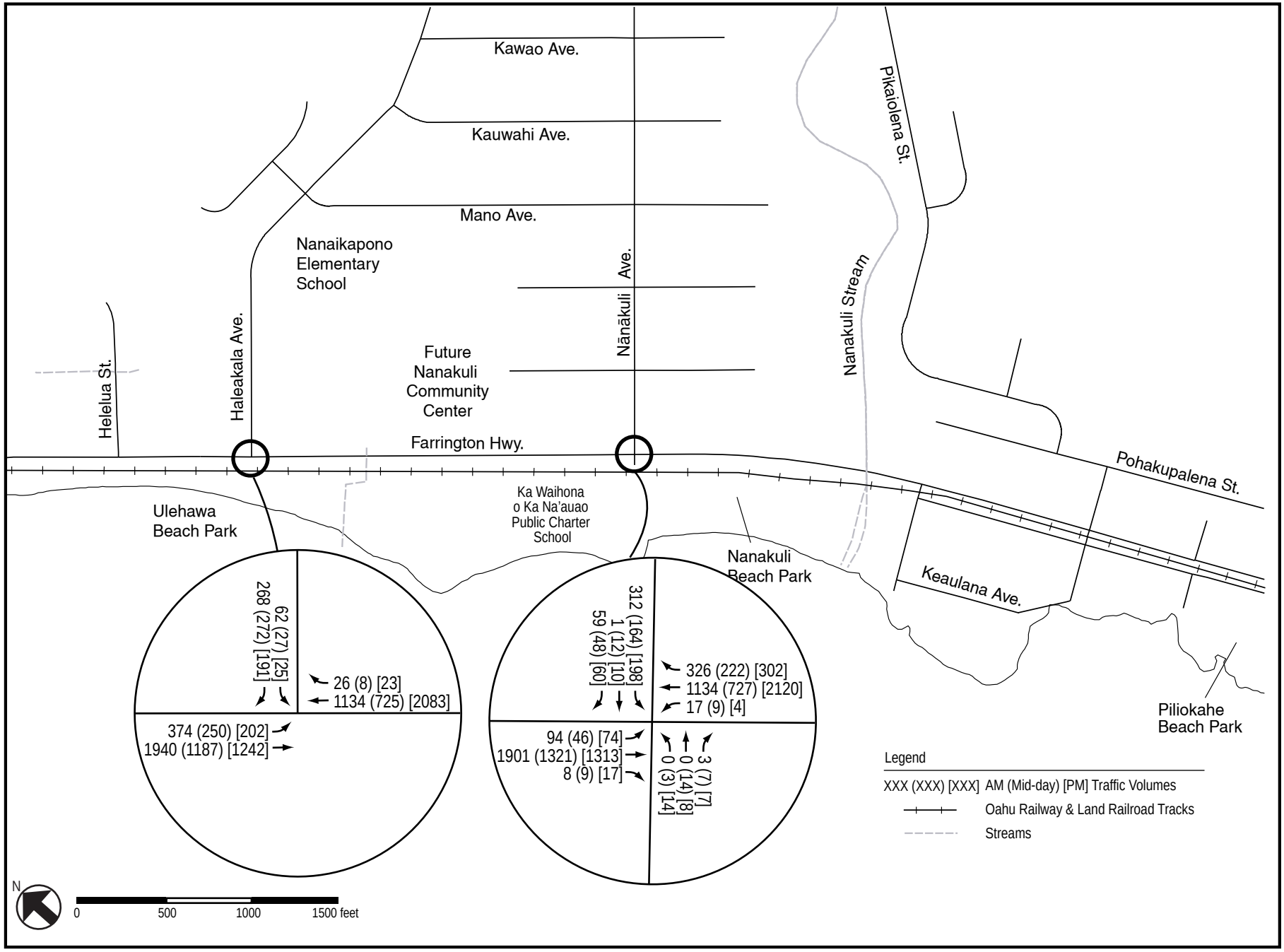
The proposed project’s potential traffic impacts were evaluated based on a year 2032 planning horizon, which is consistent with the current ORTP. As noted in Section 1.3.1, the No-Build alternative assumes that projects planned for the ORTP’s mid-range program would be in existence by 2032.

2.9.2.1.1 Projected Future Roadway Network

Figure 1-9 and 1-10 illustrate the proposed improvements to Farrington Highway under the proposed project. The No-Build alternative does not include any other roadway improvement or changes within the project limits.

2.9.2.1.2 Projected Year 2030 Traffic Volumes

Utilizing the ORTP travel demand model, Farrington Highway at Nanakuli Stream Bridge is projected to carry approximately 50,500 vehicles per day by 2032. Based on this volume, morning (AM), midday (MD), and evening (PM) traffic peak hours were calculated for the year 2032 for the No-Build Alternative and proposed project, as shown in Figures 2-9 and Figure 2 10, respectively. These volumes were then utilized to evaluate future potential traffic operations at the two intersections under for the Build and No-Build alternatives.



Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
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Projected 2030 Volumes at Haleakala and Nanakuli Avenues Under the No-Build Alternative
Figure 2-10

2.9.2.1.3 Projected Year 2030 Intersection Operations

Table 2-12 and 2-13 provide the projected 2030 level of service summaries for the No-Build and Build scenarios respectively.

Table 2-12
LOS Summary for 2030 No-Build Scenario

Intersection	AM		Midday		PM	
	LOS	Delay	LOS	Delay	LOS	Delay
Farrington Hwy/Haleakala Ave	**F**	**234**	**B**	**13**	**F**	**125**
Farrington Hwy Honolulu-bound left/through	F	368	B	15	F	90
Farrington Hwy Waianae-bound through/right	A	8	A	3	F	124
Haleakala Ave makai left/right	F	90	C	33	F	374
Farrington Hwy/Nanakuli Ave	**F**	**148**	**B**	**11**	**F**	**209**
Farrington Hwy Honolulu-bound left/through/right	F	244	B	10	F	87
Farrington Hwy Waianae-bound left/through/right	B	19	A	7	F	262
Nanakuli Ave mauka left/through/right	D	49	C	22	F	96
Nanakuli Ave makai left/through	F	161	C	31	F	462
Nanakuli Ave makai right	D	50	C	22	F	91

Source: PB Americas, Inc. February 2010
Note: Delay is in seconds per vehicle

Under the No-Build alternative, traffic conditions at both the Haleakala and Nanakuli Avenue intersections would substantially worsen.

At the Haleakala Avenue intersection, the overall LOS would drop from E to F for both the morning (AM) and evening (PM) peak hours. During the morning (AM) peak hour, the overall delay would increase from 64 seconds to 234 seconds per vehicle. In particular, the delay for the Honolulu-bound left/through movement would increase from 92 seconds to 368 seconds per vehicle. During the evening (PM) peak hour, the overall delay would increase from 123 seconds to 374 seconds per vehicle. .

At the Nanakuli Avenue intersection, the overall LOS would drop from C to F for the morning (AM) peak hour due to a projected increase in delay from 26 seconds to 148 seconds per vehicle. During the PM peak hour, the overall intersection would still operate at LOS F, but the delay would increase from 152 seconds to 209 seconds per vehicle. Similar to existing conditions at this intersection, cross street movements would also experience substantial delay due to congestion on Farrington Highway. For example, the delay for makai-bound left/through movements on Nanakuli would increase from 143 seconds to 462 seconds per vehicle.

Table 2-13
LOS Summary Build Scenario based on Proposed Improvements

Intersection	AM		Midday		PM	
	LOS	Delay	LOS	Delay	LOS	Delay
Farrington Hwy/Nanakuli Ave	**D**	**39**	**B**	**14**	**F**	**190**
Farrington Hwy Honolulu-bound left	E	67	D	40	F	122
Farrington Hwy Honolulu-bound through/right	C	34	B	12	A	10
Farrington Hwy Waianae-bound left	E	75	E	65	F	263
Farrington Hwy Waianae-bound through/right	C	31	B	12	F	294
Nanakuli Ave mauka left/through/right	D	40	C	21	E	88
Nanakuli Ave makai left/through	F	103	C	29	F	206
Nanakuli Ave makai right	D	40	C	21	D	89
Farrington Hwy/Haleakala Ave	**D**	**49**	**B**	**13**	**F**	**100**
Farrington Hwy Honolulu-bound left	F	284	C	33	F	132
Farrington Hwy Honolulu-bound through	B	15	A	5	A	4
Farrington Hwy Waianae-bound through/right	C	24	B	15	F	150
Haleakala Ave makai left/right	E	64	C	21	F	133

Source: PB Americas, Inc. February 2010

Under the proposed project, traffic operations at the Haleakala and Nanakuli Avenue intersections would perform better during the morning (PM) peak hour in comparison to the No-Build alternative because it would provide storage capacity for left-turning vehicles at both intersections, removing this particular impediment to through traffic. During the morning (AM) peak hour, both intersections would operate at LOS D. During the evening (PM) peak hour, both intersections would continue to operate at LOS F. However, the delays would be slightly better than under the No-Build alternative, but still worse than current conditions. This is largely because the proposed project does not address the causes of the Waianae-bound congestion, which occurs during the evening (PM) peak period.

2.9.2.2 Future Public Transit

The level of bus service would be the same regardless of the alternative selected. However, under the proposed project, the locations of the bus stops would be evaluated during final design to determine if moving one or more of them could reduce their impediments to through traffic, but still be strategically located to serve the transit using public. The evaluation would be coordinated with DTS. In addition, a traffic management plan would be developed to identify temporary bus facilities, if needed, during construction.

2.9.2.3 Cycling and Pedestrian Facilities

The proposed project would provide a shared use, paved path along the entire project limits, substantially improve service for cyclists, pedestrians and other non-motorized users, and improving access to Nanakuli and Ulehawa Beach Parks, and Ka Waihona PCS. The No-Build alternative will not improve service for these users.

2.10 PUBLIC UTILITIES

2.10.1 EXISTING CONDITIONS

Public utilities refer to telephone, natural gas, electricity, sewer, wastewater, and storm drain services and facilities. Farrington Highway's ROW is used for aerial electrical, telephone, and cable television (cable) lines. Electrical lines are mounted on poles situated on both the mauka and makai sides of the highway. Several primary and secondary overhead crossings provide electric service to customers on the makai side. Hawaiian Telcom and Time Warner Oceanic Cable lines are mounted on wood poles on the mauka side of Farrington Highway, with several overhead crossings to provide service to the mauka side of the roadway. Roadway street lamps are currently provided on both sides of the roadway.

2.10.2 POTENTIAL IMPACTS

The proposed project would require the relocation of a number of utilities, in particular those aligned along the makai side of the highway. During design and construction, substantial planning and coordination with utility providers would occur to minimize interruptions in utility service to customers. Disruptions to utility service, if necessary, would be restricted to short-term localized events. Careful scheduling of these disruptions and prior notification to occupants of affected properties would mitigate these impacts.

2.11 HISTORIC AND ARCHAEOLOGICAL RESOURCES

2.11.1 REGULATORY REQUIREMENTS

Section 106 of the National Historic Preservation Act (NHPA) requires actions, that are federally funded, authorized, or implemented, take into account the effect of such actions on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places (National Register). Such resources are called historic properties.

The Section 106 process involves coordination and consultation with the State Historic Preservation Officer (SHPO), and other agencies and organizations that have an interest in or is mandated to protect historic properties. In addition, the Advisory Council on Historic Preservation (ACHP) is afforded the opportunity to comment on actions that may potentially affect historic properties.

Since the project involves both federal and State agencies and funding, both regulations apply to the project. Completion of the Section 106 process normally satisfies the requirements of HRS Section 6E-8.

For a district, site, building, structure or object to be considered eligible (or be considered "historic" or a "historic property") for the National Register, it must meet any one of the following criteria:

A) The site reflects major trends or events in the history of the State or nation;
B) The site is associated with the lives of persons significant in our past;
C) The site is an excellent example of a site type/work of a master; or

D) The site has yielded or may likely yield information important in prehistory or history. The Hawaii Register of Historic Places (Hawaii Register) provides an additional criterion:

E) The site has traditional cultural significance to an ethnic group.

In accordance with regulations provided in 36 Code of Federal Regulations (CFR) 800, the federal sponsoring or regulating agency – in this case, FHWA – has the responsibility of conducting a good faith effort to identify whether there are any historic properties in the project's Area of Potential Effect (APE). If an historic property(ies) were identified within the APE, the federal agency would then assess whether it would be adversely affected by the proposed project. If the effect were "adverse", such an effect is resolved through a Memorandum of Agreement (MOA) with the SHPO.

At the State level, Section 6E-8 of the Hawaii Revised Statutes (HRS) places similar responsibilities on State agencies to evaluate their projects. The HRS Section 6E-8 process, as described in regulations provided in Title 13, Chapter 275 of the Hawaii Administrative Rules, is similar to the Section 106 process.

2.11.2 EXISTING CONDITIONS

The proposed project's APE was defined as the parcels located adjacent to the project limits. An archaeological field Inspection and literature review (historic investigation) was conducted to identify potential historic properties within the APE. The report documenting the historic investigation for the project and is provided in Appendix F. The report has been submitted to the State Historic Preservation Division (SHPD) and is currently being reviewed. Figure 2-11 shows the identified archaeological/historic properties within the vicinity of the project. Three cultural resources/historic properties that would or may be affected by the proposed project are:

1. A section of the OR&L Railroad (SIHP # 50-80-12-9714) adjacent to the current Farrington Highway, but within the highway's ROW, already listed on the National Register . The OR&L Railroad is historically significant under Criteria A, B and C. At its height, the railroad encompassed approximately 175 miles of track throughout Oahu. Currently, remnants of track are only visible from Ewa to Lualualei Homestead Road.

2. Farrington Highway was constructed in the 1930s as part of the Territorial Highway System. A portion of Farrington Highway was documented as SIHP # 50-80-7-6824 and was determined to be eligible for the National and Hawaii Registers under Criterion D (McDermott and Tulchin 2006). While identified within the archaeological report, this site is located in Makaha, beyond the project area, and therefore would not be affected by the project. This portion of Farrington Highway does not contain integrity of design, setting, materials, workmanship, feeling, or association to be considered eligible for either the National or Hawaii Register of Historic Places as part of the 1930 Territorial Highway System.

3. A subsurface cultural layer located between Haleakala Avenue and Helelua Street was previously recorded. The cultural layer was described as, "a layer of charcoal-enriched beach sand…..located underneath both the Waianae-bound and Honolulu-bound lanes of Farrington Highway" (Ostroff and Desilets 2005: 32). No cultural material was

observed in association with this layer, however, radiometirc dating indicates a 2-sigma calibrated date range of A.D. 1150-1410, while AMS dating indicates a 2-sigma date range of A.D. 1270-1410 (Ostroff and Desilets 2005: 32). The deposit does not appear to have been assigned an SIHP number or evaluated for eligibility to the National or Hawaii Registers eligibility. However, if this cultural layer is indeed the result of pre-contact human habitation, it is likely to be significant under Criterion D.

In addition, based on previous archaeological investigations conducted in the vicinity of the project area, any excavation activity could encounter pre-contact and post-contact subsurface cultural deposits related to traditional Native Hawaiian land use and habitation, historic military uses, and/or human remains, possibly of pre-contact Native Hawaiians or shortly after contact.

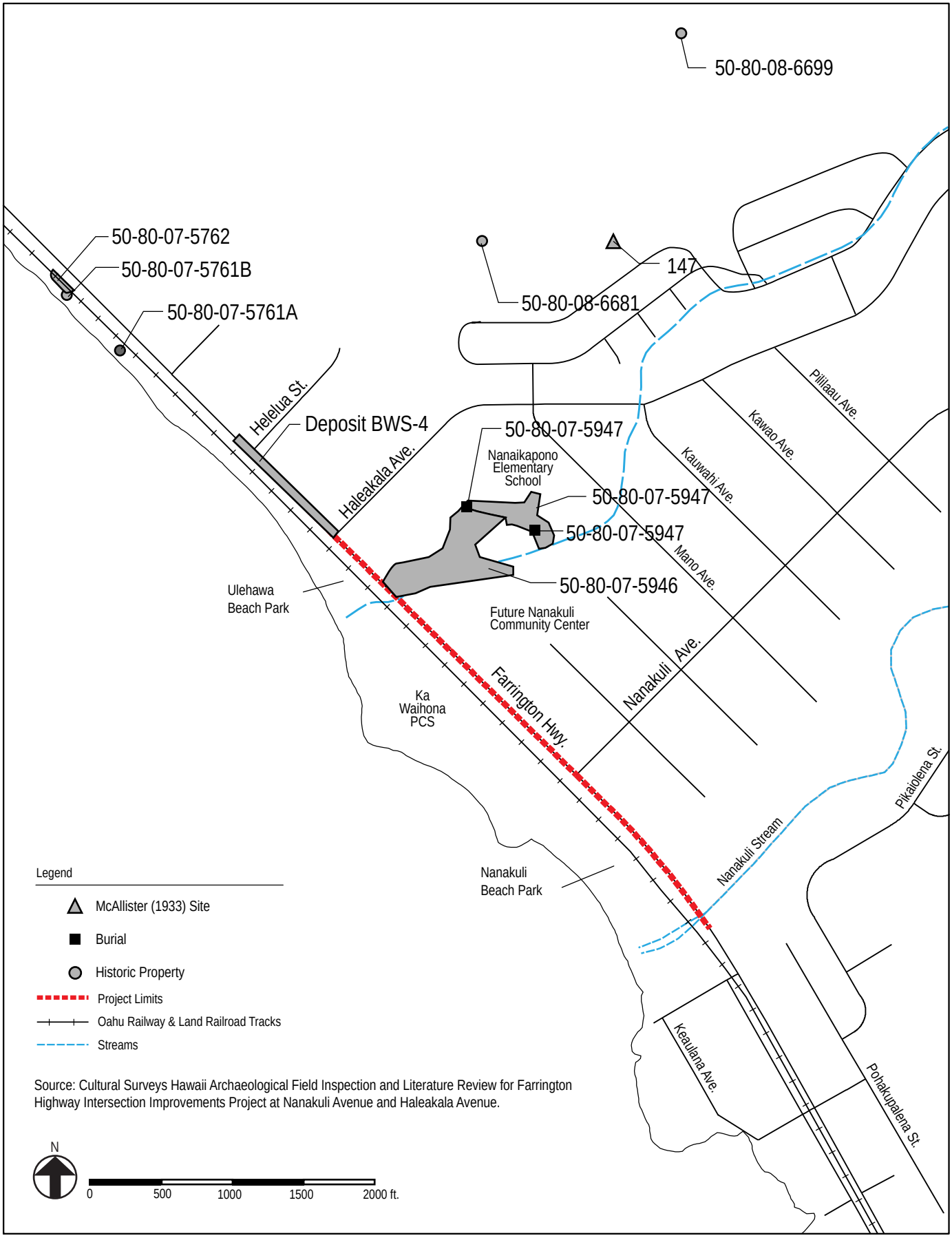
2.11.3 POTENTIAL IMPACTS

The Section 106 process is currently on-going, but would be completed before the Final EA. SHPD is expected to conduct its HRS Chapter 6E review responsibilities in conjunction with their Section 106 responsibilities.

Because the No-Build alternative does not require construction within the project corridor, the historic properties within the APE would be unaffected.

Under the Build alternative, the OR&L Railroad would be relocated to the makai border of the highway right-of-way. Section 3.2.1 provides a log of consultation activities with the SHPO and the Hawaiian Railway Society (HRS) to date. Early coordination between the SHPO, HRS, FHWA and HDOT indentified that a Programmatic Agreement would be appropriate since there is another project along Farrington Highway that would affect the same historic resource. During these early coordination meetings, it was also determined that because the proposed project would shift the track alignment only by an estimated ten feet, relocation of the OR&L would remain within the historic corridor. Therefore, FHWA would probably render a “No adverse effect” in accordance with Section 106. Shortly thereafter, FHWA and the SHPO would prepare an PA so that the relocation of the OR&L can be conducted in a manner to preserve its historic characteristics. The relocation of the Historic OR&L would be also be coordinated with the Hawaiian Railway Society.

Section 4f of the US Department of Transportation Act of 1966, amended 1968 and 1983 provides that FHWA cannot approve the use of land from historical sites within federally funded transportation projects unless there is no feasible and prudent alternative to the use of the land, and the action includes all possible planning to minimize harm to the property from its use. This law was further revised by Section 6009 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act (SAFETEA-LU), where projects in which it is determined that there is “No Adverse Effect” to the resource may be considered to have *de minimis* impacts on resources protected by Section 4(f). Therefore after consideration of any impact avoidance, minimization, and mitigation or enhancements measures, if a property is determined to have a *de minimis* impact, further evaluation of avoidance alternatives would not be required and the Section 4(f) evaluation would be complete. Upon completion of coordination with the SHPO, FHWA will evaluate to determine whether the *de minimis* process is appropriate for the proposed project.



Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave.
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Identified Archaeological and Historic Properties
Figure 2-11

In addition, since the extent of the previously recorded subsurface cultural deposit between Helelua Street and Haleakala Avenue is unknown, further investigation would be needed to determine its extent. Given that this area is a congested highway, an archaeological inventory survey may not be feasible, therefore preparation of a comprehensive archaeological monitoring program is being considered. Coordination with the SHPO is on-going to determine appropriate further investigation.

2.12 PARKLANDS AND RECREATIONAL RESOURCES

2.12.1 EXISTING CONDITIONS

As shown in Figure 2-4, there are two parks in the project study area; Ulehawa Beach Park and Nanakuli Beach Park. Both parks are heavily utilized by the community for recreation and activities.

2.12.2 POTENTIAL IMPACTS

Under both the No-Build alternative and the proposed action, the activities, facilities and vehicular access to the two beach parks would remain unchanged. However, the Build alternative would eliminate space within the ROW currently used for parking by some Ulehawa Beach Park users. However, the Ulehawa Beach Park parking facility is currently under-utilized.

The proposed shared use path would benefit cultural resources, since it would create another opportunity for kama'aina to appreciate or access the beach parks, which are an important part of the local lifestyle.

During construction a traffic management plan will be developed to maintain public access to the Ulehawa and Nanakuli Beach Parks.

2.13 VISUAL AND AESTHETIC RESOURCES

2.13.1 EXISTING CONDITIONS

Farrington Highway passes through a coastal community with mountain vistas and coastal views that are at times visible from the roadway.

2.13.2 POTENTIAL IMPACTS

Under the Build alternative, the roadway would be wider by a lane width with a grade adjustment wall and vertical handrail between Helelua Street and the Ulehawa Beach Park entrance. However, the proposed project would not create visual obstructions to the coastal and mountain views.

CHAPTER 3: COMMENTS AND COORDINATION

This chapter summarizes public and agency consultation and coordination activities associated with this project that have been conducted to date. Project pre-assessment consultation and coordination activities included meetings and correspondence with government agencies, adjacent landowners, and community organizations.

3.1 AGENCY AND STAKEHOLDER CONSULTATION

The following agencies, elected officials, and other organizations were contacted by letter, and were asked if they were aware of any environmental or social issue associated with the proposed project. They were also invited to attend a public informational meeting (See Section 3.3). A list of recipients is provided below and an asterisk appears next to those entities that responded to the letter. A copy of the responses is provided in Appendix A. The responses helped prepare this Draft EA.

- Federal Agencies
  - U.S. Army Corps of Engineers
  - U.S. Environmental Protection Agency
  - U.S. Fish and Wildlife Service* (USFWS)
  - U.S. Navy *
- State of Hawaii Agencies
  - Department of Accounting and General Services*
  - Department of Business Economic Development and Tourism, Office of Planning*
  - Department of Business Economic Development and Tourism, Coastal Zone Management Program
  - Department of Defense, Civil Defense*
  - Department of Education*
  - Department of Hawaiian Home Lands
  - Department of Health, Environmental Health Administration
  - Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife*
  - DLNR Land Division
  - DLNR State Historic Preservation Division*
  - Office of Environmental Quality Control
  - Office of Hawaiian Affairs*
- City and County of Honolulu Agencies
  - Board of Water Supply*
  - Department of Design and Construction*
  - Department of Community Services*
  - Department of Emergency Management
  - Department of Environmental Services
  - Department of Facility Maintenance*
  - Department of Parks and Recreation
  - Department Planning and Permitting
  - Department of Transportation Services*
  - Honolulu Fire Department

  - Honolulu Police Department
- Elected Officials
  - Honorable Todd K. Apo, City Council Chair
  - Honorable Colleen Hanabusa, State Senator 21st District
  - Honorable Karen Awana, Representative 44th District
  - Honorable Maile Shimabukuro, Representative 45th District
- Neighborhood Boards
  - Nanakuli-Maili Neighborhood Board, No. 36*
  - Waianae Coast Neighborhood Board, No. 24
- Utilities
  - The Gas Company*
  - Hawaiian Telecommunications, Inc.*
  - Oceanic Time Warner Cable*
  - Hawaiian Electric Company
  - Sandwich Isles Communications
- Community and Other Organizations
  - Nanakuli Hawaiian Homestead Community Association
  - Kamehameha Schools, Community Learning Center
  - Punana Leo
  - Ka Waihona o Ka Na'auao Public Charter School
  - Boys and Girls Club of Hawaii
  - Oahu Head Start Program, Nanakuli I and II
  - St. Rita's Catholic Church
  - His Highest Praise Westside
  - Hawaiian Railway Society
  - Leeward Kai Canoe Club
  - Leeward Oahu Transportation Management Association (LOTMA)

Twenty agencies and organizations submitted written or oral comments in response to a request for pre-assessment consultation. Further consultation was conducted with eight agencies. Meeting minutes and telephone logs not contained in Appendix A are available for review at the HDOT - Highways Division, Design Branch office (HWY-DD).

3.2 REGULATORY COORDINATION

Since the project must comply with certain federal and State environmental laws and regulations, the following coordination and consultation activities were conducted by HDOT and/or its consultant Parsons Brinckerhoff (PB). See Appendix A for records of all written correspondence and communications referenced in the discussion below.

3.2.1 NATIONAL HISTORIC PRESERVATION ACT SECTION 106 AND HAWAII REVISED STATUTES SECTION 6E-8

The National Historic Preservation Act (NHPA) requires that actions that are federally funded, authorized, or implemented take into account the effect of such actions on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places (NRHP). Such resources are called historic properties. The Section 106 process involves coordination and consultation with the State Historic Preservation Officer (SHPO), and other agencies and organizations that

have an interest in or is mandated to protect historic properties. In addition, the Advisory Council on Historic Preservation is afforded the opportunity to comment on actions that may potentially affect historic properties. At the State level, Section 6E-8 of the Hawaii Revised Statutes (HRS) places similar responsibilities on State agencies to evaluate their projects. Since the project involves both federal and State agencies, both regulations apply to the project. Completion of the Section 106 process normally satisfies the requirements of HRS Section 6E-8.

The following consultation and coordination activity was conducted with the State Historic Preservation Division (SHPD) and the SHPO:

- March 20, 2009, meeting of SHPD, HDOT, FHWA, PB, and subconsultant Cultural Surveys Hawaii to discuss efforts to date to identify and analyze potential impacts on cultural / historic properties. SHPD provided further guidance on actions to be taken for 106 consultation.

- June 18, 2009 – meeting of SHPD, HDOT, and PB to follow-up in gathering additional scoping input on archaeological resources and to continue coordination with SHPD for the Programmatic Agreement and the project's proposed OR&L track relocation.

- August 5, 2009 – meeting of SHPD, HDOT and PB to follow-up based on continued coordination with the Hawaiian Railway Society for relocation of historic railroad and determine historic preservation requirements.

- September 2009 – Letter from HDOT to SHPD formally initiating Section 106 consultation.

- September 28, 2009 – Letter from SHPD to HDOT requesting an update for evaluation of an alternative shared use path alignment discussed in the August 5, 2009 meeting.

The following consultation activities with other organizations were also conducted:

- Hawaiian Railway Society:

    - April 15, 2009 – meeting with the Hawaiian Railway Society, HDOT, FHWA, and PB to initiate project coordination and collect scoping information.

    - August 5, 2009 – meeting with the Hawaiian Railway Society, HDOT, and PB to continue coordination of potential impacts to the historic OR&L and present constraints involved with design for input.

    - September 8, 2009 – Letter from the Hawaiian Railway Society responding to a request for pre-assessment scoping input.

    - September 9, 2009 – Letter to the Hawaiian Railway Society from HDOT requesting scoping input and announcing public informational meeting.

- Department of Hawaiian Homelands (DHHL):
    - May 21, 2009 – meeting with DHHL as mauka stakeholder to determine whether there were any prudent and feasible alternatives to avoid relocating the OR&L by widening on the mauka side of the roadway.
    - July 8, 2009 – meeting with DHHL, DKKY (Consultant for Nanakuli Village Center), HDOT, and PB to discuss the potential conflict between the Ka Waihona PCS bus pull-out and proposed Farrington Highway Intersection Improvements.
    - July 23, 2009 – meeting with PBR Hawaii, HCDB, DKKY, EDC, Group Pacific, HDOT, and PB to further project coordination.

3.2.2 SECTION 7 OF THE ENDANGERED SPECIES ACT AND CHAPTER 195D OF THE HAWAII REVISED STATUTES

Section 7 of the Endangered Species Act (ESA) requires that federally-funded actions not jeopardize any species listed as threatened or endangered, or adversely modify designated critical habitat. Chapter 195D of the Hawaii Revised Statutes (HRS), the State counterpart law to the ESA, requires evaluation of the potential impact of State projects on threatened and endangered species.

The following consultation and coordination activities were conducted with the U.S. Fish and Wildlife Service (USFWS) pursuant to Section 7:

- September 29, 2009, letter from HDOT to USFWS requesting a species list (request included in pre-assessment consultation letter).
- October 16,2009 letter from USFWS to HDOT indicating that no federally listed endangered, threatened, or proposed threatened or endangered species, or proposed or designated critical habitat occur on the proposed project site.

The following consultation was conducted with the State of Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife:

- September 2009, pre-assessment consultation letter from HDOT to DLNR.
- September 24, 2009 letter from DLNR to HDOT indicating no objections to the proposed improvements.

3.2.3 SECTION 404 OF THE CLEAN WATER ACT

The law prohibits discharge of dredged materials into the Waters of the U.S., which includes non-navigable streams, wetlands, and mudflats, unless the USACE provides a permit.

The following consultation and coordination activities were conducted with USACE:

- September 2009 letter from HDOT to USACE pre-assessment consultation letter, no response from USACE has been received.

3.3 PUBLIC INVOLVEMENT ACTIVITIES

Public involvement activities include, a pre-assessment public information meeting that was held on September 10, 2009. In addition presentations regarding the proposed project were made to the Nanakuli-Maili Neighborhood Board, No. 36 on January 5, 2010, and the Waianae Coast Neighborhood Board, No. 24 on October 20, 2009. Comments received during this process are provided in a comments log in Appendix A.

Methods such as advertising in local newspapers were used to notify the community of the public information meeting. HDOT will continue to inform members of the public of future meetings as well as construction activities and potential inconveniences.

After the publication of this Draft EA, a public information meeting will be held in Nanakuli to inform the public about the proposed project. The results of these future public involvement activities will be included as a part of the Final EA, prepared pursuant to HRS Chapter 343.

CHAPTER 4: ANTICIPATED FINDING OF NO SIGNIFICANT IMPACT

In accordance with Hawaii Revised Statutes (HRS) Chapter 343 and Hawaii Administrative Rules (HAR) Sections 11-200-9 and 11-200-11.2, HDOT anticipates issuing a FONSI for the proposed project. This anticipated FONSI will be announced in the State's Environmental Notice along with an announcement of the availability of this Draft EA. This assessment is based on an evaluation of project impacts in relation to the "Significance Criteria" specified in HAR 11-200-12 (b).

The discussion below is the preliminary significance evaluation, subject to changes that may be made upon receipt of public and agency review comments that may be filed during the public comment period of this Draft EA. The Significance Criteria appear below in italics, followed by a brief discussion of the project in relation to the specific criterion. The nature of the project's potential impacts, and committed mitigation measures to minimize adverse impacts, are discussed in detail in Chapter 2.

1. *Involves an irrevocable commitment to loss or destruction of any natural or cultural resource* – The proposed project would not cause the loss or destruction of any natural, historic, or cultural resource for the following reasons:

   The project would be constructed fully within the existing Farrington Highway Right-of-Way (ROW) to avoid displacing residences on the mauka side and beach parks on the makai side, one of which contains historic or cultural resources beyond the ROW. A portion of the historic OR&L railroad, which is listed on the Hawaii and National Register of Historic Properties would be re-located to the makai-most side of the ROW.

   The relocation is required to provide for the turning lane and shared-use path. The relocation would not affect the continuity of the railroad, and therefore, the overall historic property would not be affected. However, the details of removing and replacing the tracks and ties would need to be coordinated with the Hawaiian Railway Society and the State Historic Preservation Division.

2. *Curtails the beneficial uses of the environment* – The proposed project would be constructed within the existing ROW, and therefore, not affect the beneficial uses of the two beach parks adjacent to the project site.

3. *Conflicts with the State's long-term environmental policies or goals and guidelines expressed in Chapter 344, HRS, and any revisions thereof and amendments thereto, court decisions, or executive orders* – The proposed improvements are consistent with the policies and guidelines specified in HRS Chapter 343, as demonstrated by the discussion in this chapter and Chapter 2.

4. *Substantially affects the economic or social welfare of the community or State* – The proposed project would improve public safety for vehicles and students that utilize Farrington Highway. Improved traffic conditions and provision of a shared use path would facilitate regional mobility as people from this region commute in and out of the Waianae coast to their places of work, school, and recreation.

5. *Substantially affects public health* – The proposed project would improve traffic safety within the project limits.
6. *Involves substantial secondary impacts* – The proposed project would not involve substantial secondary impacts. The proposed improvements are within a relatively small and localized location where uncharacteristic growth is limited due to land ownership and topography. While the proposed project would slightly improve regional mobility, the time savings and improvements provided in this isolated corridor would not be large enough to spur development and associated population growth within the surrounding parcels, much less the larger region.
7. *Involves substantial degradation of environmental quality* – The proposed roadway improvements would not result in substantial degradation of environmental quality. The project area is within a designated ROW, surrounded by urban use and coastline.
8. *Substantially affects a rare, threatened, or endangered species, or its habitat* – The project site does not contain rare, threatened, or endangered species, or important habitats.
9. *Is individually limited but cumulatively has considerable effect upon the environment or involves a commitment for larger actions* – The proposed project is a complete, independent project, with logical termini, and would not result in commitments for other roadway projects that would result in cumulative impacts to the environment. While the shared use path would link with the future other elements of the Leeward Bikeway Plan, its development as an element within this project does not commit that other bikeway projects be completed. Earlier phases of the Leeward Bikeway plan have already completed the environmental review process, and would be built regardless of implementation of the proposed project. Because transportation improvements are needed to address existing traffic congestion and safety, the proposed project is consistent with regional land use plans.
10. *Detrimentally affects air or water quality or ambient noise levels* – The proposed project would not detrimentally affect air or water quality or ambient noise levels.

    The proposed project would not lead to violations of State or National Ambient Air Quality Standards.

    Thirty six residential units and one church would experience “noise impacts” in accordance with the HDOT Noise Policy, as a result of the project. However, the project would not change or affect current traffic noise levels at these locations, and the “impacts” are a result of these locations already experiencing traffic noise levels that exceed the FHWA noise abatement criteria (NAC). All 36 residences and church are directly on the mauka side Farrington Highway. Nevertheless, the Noise Policy requires that HDOT consider mitigation measures, but they were found not to be reasonable and feasible because these locations have direct driveway access to Farrington Highway and any noise mitigation measure (i.e., noise walls) would block this access.
11. *Affects or is likely to suffer damage by being located in an environmentally sensitive area such as a floodplain, tsunami zone, beach, erosion-prone area,*

geologically hazardous land, estuary, fresh water, or coastal waters –The project site is already located along the coast within the Tsunami inundation zone.

12. *Substantially affects scenic vistas and viewplanes identified in county or state plans or studies* – The proposed project would not block or significantly affect any existing scenic views, in particular views of the Waianae Mountains and coastal areas. Proposed roadway improvements would be predominantly at ground level along an existing roadway alignment.
13. *Requires substantial energy consumption* – The proposed project would not result in substantial energy consumption, although short-term construction-phase energy consumption would be needed. Because the proposed project slightly improves traffic conditions in comparison to doing nothing, a small amount of energy savings would result with less queuing and congestion.

CHAPTER 5: REFERENCES

City and County of Honolulu, Department of Community Services. January 2006. Nanakuli Community Center Final Environmental Assessment

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State Department of Transportation, Highways Division. November 2002. Farrington Highway Drainage Improvements, Vicinity of Nanakuli Avenue to Nanakuli Stream, and Vicinity of Lualei Place to Princess Kahanu Avenue, Project Nos. 93A-01-01 and 93A-02-01 Final Environmental Assessment.

State Department of Transportation. August 2000. Leeward Bikeway OR&L Right-of-Way, Ewa and Waianae Districts, FAID Project no. STP-BW-0300(8) Final Environmental Assessment.

Farrington Highway Intersection Improvement Project: Public Comments

Farrington Highway Intersection Improvements		
Public Meeting Comment Log		
Name	Comment	Public Meeting
Johnnie-Mae Perry	Comment 1: Is it possible to consider a contraflow lane from Hakimo Road to Piliokahi, taking one westbound lane to provide 3 eastbound lanes from 5	9-10-09, Project Information Mtg.
David Auwae	Comment 3: Improvements within ROW alternative is a good alternative to consider.	9-10-09, Project Information Mtg.
Mel Kahele	Comment 6: Consider undergrounding utilities within the corridor. Storm conditions can impact overhead utilities and cause traffic disruptions.	9-10-09, Project Information Mtg.
James Manaku Sr.	Comment(s) 8: Construction duration and phasing: minimize impacts to community during construction.	9-10-09, Project Information Mtg.
Alvin Parker	Comment 11: Consider left turn operations into the school on the makai side of Farrington.	9-10-09, Project Information Mtg.
	Comment 14: Has any consideration been made to extend improvements further west to Lualualei ?	9-10-09, Project Information Mtg.
Hal Levy	Comment 15: Is the additional left turn lane going to service left turns into Nanakuli Beach Park?	9-10-09, Project Information Mtg.
Clarence Schutte	Comment 17: Look at integrating the project with future growth in mind, future development and Waianae Coast improvements. Overall dedicated	9-10-09, Project Information Mtg.
Emily Auwae	Comment 19: The community is growing - Pokai Bay development, development behind City Mill, DHHL and Kamehameha Schools developments	9-10-09, Project Information Mtg.
Alvin Bunton	Comment 20: Consider improvements for left turn lane at Lualualei Road and Auyoung Homestead Road.	9-10-09, Project Information Mtg.
Jojan Barrett	Comment 21: Consider flooding from the makai side due to high surf conditions.	9-10-09, Project Information Mtg.

Farrington Highway Intersection Improvement Project: Public Comments

Name	Comment	Public Meeting
	Comment 23: When taking ROW keep private and DHHL lease holders in mind.	9-10-09, Project Information Mtg.
Johnnie-Mae Perry	Comment 24: Parking currently available to park users whether legal or not is being eliminated, will this parking be replaced?	1-5-10, Waianae Neighborhood Board Mtg.
Albert Silva	Comment 29: Moving RR tracks closer to the beach means loss of beach, mauka widening should be a serious consideration.	1-5-10, Waianae Neighborhood Board Mtg.
Calvin Endo	Comment 30: Consider using the open space makai of the RR tracks for pull-outs that serve the left turn movements at the intersections (dog legs).	1-5-10, Waianae Neighborhood Board Mtg.
Jo Jordan	Comment 31: Consider a rail or fence on grade adjustment wall for safety.	1-5-10, Waianae Neighborhood Board Mtg.

TRAFFIC STUDY

Farrington Highway Intersection Improvements at Nanakuli Avenue and Haleakala Avenue

WAIANAE, OAHU, HAWAII

February 2010

Over a Century of Engineering Excellence

TRAFFIC STUDY

Farrington Highway Intersection Improvements at Nanakuli Avenue and Haleakala Avenue

Waianae, Oahu, Hawaii

February 2010

Prepared For:
State of Hawaii
Department of Transportation
601 Kamokila Boulevard, #688
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CHAPTER 1 INTRODUCTION

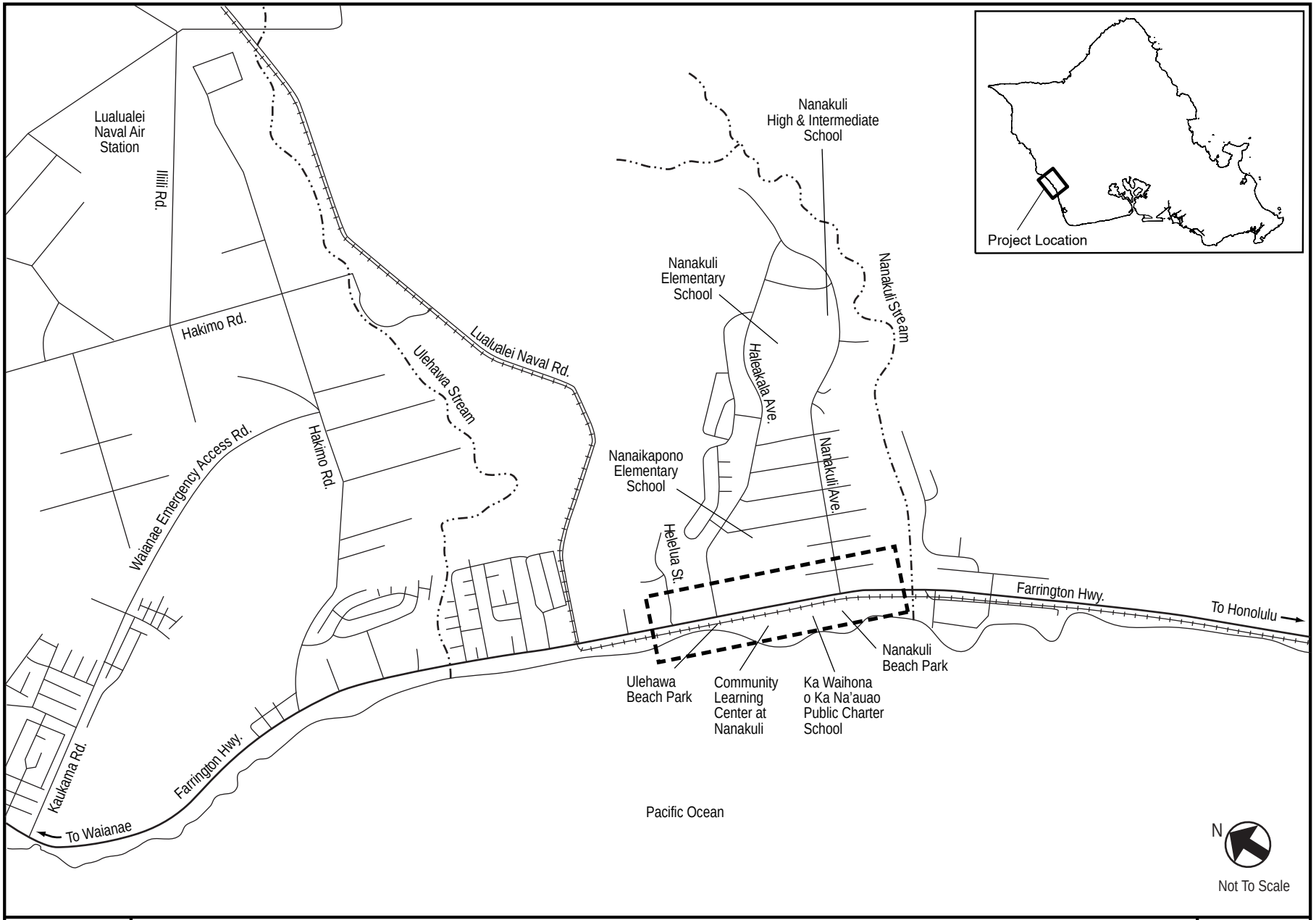
The State of Hawaii Department of Transportation (HDOT) initiated this study to improve traffic flow and safety along Farrington Highway. The study is to support the environmental assessment that is being conducted along Farrington Highway at Haleakala Avenue and Nanakuli Avenue. Figure 1 indicates the location of the project area within Oahu.

A. Purpose

The purpose of this technical report is to provide both initiatives and strategies to improve traffic flow and safety on Farrington Highway in Nanakuli, HI. The current conditions of the roadway and its surrounding area are detailed in Chapter 2. Chapter 3 then provides detailed information regarding vehicular and pedestrian flow as well as a level-of-service analysis. Chapter 4 describes short-term improvements and their benefits. Chapter 5 shows mid-range future conditions and, Chapter 6 summarizes the conclusions and recommendations of this study.

B. Background

The segment of Farrington Highway under study consists of Haleakala Avenue, Nanakuli Avenue, and a pedestrian signal. Also, a heritage railroad parallels Farrington Highway on its makai side. All improvements recommended in this study, such as the addition of left-turn pockets and the creation of exclusive pedestrian/bicycle space, are consistent with the 2030 Oahu Regional Transportation Plan (ORTP), the Waianae Development Plan (Waianae DP), as well as Hawaii's Statewide Transportation Improvement Program (FY 2008 to FY 2013).



PROJECT LOCATION

Figure 1

PB Americas, Inc.

Farrington Highway
February 2010

CHAPTER 2 EXISTING ROADWAY INFRASTRUCTURE

A. General Roadway Characteristics

1. Farrington Highway

Farrington Highway is a four-lane roadway whose length from Haleakala Avenue to Nanakuli Avenue is approximately 2100 feet (2/5 mile), and has no median separation. Northwestward beyond the study area, Farrington Highway continues through Waianae District, terminating at Ka'ena Point State Park. Southeastward beyond the study area, Farrington Highway continues along the coastline, turns inland around Ko Olina Golf Club, and becomes H-1 Freeway in the Kamokila Community Park vicinity. Farrington Highway is classified as a principal arterial, and has a posted speed limit of 35 mph in the study area. However, since the study area segment is also a school zone, the speed limit drops to 25 mph when indicated by a yellow flashing light. Though roadside parking is not permitted on this segment of Farrington Highway, vehicles park on the makai side shoulder for school pick-ups and drop-offs.

2. Haleakala Avenue

Haleakala Avenue is a two-lane roadway without median separation, and from Farrington Highway runs northeastwards curving to intersect Nanakuli Avenue at the base of the Waianae Mountains. It is a three-legged intersection and along with Nanakuli Avenue is a primary access/egress point for Hawaiian Homestead residents of Nanakuli Valley to and from Farrington Highway in Waianae. Haleakala Avenue has a posted speed limit of 25mph, and curbside parking is permitted on this roadway.

3. Nanakuli Avenue

Nanakuli Avenue is also a two-lane roadway without median separation that runs northeastwards from Farrington Highway. It is a four-legged intersection with its southwest leg being the entrance and exit to and from Nanakuli Park. Nanakuli Avenue and Haleakala Avenue both serve as passageways to and from the schools and

residences in the area. Nanakuli Avenue has a posted speed limit of 25 mph, and curbside parking is permitted on this roadway.

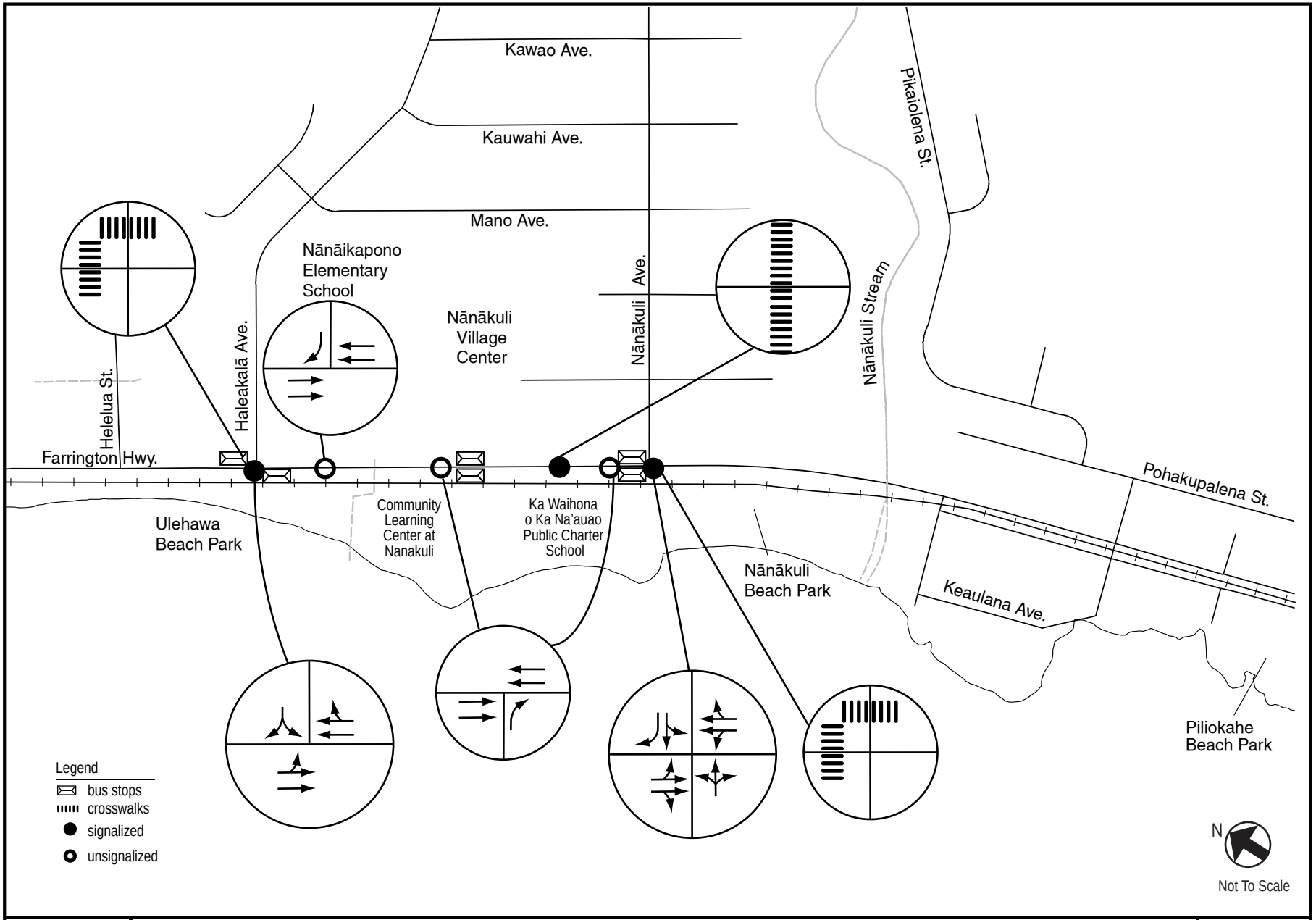
B. Intersections

1. Lane Configurations

Haleakala Avenue is a three-legged intersection with Ulehawa Beach Park on its makai-side (no park entrance/exit at this intersection). The northwest-bound approach on Farrington Highway contains one through lane and one shared through-right turn lane. The southwest-bound approach contains one through lane and one shared through-left turn lane. Haleakala Avenue contains one shared left-turn right-turn lane at its intersection with Farrington Highway.

The intersection with Nanakuli Avenue is a four-legged intersection with the Nanakuli Beach Park entrance/exit on the northeast-bound approach. While this side of Nanakuli contains one shared lane for left-turn, through, and right-turn movements, the southwest-bound approach contains one right-turn pocket, and one shared left turn-through lane. In both directions, Farrington Highway contains one shared left turn-through lane and one shared through-right turn lane for a total of two lanes in each direction. Figure 2 illustrates lane configurations for both intersections in the study area. All legs of all intersections allow right-turns on red.

There are three school access driveways along the study area segment. One driveway is on the makai side of Farrington Highway leading to Nanakaipono Elementary School and allows access for school buses only. It is stop sign controlled and has no crosswalks. The remaining two driveways are on the makai side of Farrington Highway. One driveway provides access and egress to and from the Honolulu side of Ka Waihona o ka Na'auao Public Charter School, and the other driveway provides joint access and egress to and from the Waianae side of the same Public Charter School and the Community Learning Center at Nanakuli. Both driveways are stop sign controlled without exclusive turn lanes.



INTERSECTION LANE CONFIGURATIONS

Figure 2

2. Signalization

The traffic signals at both Haleakala Avenue and Nanakuli Avenue are currently fully-actuated with an inbound protected-permitted left-turn. The pedestrian signal located in front of the charter school entrance is push-button activated and is used generally before and after school by primarily students commuting to and from school. Table 1 shows cycle lengths for the three signals in the study area. The detailed signal timing is included in Appendix A.

Table 1 Intersection Cycle Lengths

Intersection	Cycle Length (sec)		
	AM	Mid-day	PM
Nanakuli Avenue	160	90	240
Haleakala Avenue	160	90	240
Pedestrian Crossing	160	90	240

C. Sidewalks and Pedestrian/Non-Motorized Facilities

The makai side of the study area segment has neither sidewalks nor any other pedestrian/non-motorized facilities. The roadway shoulder on this side is at-grade, indicated by striping, and is paved intermittently. The paved portion is about two-feet wide, from where the shoulder becomes grass until it meets the railway embankment. The mauka side of this segment contains a raised sidewalk from the intersection of Nanakuli Avenue and Farrington Highway northwestwards for about 75 feet. From this point until the intersection of Farrington Highway and Haleakala Avenue, intermittent asphalt-concrete curbs protect a narrow, at-grade AC sidewalk.

D. Crosswalks and Buses

Figure 2 also shows the existing crosswalks and the bus stops in the study area. Haleakala Avenue and Nanakuli Avenue both have marked crosswalks on their northwest and northeast sides. This is to accommodate the considerable volume of pedestrian traffic stemming from bus passengers as well as students. A pedestrian-crossing signal is located approximately 600 feet northwest of Nanakuli Avenue which provides an alternate route for pedestrians crossing Farrington Highway.

There are currently six bus stops in the study area. The intersection of Nanakuli Avenue and Farrington Highway has two bus stops, and both are located on the northwest side of the intersection - one for inbound buses and the other for outbound buses. Heading northwest, another pair of bus stops is located in front of the public charter school and across Farrington Highway in front of a vacant parcel. The remaining two bus stops are located at the intersection of Haleakala Avenue and Farrington Highway. The inbound bus stop is on the southeast side of the intersection, and the outbound bus stop is on the northwest side. Bus service is provided by TheBus, and the routes that traverse the segment under study are: C, F11, 40, 93, and 403. Inbound frequency during the AM peak-hour is ten buses per hour, that for the mid-day peak hour is five buses per hour, and that for the PM peak hour is six buses per hour. Outbound frequency during the AM peak hour is six buses per hour, that for the mid-day peak hour is five buses per hour, and that for the PM peak hour is six buses per hour.

CHAPTER 3 EXISTING TRAFFIC CONDITIONS

A. 24-Hour Volumes

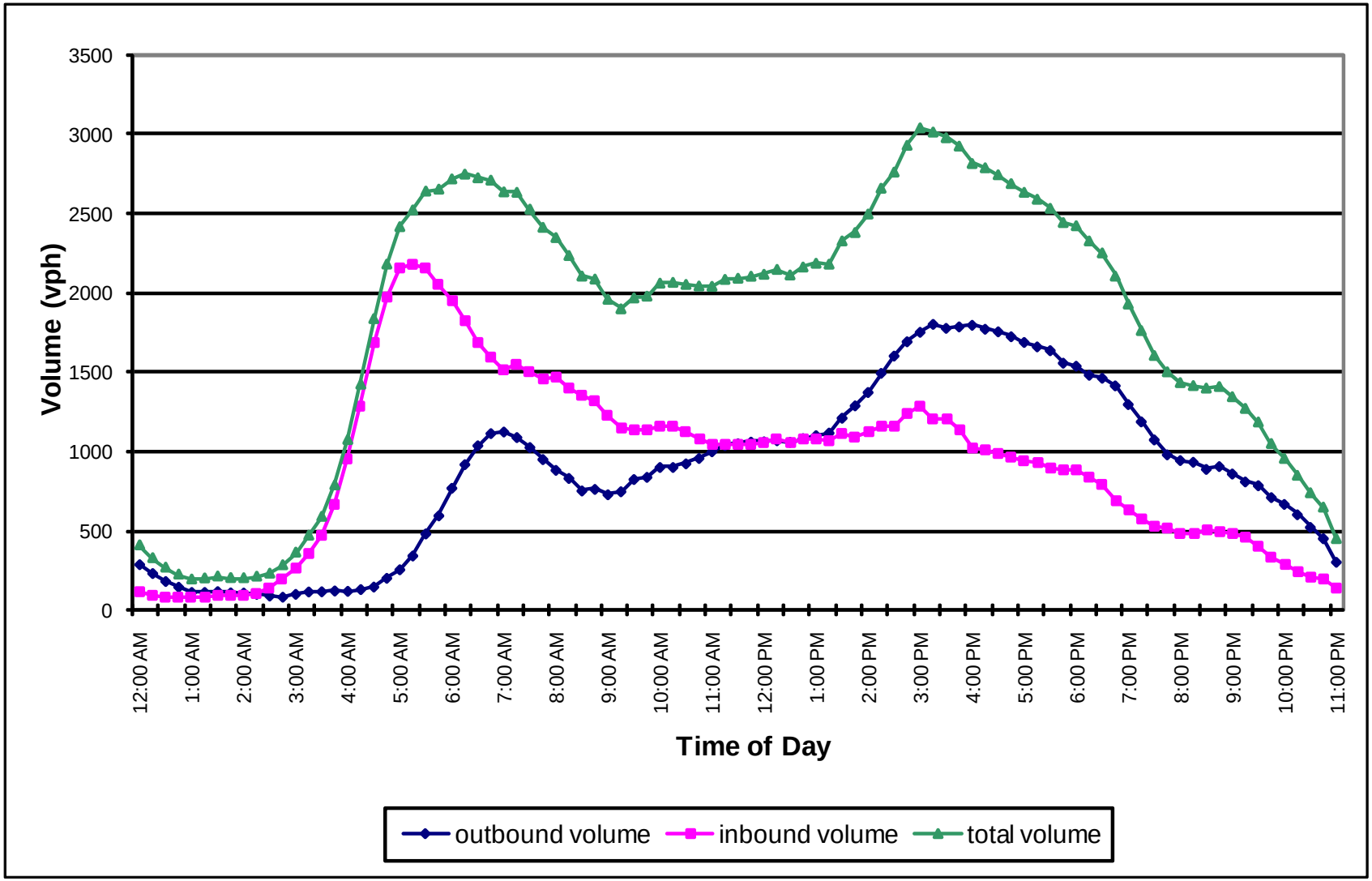
To gain a general perspective on traffic volumes as well as to help determine peak traffic periods throughout the day, HDOT 24-hour volumes from January 24, 2007 were utilized. The volumes were taken at Nanakuli Stream Bridge, directly south of the study area. Figure 3 shows one-hour volumes aggregated by 15-minute intervals over the course of one 24-hour day. The total bi-directional 24-hour volume is 42,248. Farrington Highway traffic has a distinctly directional commuter peak, with inbound traffic much heavier during the morning and return traffic heavier during the afternoon and evening.

B. Peak-Hour Traffic Counts

Vehicle turning movement counts were surveyed on April 8, 2009 at both the intersection with Haleakala Avenue as well as Nanakuli Avenue during three time periods: 5:45am to 7:45am, 12:15pm to 2:15pm, 2:30pm to 4:30pm. The surveyed turning movement counts of April 8, 2009 were aggregated to produce peak-hour volumes that were used in the Synchro traffic analysis. Existing peak-hours were found to be 6:45am to 7:45am, 12:30pm to 1:30pm, and 3:15pm to 4:15pm, for the AM, MD, and PM periods, respectively. These peak-hour traffic movements can be seen in Figure 4. Ka Waihona o ka Na'auao Public Charter School is located between Nakakuli Avenue and Haleakala Avenue on the makai side of Farrington Highway. Vehicle access and egress counts at this school were taken September 29, 2009 from 6:30 am to 8:30 am and from 2:30 pm to 4:30 pm at its Waianae-side and Honolulu-side entrances/exits. These peak-hour access and egress vehicle counts are also shown in Figure 4. A more detailed compilation of these counts can be found in Appendices A and B.

C. Peak-Hour Pedestrian Counts

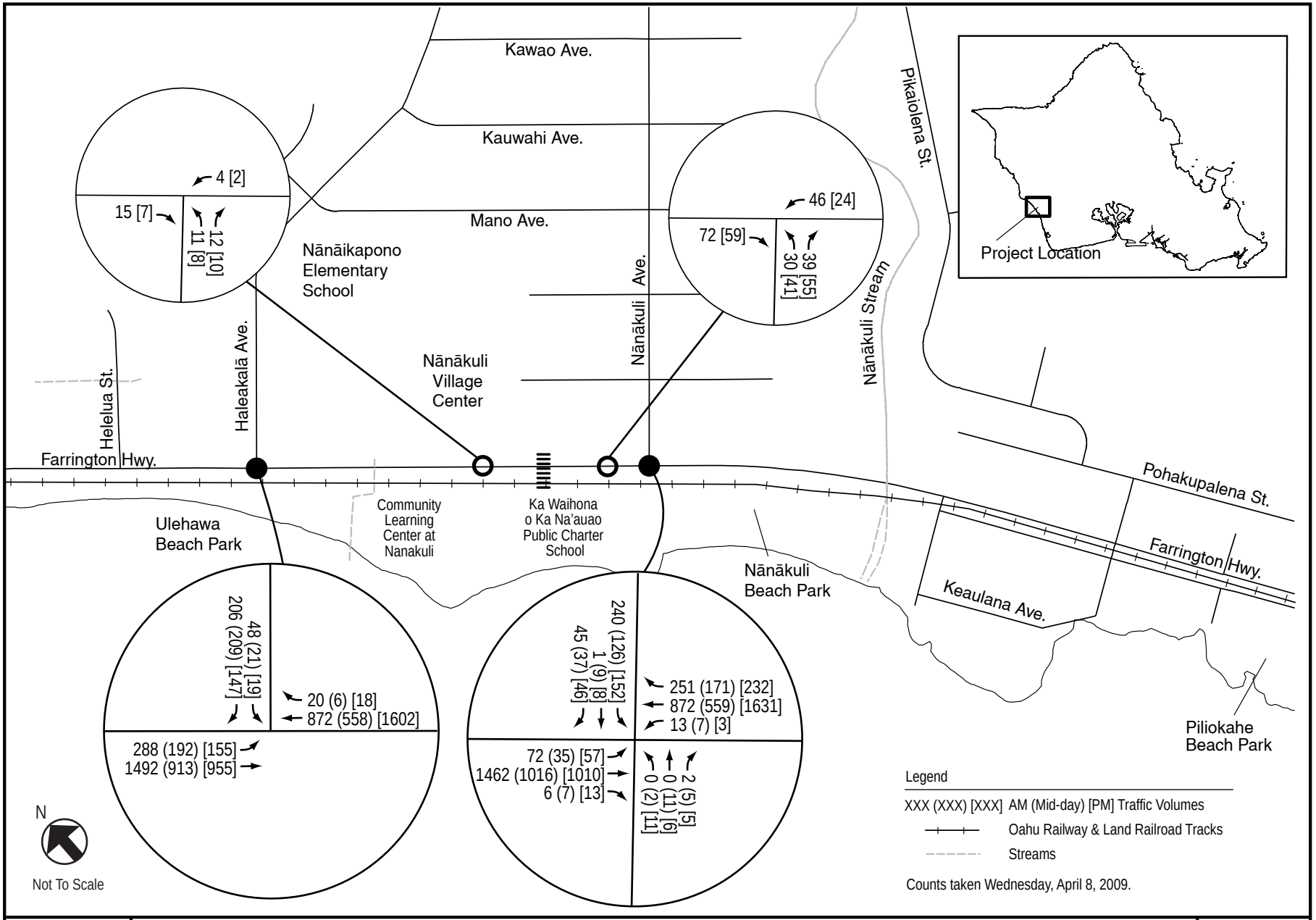
Along with vehicular turning movements, pedestrian movements were also recorded at both intersections. Due to the presence of two schools in Nanakuli, a considerable number of pedestrians cross Farrington Highway, Nanakuli Avenue, and Haleakala Avenue. Peak-hour pedestrian counts are shown in Figure 5.



Note: Measurements taken January 24, 2007.

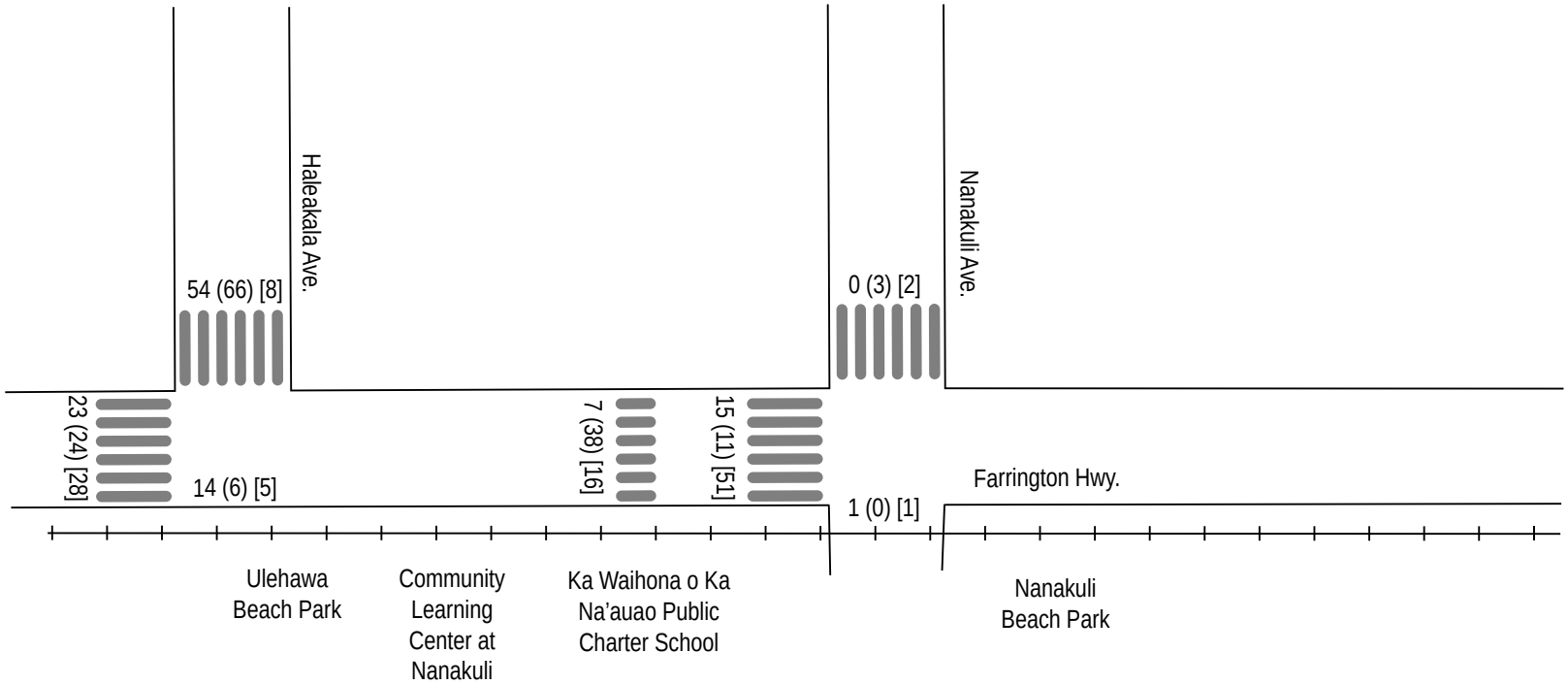
FARRINGTON HIGHWAY 24-HOUR VOLUMES
AT NANAKULI STREAM BRIDGE

Figure
3



EXISTING PEAK-HOUR TRAFFIC COUNTS

Figure 4



Legend

XX (XX) [XX] - AM (Mid-day) [PM] Pedestrian Volumes

Counts taken Wednesday, April 8, and Tuesday, June 2, 2009.

N

Not To Scale

EXISTING AM, MID-DAY, AND PM PEAK-HOUR PEDESTRIAN COUNTS

Figure 5

D. Existing Traffic Operations

(1) Existing Queue Lengths

Queue lengths are longest during the AM and PM peak-hours. During the AM peak-hour, the inbound queue at Farrington Highway and Haleakala Avenue can reach up to 20 vehicles. The queuing in the outbound direction during the AM peak-hour is not nearly as significant. During the PM peak-hour, the queuing in the outbound direction is extremely pronounced, with vehicle queues reaching as far as Kahe Power Plant - a distance of almost 3.5 miles. Figures 6 and 7 show AM and PM peak-hour queuing distances in the study area.

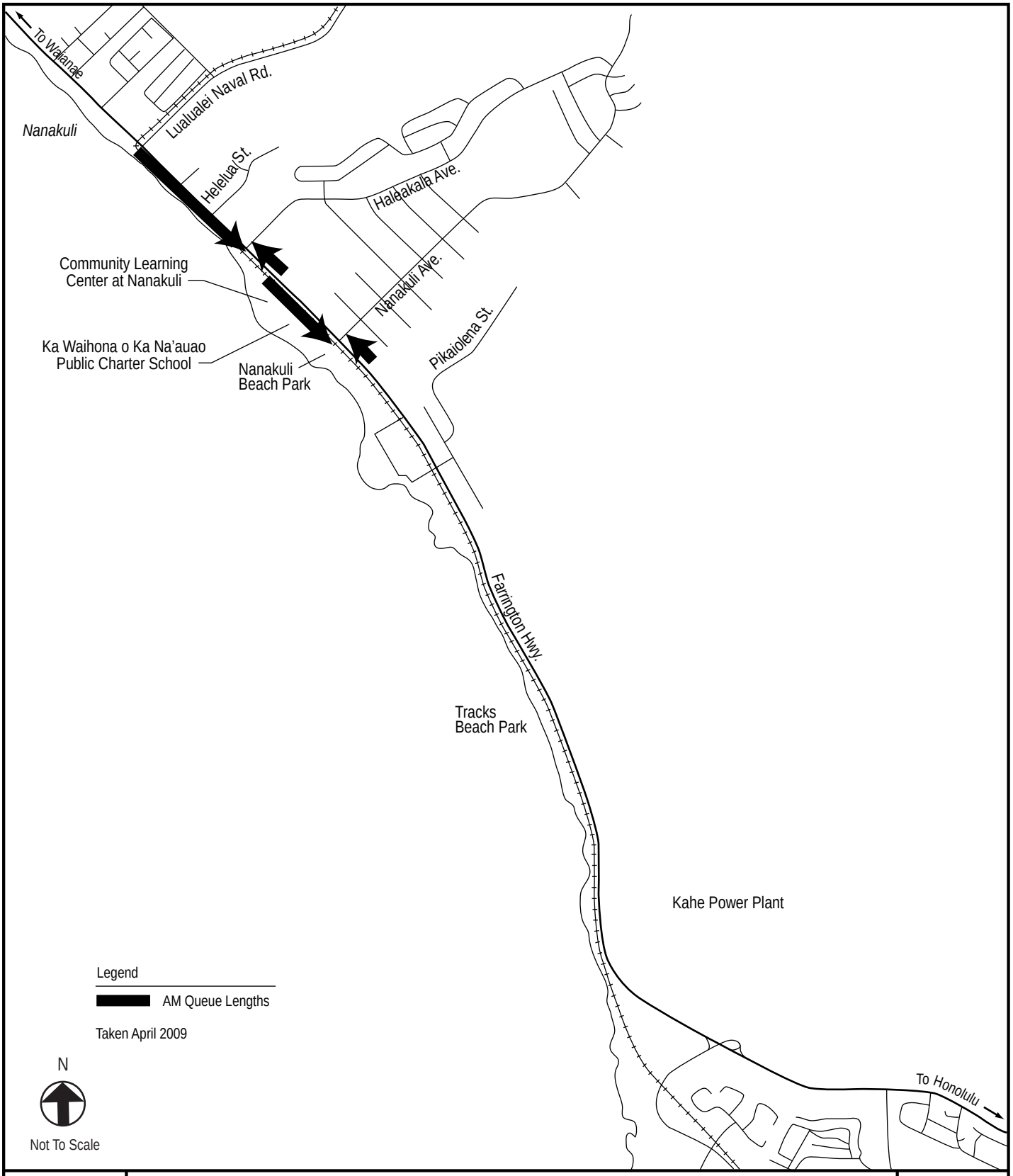
(2) Intersection LOS

The intersection capacity analysis methods documented in the 2000 Highway Capacity Manual were used to evaluate intersection operations at these intersections.

A. Farrington Highway/Haleakala Avenue

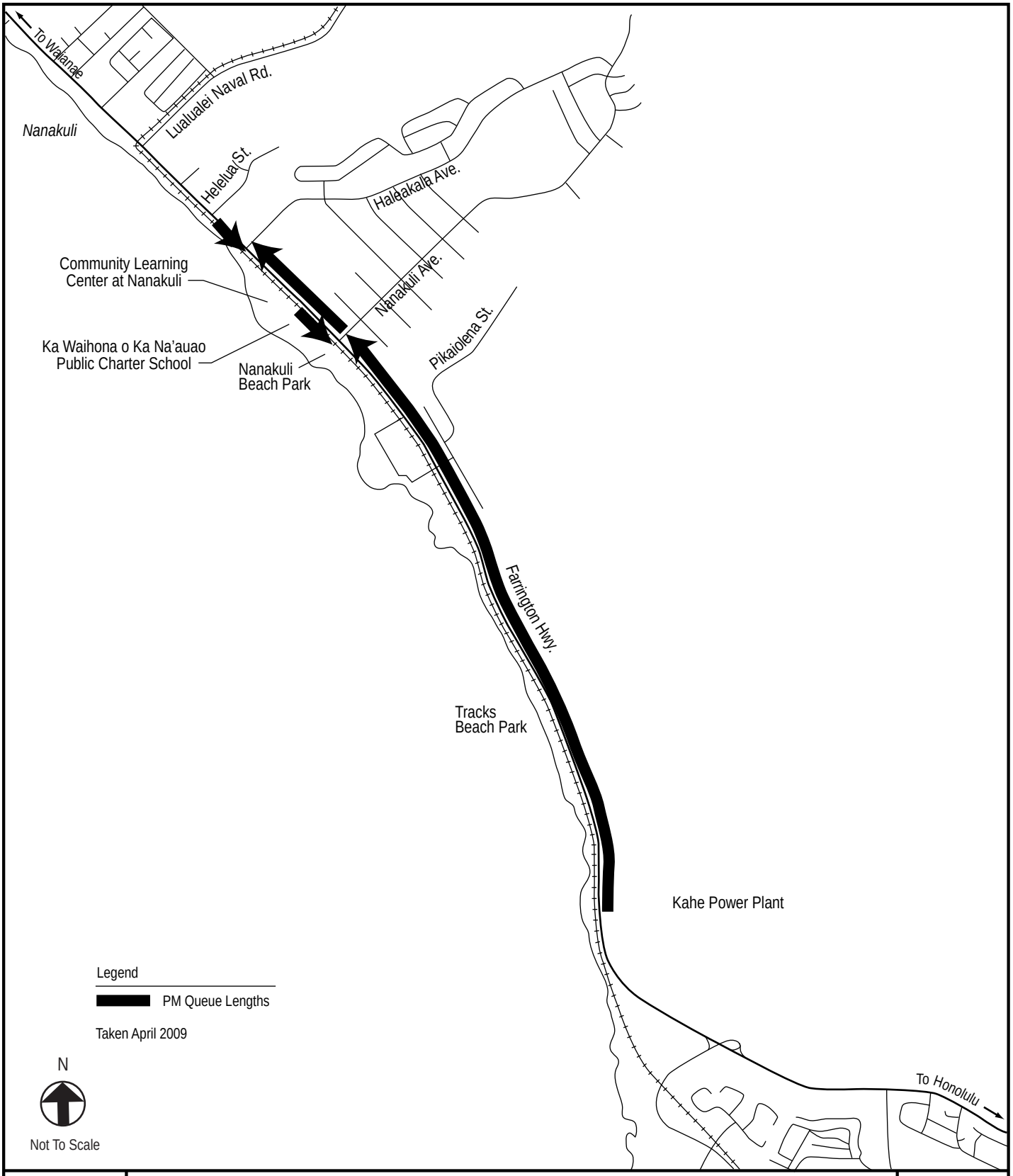
This intersection operates at an overall LOS E during the AM peak hour, LOS A during the mid-day peak hour, and LOS E during the PM peak hour. The findings are summarized as follows:

1. During the AM peak hour the inbound left-turn movement is shared with the inbound through movement and operates at LOS F. Heavy left turning volumes to the three schools located mauka of Farrington Highway were served by a leading left turn green followed by permissive left turn phase.
2. Figure 8 shows that there is a bus stop at the far-side of the intersection. The presence of a stopped bus at the bus stop along with a waiting left turning vehicle could essentially block both inbound travel lanes.
3. During the PM peak hour the outbound queuing is long and continuous with its only interruption at the intersection with Nanakuli Avenue.
4. Makai-bound Haleakala Avenue has no exclusive turn-pockets, and experiences much higher delay during the AM and PM peak hours. Delay for this movement is 77 seconds per vehicle during the AM peak-hour and 123 seconds per vehicle for the PM peak-hour. Further, pedestrian traffic, especially after-school pedestrians, were heavy during the mid-day peak-hour.



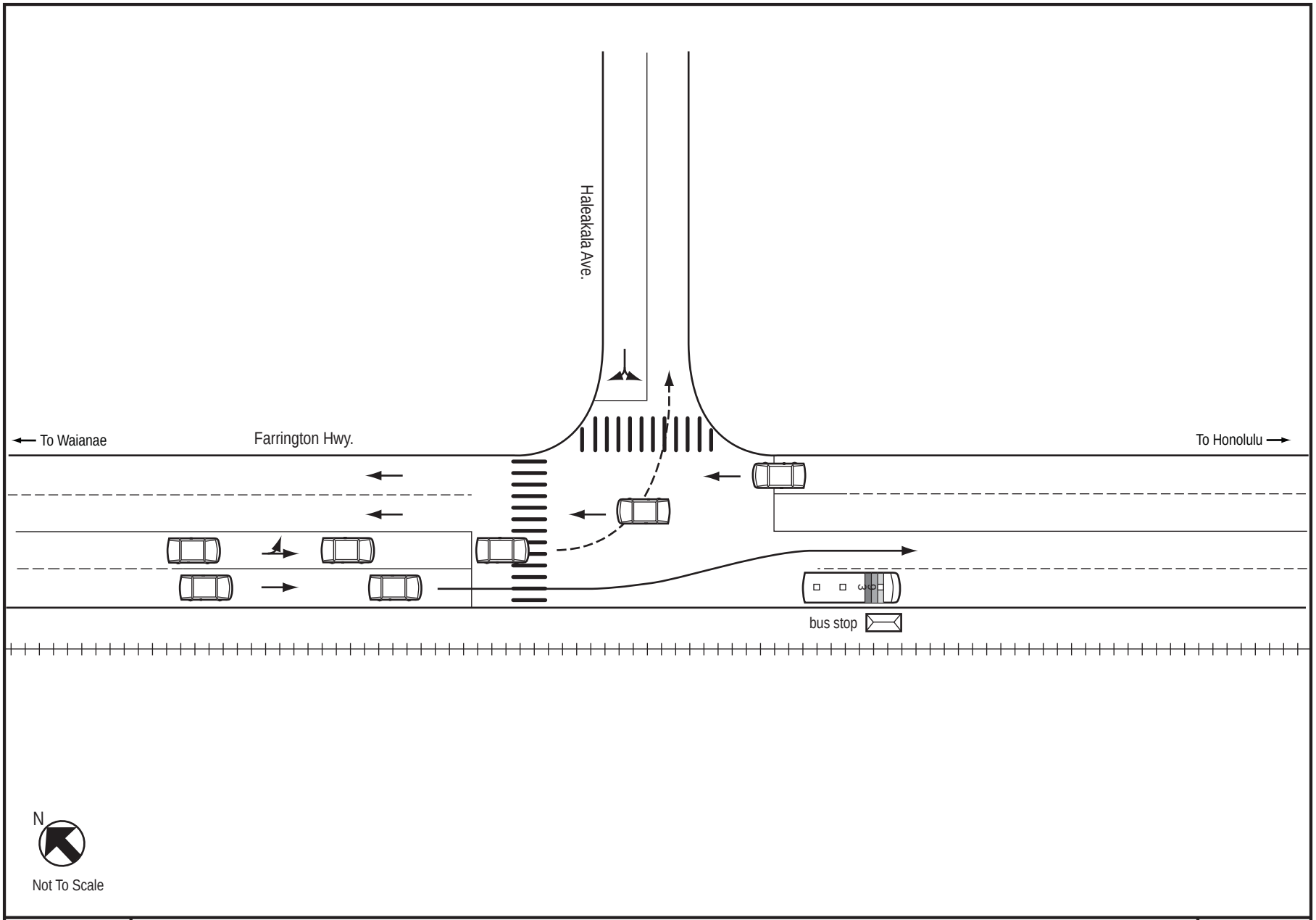
AM PEAK HOUR QUEUE LENGTHS

Figure 6



PM PEAK HOUR QUEUE LENGTHS

Figure 7



EXISTING OPERATIONS AT HALEAKALA AVENUE

Figure 8

B. Farrington Highway/Nanakuli Avenue

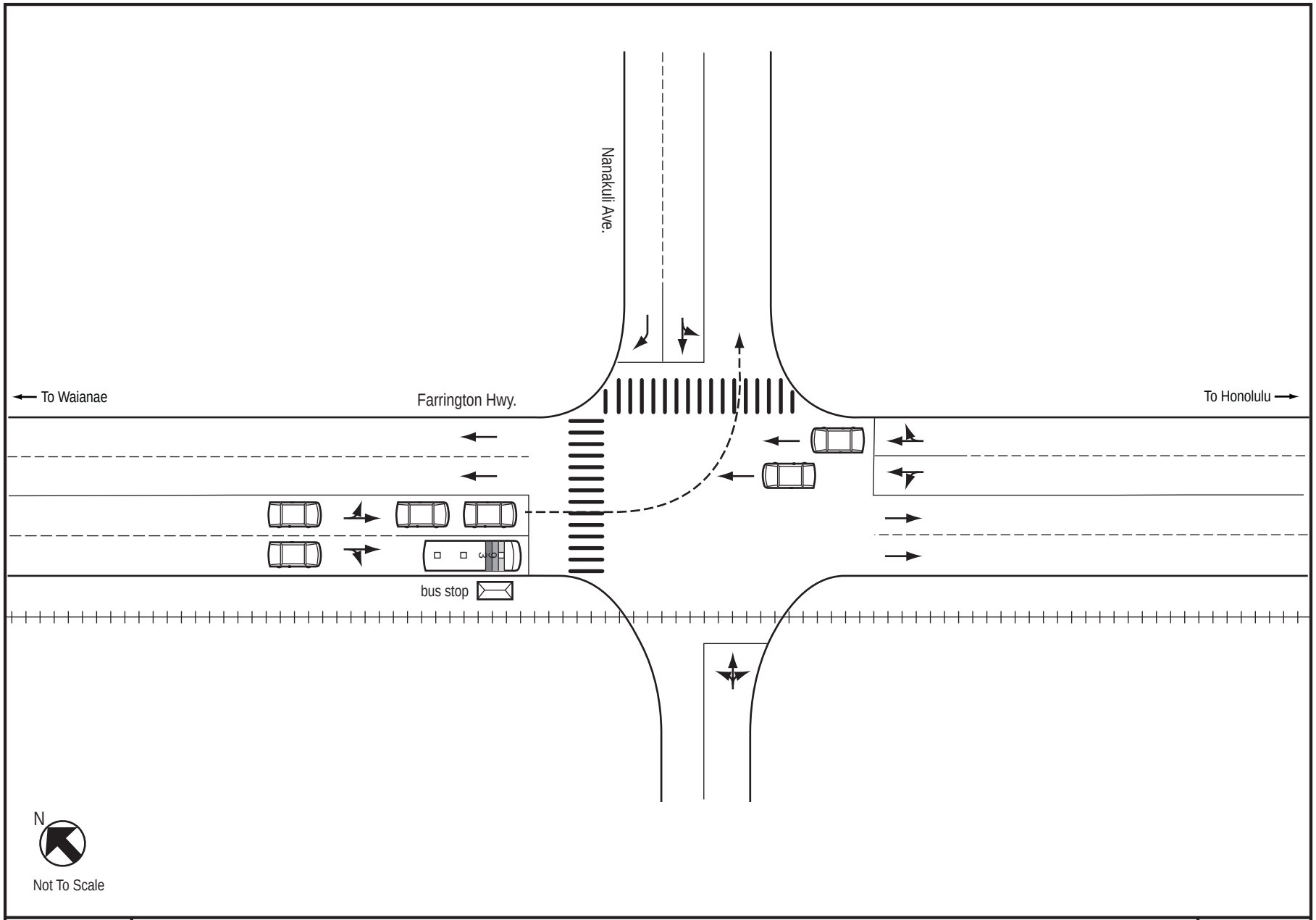
This intersection operates at LOS C during the AM peak hour, LOS A during the mid-day peak hour, and LOS F during the PM peak hour.

1. During the AM peak hour the inbound movement operates at LOS C due to high commuting volumes and lack of a left turning storage lane.
2. Figure 9 shows that there is a bus stop at the near-side of the intersection. The presence of a stopped bus at the bus stop along with a waiting left turning vehicle could essentially block both inbound travel lanes.
3. During the PM peak hour, the queuing in the outbound direction is extremely pronounced, with vehicle queues reaching as far as Kahe Power Plant - a distance of almost 3.5 miles.
4. The makai-bound left and through vehicles on Nanakuli Avenue experience an average delay of 96 seconds per vehicle during the AM peak-hour and 143 seconds per vehicle during the PM peak-hour. The queue lengths on Nanakuli Avenue reached a maximum of 18 vehicles during the AM peak hour. Pedestrian volume is highest during the PM peak hour, with 51 pedestrians crossing Farrington Highway.

Table 2 Farrington Highway Existing (2009) Intersection LOS Summary

Intersection	AM		Midday		PM	
	LOS	Delay	LOS	Delay	LOS	Delay
Farrington Hwy/Nanakuli Ave	**C**	**26**	**A**	**7**	**F**	**152**
Farrington Hwy inbound left/through/right	C	25	A	7	B	11
Farrington Hwy outbound left/through/right	A	10	A	5	F	237
Nanakuli Ave mauka left/through/right	D	50	B	16	F	90
Nanakuli Ave makai left/through	F	96	B	20	F	143
Nanakuli Ave makai right	D	50	B	15	F	90
Farrington Hwy/Haleakala Ave	**E**	**64**	**A**	**8**	**E**	**76**
Farrington Hwy inbound left/through	F	92	A	5	A	8
Farrington Hwy outbound through/right	A	5	A	3	F	117
Haleakala Ave makai left/right	E	77	C	30	F	123

*Delay is in seconds per vehicle.



EXISTING OPERATIONS AT NANAKULI AVENUE

Figure 9

CHAPTER 4 SHORT-TERM FUTURE CONDITIONS

A. Short-Term Improvements

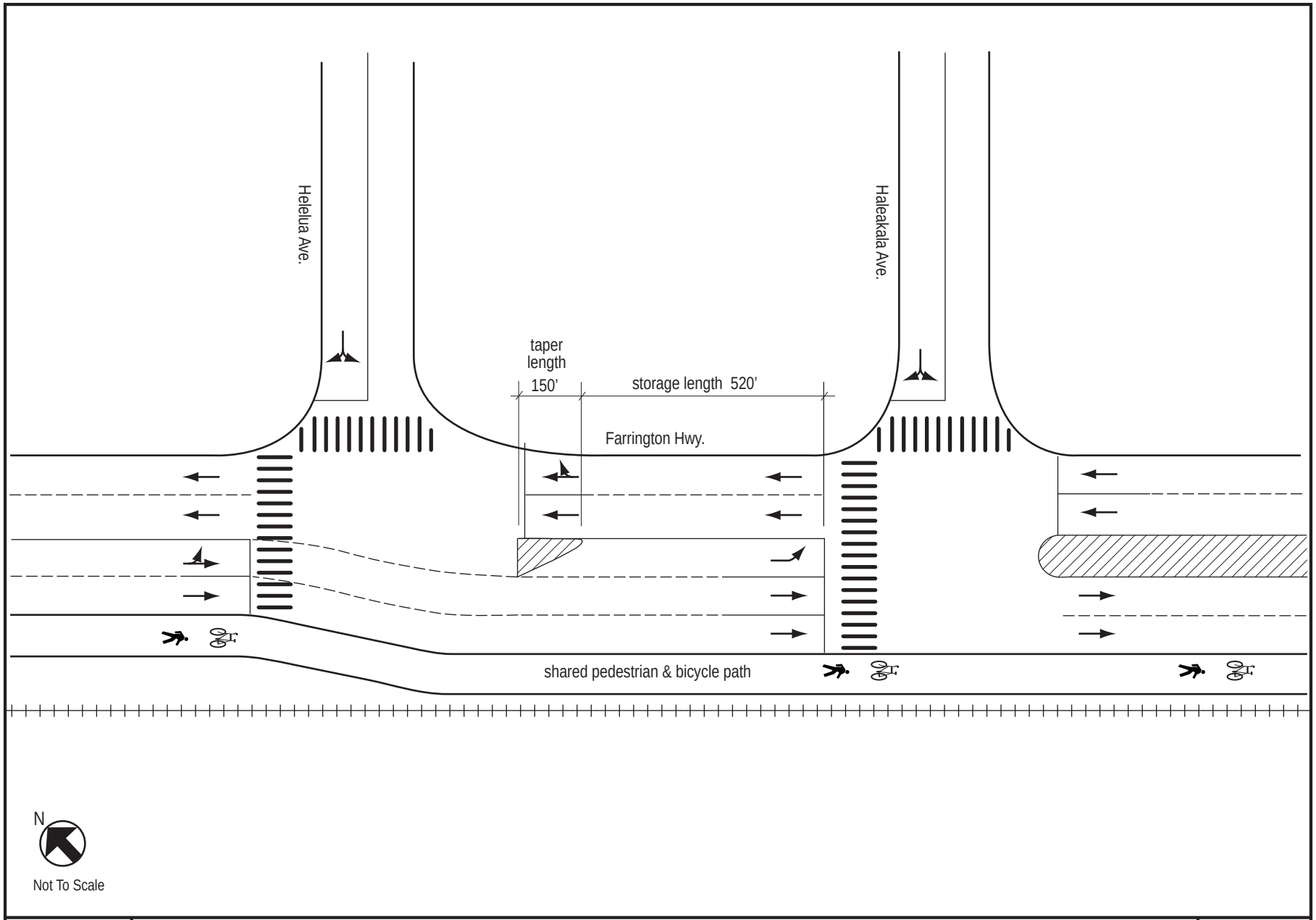
Hawaii's State Transportation Improvement Program has identified Farrington Highway Intersection Improvements at Haleakala Avenue and Nanakuli Avenue for funding during fiscal years 2008 to 2013. These improvements include: inbound left-turn pockets at both Haleakala Avenue and Nanakuli Avenue, an outbound left-turn pocket at Nanakuli Avenue, curb and gutter improvements on both sides of Farrington Highway, creation of a pedestrian/bicycle lane alongside the railroad tracks for the entire segment length, and a six-foot tall metal fence separating the railroad tracks and the pedestrian/bicycle lane where necessary. These are shown in Figures 10 & 11.

B. Short-Term Volumes

For the short-term, 2012 was used as the target year, and an annual growth rate was applied to existing volumes to generate year 2012 volumes. This annual growth rate was derived from Oahu Metropolitan Planning Organization's travel demand forecasting model. A number of meetings have been held with the major stakeholders along Farrington Highway including Nanakaipono Elementary School, Nakakuli Village Center, and Ka Waihona o ka Na'auao Public Charter School. It was determined for this analysis that no major developments will be completed by the year 2012. The volumes that were projected are shown in Figure 12.

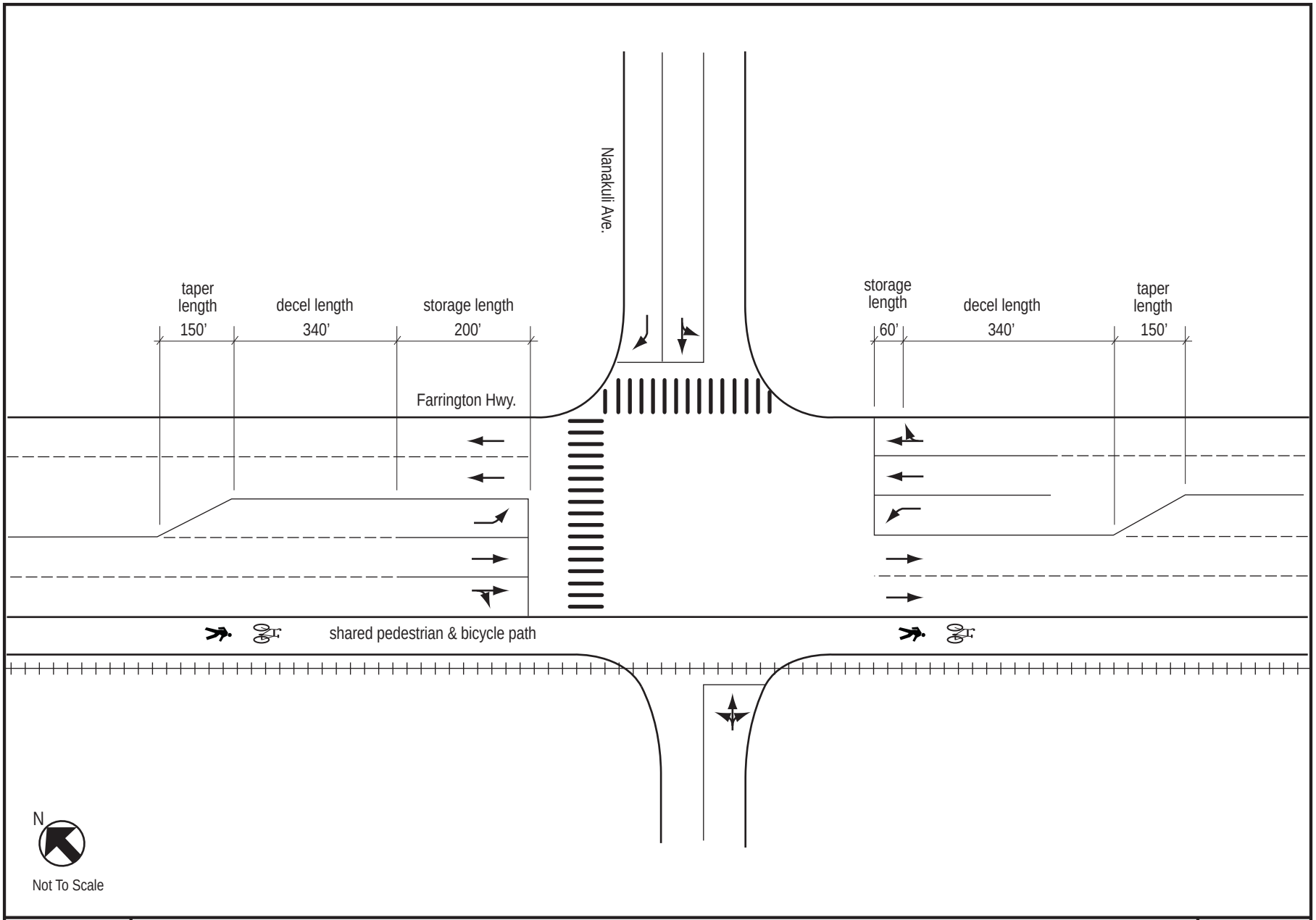
C. Left-Turn Storage Lengths

To determine the necessary length of the left-turn pockets that are recommended in the short-term, existing volumes for each corresponding left-term movement were utilized to generate left-turn storage lengths. For each left-turn movement described in Section E1, storage lengths were calculated for both AM and PM peak-hours. Subsequently, the maximum calculated storage length for each left-turn movement was used to determine total turn pocket lengths. Table 3 shows recommended storage lengths for each of the three recommended turn pockets.



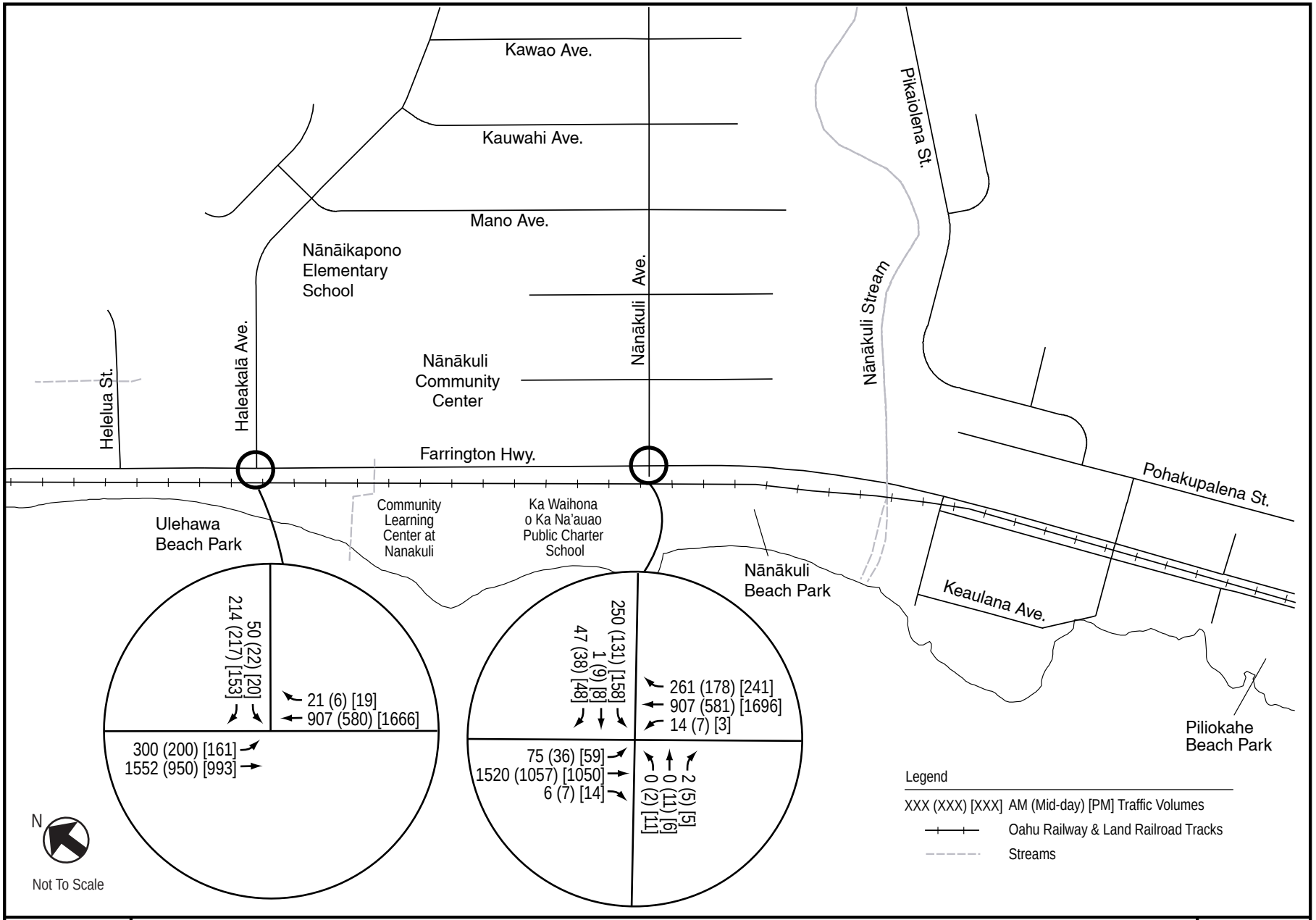
RECOMMENDED SHORT-TERM IMPROVEMENTS AT HALEAKALA AVENUE

Figure 10



RECOMMENDED SHORT-TERM IMPROVEMENTS AT NANAKULI AVENUE

Figure 11



2012 AM, MID-DAY, AND PM PEAK-HOUR PROJECTED VOLUMES

Figure 12

Table 3 Turn Pocket Storage Lengths

Intersection	Approach	2012 Actual Volume (vph)	Cycle Length (Sec)	Cycles per Hour	Ave Veh per Cycle	AASHTO Rec'd Length				Synchro 95th % Max Q Length (Ft)	# of Lanes Rec'd	Length Rec'd (Ft)
						Minimum		Desirable				
						Veh	Ft	Veh	Ft			
Farr Hwy & Nanakuli Ave	NWBL	14	160	23	1	2	50	2	50	35	1	**60**
Farr Hwy & Nanakuli Ave	SEBL	59	240	15	4	6	150	8	200	160	1	**200**
Farr Hwy & Haleakala Ave	SEBL	300	160	23	13	20	500	26	650	405	1	**650**

These storage lengths were added to taper lengths and deceleration lengths recommended by AASHTO's 2004 Geometric Design of Highways and Streets to produce turn pocket lengths for all three turning movements as shown in Table 4. However, due to the proximity of Haleakala Avenue and Helelua Street, the desirable inbound left-turn pocket length cannot be accommodated. Therefore it is recommended to use the available storage length of 520 feet, keeping the taper length at 150 feet. Figures 13 and 14 show typical roadway cross-sections after short-term improvements.

Table 4 Turn Pocket Length Breakdown

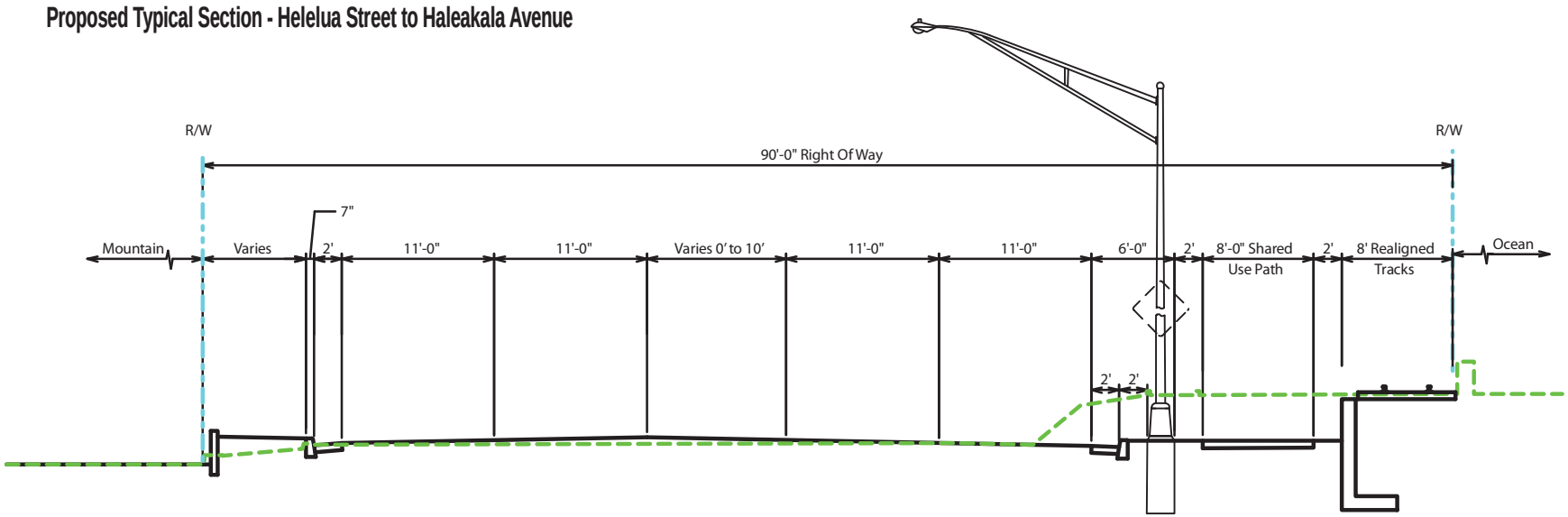
Intersection	Auxilliary Lane Type	Approach	Taper Length	Decel Length	Storage Length
Farrington Hwy & Nanakuli Ave	left-turn pocket	SEB	150'	340'	200'
Farrington Hwy & Nanakuli Ave	left-turn pocket	NWB	150'	340'	60'
Farrington Hwy & Haleakala Ave	left-turn pocket	SEB	150'	340'	650'

D. Traffic Operations based on Short-Term Improvements

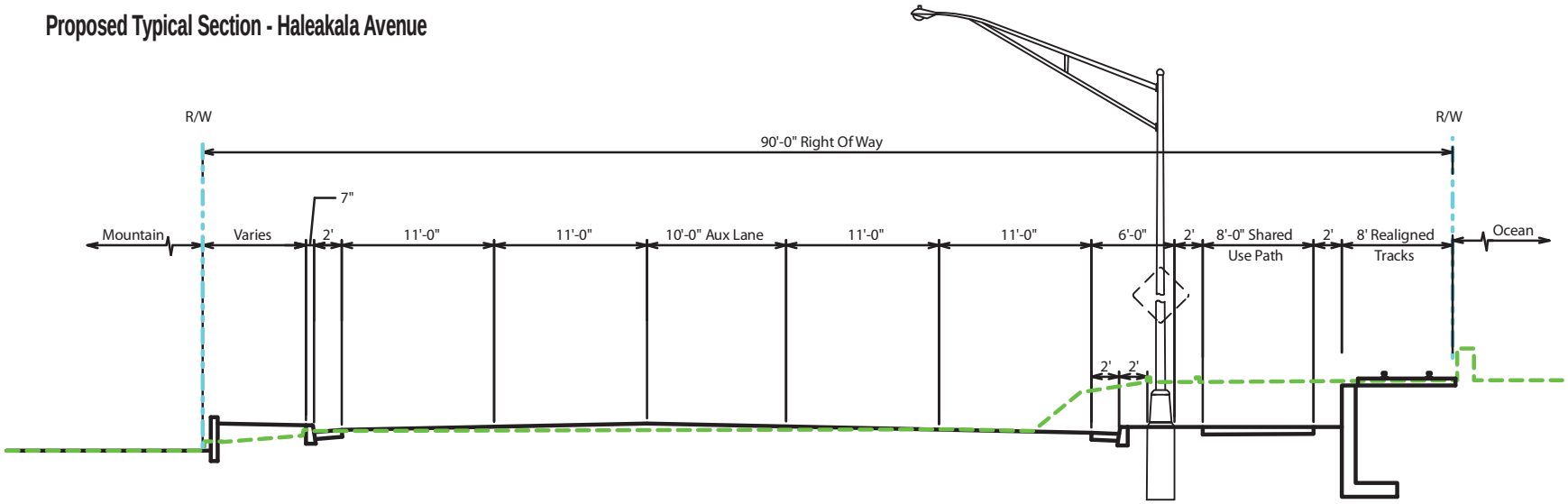
1. Farrington Highway/Haleakala Avenue

Due to the enormous volume of commuter traffic on Farrington Highway, building an inbound left-turn pocket considerably improves the overall operation of this intersection

Proposed Typical Section - Helelua Street to Haleakala Avenue



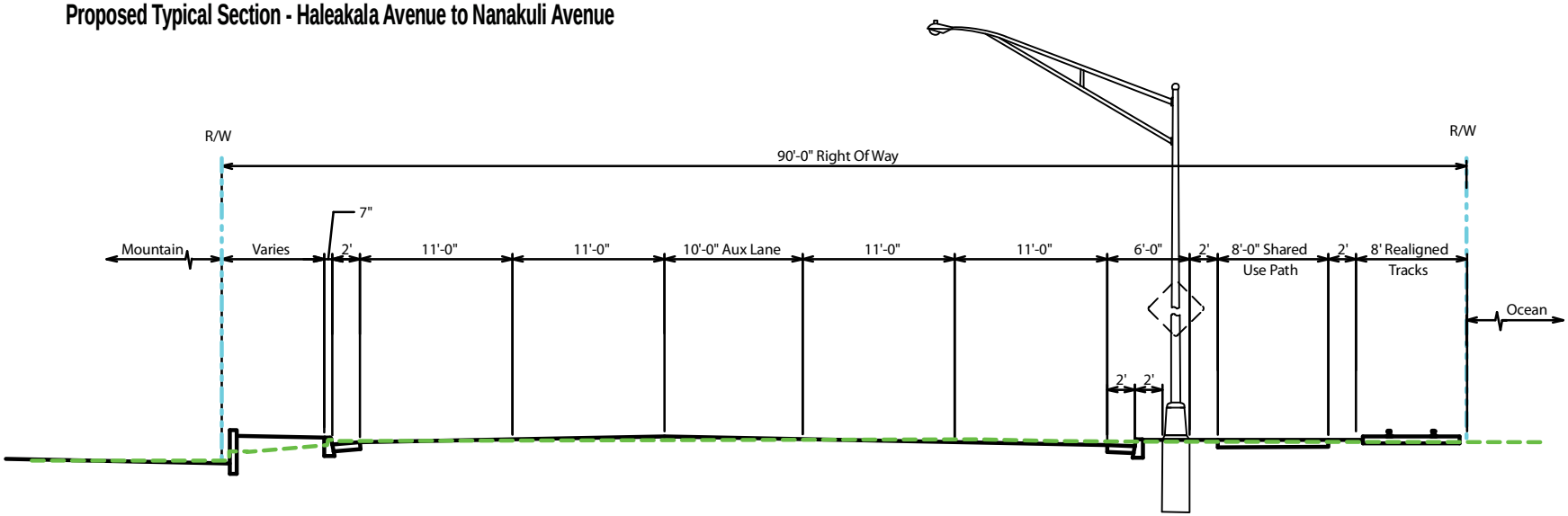
Proposed Typical Section - Haleakala Avenue



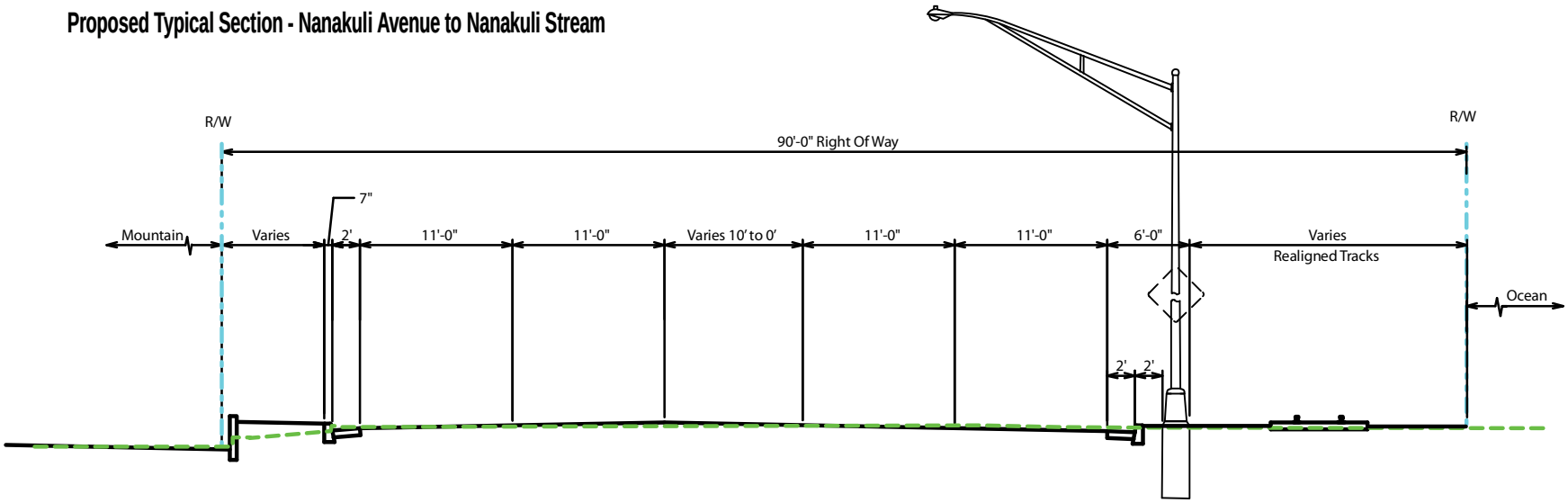
FUTURE (2012) TYPICAL SECTIONS AT HALEAKALA AVENUE

Figure
13

Proposed Typical Section - Haleakala Avenue to Nanakuli Avenue



Proposed Typical Section - Nanakuli Avenue to Nanakuli Stream



FUTURE (2012) TYPICAL SECTIONS AT NANAKULI AVENUE

Figure 14

during the AM peak hour, rising from LOS E to LOS B. The left-turn pocket allows both the inbound left and inbound through movements to proceed more smoothly. The overall delay during the AM peak hour decreases to 18 seconds per vehicle. The mid-day and PM peak hours are relatively similar to existing conditions except that the inbound left-turn movement during the PM peak hour falls from LOS A to LOS F. This is expected because its delay value is shared for the existing scenario but isolated for the short-term improvement scenario.

2. Farrington Highway/Nanakuli Avenue

At Nanakuli Avenue, overall LOS remains essentially the same for the AM and PM peak hours. The midday peak hour worsens slightly from LOS A to LOS B. During the PM peak hour, the inbound left, outbound left, and the shared makai-bound left & through all experienced delay above 110 seconds per vehicle. A summary of LOS based on the short-term improvements is shown in Table 5.

Table 5 LOS Summary based on Short-Term Improvements (2012)

Existing	AM		Midday		PM	
	LOS	Delay	LOS	Delay	LOS	Delay
Farrington Hwy/Nanakuli Ave	**C**	**25**	**B**	**11**	**F**	**160**
Farrington Hwy inbound left	E	55	D	54	F	119
Farrington Hwy inbound through/right	B	20	A	9	A	8
Farrington Hwy outbound left	E	64	D	45	F	170
Farrington Hwy outbound through/right	C	23	A	9	F	249
Nanakuli Ave mauka left/through/right	C	34	B	17	F	89
Nanakuli Ave makai left/through	D	54	C	22	F	144
Nanakuli Ave makai right	C	35	B	17	F	88
Farrington Hwy/Haleakala Ave	**B**	**18**	**B**	**11**	**F**	**86**
Farrington Hwy inbound left	D	42	B	19	F	119
Farrington Hwy inbound through	A	8	A	5	A	2
Farrington Hwy outbound through/right	C	23	B	14	F	129
Haleakala Ave makai left/right	D	37	B	18	F	111

*Delay is in seconds per vehicle.

CHAPTER 5 MID-RANGE FUTURE CONDITIONS

A. General Demographics

According to the 2000 US Census, the population of Oahu stood at 876,156. Of this total, 42,259 resided in the Waianae District with approximately 28% of this population (11,866) living in Nanakuli. The average household size in Nanakuli is the highest in Oahu at 4.64 persons per household, markedly above the Oahu-wide average of 2.95. In contrast, household income in Nanakuli is the lowest in Oahu, with an average of approximately $43,000 compared with an island-wide average of approximately $52,000. Based on City and County of Honolulu DPP 2007 Annual Report forecasts, the populations of Oahu and Waianae District, will rise to 1.12 million and 52,285, respectively by the year 2030. Nearly half of Waianae District's population increase will occur in Nanakuli over the same term. Contrary to the increase in population in Nanakuli and other sub-areas of Waianae District, total employment in both areas is projected to decrease over the same term. This is shown in Table 6.

Table 6 Employment Trend Comparisons

Jurisdiction	Population (2000)	Employment (2000)	Population (2030)	Employment (2030)
Oahu	876,156	485,795	1,117,322	616,873
Waianae	42,259	6,888	52,285	6,849

Source: C & C Honolulu, DPP 2007 Annual Report

The overwhelming majority of development in Waianae will be residential, with a planned increase of at least 4,000 housing units by 2030. The largest percentage of this increase will occur in Nanakuli.

B. Statewide Plans, Oahu General Plan & Other Sub-Area Plan Considerations

In May 2000, an ordinance was approved to adopt the Sustainable Communities Plan of Waianae District for the City and County of Honolulu. This plan was created as a blueprint for the district and also reflects the policies of the Oahu General Plan which stipulates for Waianae District, among other things, to prevent the undesirable spreading of development, and to keep its proportion of the island-wide resident

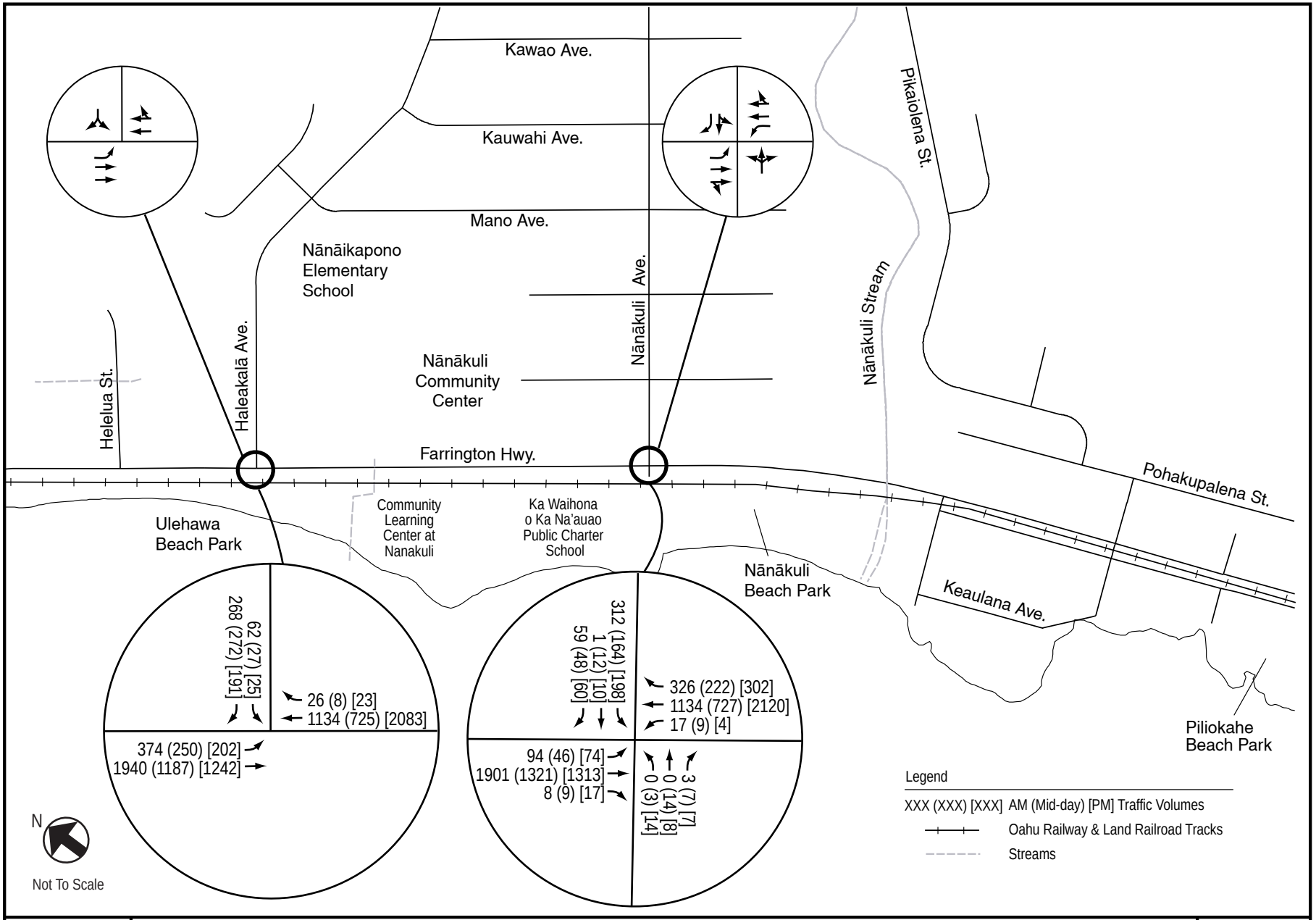
population unchanged (between 3.8 and 4.2 percent through 2010). Waianae District is seen as a rural community by both its residents and the government, and adopted plans intend to maintain this character.

C. Year 2030 Volumes

Utilizing the ORTP travel demand model, the 2030 bi-directional volume in the vicinity of Nanakuli Stream Bridge was found to be 50,533 for a 24-hour day. This is a screenline projection that includes the volume of Waianae Secondary Access Road. Based on the 2030 24-hour volume and its corresponding growth rate, AM, mid-day (MD), and PM traffic peak hours were determined for the year 2030 as shown in Figure 15.

D. Year 2030 Traffic Operations for No-Build Scenario

The 2030 volumes described in Section C were used to calculate LOS values for the no-build scenario. The intersection configurations at both Haleakala Avenue and Nanakuli Avenue were kept identical to their existing configurations, and traffic operations were analyzed. Table 7 shows LOS values for the 2030 no-build scenario. At the intersection of Farrington Highway and Nanakuli Avenue during the AM peak hour, the overall LOS drops from C to F, and the delay increases from 26 seconds per vehicle to 148 seconds per vehicle. This drop in the overall LOS is caused primarily by a large increase in delay for inbound traffic on Farrington Highway as well as for makai-bound left/through traffic on Nanakuli Avenue. At the same intersection during the PM peak hour, all movements operate at LOS F. The largest increase in delay is experienced by the makai-bound left/through movement, increasing to approximately 462 seconds per vehicle. The mid-day peak hour does not experience any significant increases in delay at this intersection.



2030 AM, MID-DAY, AND PM PEAK-HOUR PROJECTED VOLUMES

Figure 15

The intersection of Farrington Highway and Haleakala Avenue also experiences significant increases in delay during the AM and PM peak hours. During the AM peak hour, the overall LOS drops from E to F and the overall delay increases from 64 seconds per vehicle to 234 seconds per vehicle. The largest increase in delay is experienced by the inbound left/through movement, increasing from 92 seconds per vehicle to 368 seconds per vehicle. Similar to the existing conditions, the large volume of inbound left turns accessing the three schools located mauka of Farrington Highway share the inner lane with though traffic causing an increase in overall inbound delay. The overall LOS drops from E to F during the PM peak hour as well. The largest increase in delay is experienced by the makai-bound left/right movement, increasing from 123 seconds per vehicle to 374 seconds per vehicle. This movement has no exclusive turn pockets therefore the increase in volume causes an increase in delay. Similar to the intersection at Nanakuli Avenue, the mid-day peak hour does not experience any significant increases in delay at this intersection.

Table 7 LOS Summary for 2030 No-Build Scenario

Existing	AM		Midday		PM	
	LOS	Delay	LOS	Delay	LOS	Delay
Farrington Hwy/Nanakuli Ave	**F**	**148**	**B**	**11**	**F**	**209**
Farrington Hwy inbound left/through/right	F	244	B	10	F	87
Farrington Hwy outbound left/through/right	B	19	A	7	F	262
Nanakuli Ave mauka left/through/right	D	49	C	22	F	96
Nanakuli Ave makai left/through	F	161	C	31	F	462
Nanakuli Ave makai right	D	50	C	22	F	91
Farrington Hwy/Haleakala Ave	**F**	**234**	**B**	**13**	**F**	**125**
Farrington Hwy inbound left/through	F	368	B	15	F	90
Farrington Hwy outbound through/right	A	8	A	3	F	124
Haleakala Ave makai left/right	F	90	C	33	F	374

E. Year 2030 Traffic Operations with Mid-Range Improvements

The Oahu MPO's 2030 Oahu Long Range Transportation Plan recommends that Farrington Highway within the study area be widened to six lanes by the year 2030. But to evaluate the left-turn pockets implemented by the STIP at both Haleakala Avenue and Nanakuli Avenue, it was assumed that the lane configuration of Farrington Highway in the study area would remain as two through lanes in each direction. Compared with the existing conditions, overall LOS and delay improved only at Haleakala Avenue during the AM peak hour (E to D). This is due to the left-turn lane provided for the proportionately high number of vehicles accessing Nanaikapono Elementary School in the morning. For the mid-day peak hour, overall delay does not change dramatically. The inbound and outbound left-turn movements at Nanakuli Avenue as well as the inbound left-turn movement at Haleakala Avenue all operate at LOS F and experience delay above 120 seconds per vehicle during the PM peak-hour. Outbound long queuing is expected due to the heavy demand and is reflected in the delay values at both intersections (150 seconds per vehicle at Haleakala Avenue and 294 seconds per vehicle at Nanakuli Avenue). Table 8 summarizes LOS values for the mid-range improvements.

Table 8 LOS Summary based on Mid-Range Improvements

Existing	AM		Midday		PM	
	LOS	Delay	LOS	Delay	LOS	Delay
Farrington Hwy/Nanakuli Ave	**D**	**39**	**B**	**14**	**F**	**190**
Farrington Hwy inbound left	E	67	D	40	F	122
Farrington Hwy inbound through/right	C	34	B	12	A	10
Farrington Hwy outbound left	E	75	E	65	F	263
Farrington Hwy outbound through/right	C	31	B	12	F	294
Nanakuli Ave mauka left/through/right	D	40	C	21	E	88
Nanakuli Ave makai left/through	F	103	C	29	F	206
Nanakuli Ave makai right	D	40	C	21	D	89
Farrington Hwy/Haleakala Ave	**D**	**49**	**B**	**13**	**F**	**100**
Farrington Hwy inbound left	F	284	C	33	F	132
Farrington Hwy inbound through	B	15	A	5	A	4
Farrington Hwy outbound through/right	C	24	B	15	F	150
Haleakala Ave makai left/right	E	64	C	21	F	133

CHAPTER 6 CONCLUSIONS & RECOMMENDATIONS

Short term improvements are recommended including: inbound left-turn pockets at both Haleakala Avenue and Nanakuli Avenue, an outbound left-turn pocket at Nanakuli Avenue, curb and gutter improvements on both sides of Farrington Highway, and a pedestrian/bicycle lane alongside the railroad tracks for the entire segment length. The geometry of these short-term improvements have also been recommended.

Traffic analysis showed that these short-term improvements improve the traffic flow and operation for all left-turning movements at both intersections but the pronounced queuing during PM peak hour will persist due to the high commuting volumes. In addition, the following should be considered:

1. Throughout the project limits, a milled centerline and shoulder rumble strips should be installed to proactively reduce the severity and frequency of accidents. The location of driveways and bicyclists needs to be considered when installing rumble strips.

2. The existing pedestrian signal timing at the three signalized intersection meets the requirements of MUTCD. But because the added left turning lane increased the crossing distance, the proportional increase on pedestrian signal timing should be considered.

3. Displaced vehicles that currently park on the shoulder at Ka Waihona o Ka Naauao Public Charter School should be mitigated through coordination with the school and the parents.

4. The future developments along this segment of Farrington Highway should incorporate this design into their plans in order to improve traffic operation and safety.

5. During the construction of the short-term improvements, a TMP plan is recommended to alleviate unnecessary congestion and improve safety.

APPENDIX A SIGNAL TIMINGS

INTERSECTION: FARRINGTON at NANAKULI

by: _____ Date: 4-5-94 UPDATED

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BASE DISPLAY

COORDINATION — 0
DEMAND (VEH & PEDS) — 1, 2, 3, 4, 5, 6, 7, 8
PREEMPTION — 9

A	b
PHASE INTVL	PHASE INTVL

RING A | RING B

1	2	3	4	RING A
5	6	7	8	RING B

PHASES

INTERVALS

0 - WALK
1 - FLASH DONT WALK
2 - MINIMUM GREEN
3 -
4 - VARIABLE INITIAL
5 - EXTENSION
6 -
7 - REDUCED GAP
8 - RED REST
9 - PREEMPTION
A - STOP TIME
B - RED REVERT
C - GAP TERMINATION
D - MAX TERMINATION
E - FORCEOFF
F - RED CLEARANCE

OVERLAP LOAD SWITCH ASSIGNMENT D-0-

OVERLAP A		(0-8)
OVERLAP B		(0-8)
OVERLAP C		(0-8)
OVERLAP D		(0-8)

bAdE EPROM ERROR, SEE C-E-D
WATCHDOG STOPS IF F-C-F = 0

bAdA TURN STOPTIME SW ON THEN OFF TO REINITIALIZE

CONFIGURATION DATA

NOTE: "E" KEY ENABLED (F-9-E ≠ 0)

KEYSTROKES: E+E+INTERVAL

INTERVAL		PHASE 1	2	3	4	5	6	7	8
0	EXCLU PH								
1	RR1 GRN CL								
2	RR2 GRN CL								
3	RR2 LTD								
4	PROT/PERM					X			
5	OLA GOMIT								
6	OLB GOMIT								
7	OLC GOMIT								
8	OLD GOMIT								
9	OV FL YEL								
A	EMVEH A								
B	EMVEH B								
C	EMVEH C								
D	EMVEH D								
E	EXTRA	X							
F	IC SELECT					X			

EXTRA (E+E+E)

1-TBC TYPE 1
3-DAYLIGHT SAV
4-EV ADVANCE
5-RESERVED
6-SPECIAL EVENT
7-PRETIMED
8-SPLIT RING

IC SELECT (E+E+F)

2-DUPLEX LOCAL
3-7 WIRE IN
4-FLH/FREE 25 SIMPLEX 17
6-SIMPLEX MASTER
7-7 WIRE OUT
8-OFFSET INTERRUPTER

ASSIGN5 (E+F+F)

1-RT OVERLAP
2-TOD OUTPUTS
3-STEADY EV BEACON
4-FLASH EV BEACON
5-RESERVED
6-PHASES 3 & 7 PED
7-ADVANCE WARNING BEACON
8-SPECIAL EVENT

KEYSTROKES: E+F+INTERVAL

INTERVAL		PHASE 1	2	3	4	5	6	7	8
0									
1	RR OLAP A								
2	RR OLAP B								
3	RR OLAP C								
4	RR OLAP D								
5	PED2P								
6	PED6P						X		
7	PED4P				X				
8	PED8P								
9	FLH YELO								
A	OVERLAP A								
B	OVERLAP B								
C	OVERLAP C								
D	OVERLAP D								
E	RESTRICT								
F	ASSIGN5								

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COORDINATION TIMING

KEYSTROKES: C+PLAN+FEATURE

FEATURE		PLAN 1	2	3	4	5	6	7	8	9	
CYCLE	0	90	120	120	160	200	220	240	150	160	0
FORCE1	1										1
FORCE2	2	0	0	0	0	0	0	0	0	0	2
FORCE3	3										3
FORCE4	4	40	40	40	40	40	40	40	40	40	4
FORCE5	5	55	61	61	61	61	61	61	61	80	5
FORCE6	6	0	0	0	0	0	0	0	0	0	6
FORCE7	7										7
FORCE8	8										8
RING OFFSET	9										9
OFFSET A	A	0	36	15	91	90	90	90	36	132	A
OFFSET B	B								25		B
OFFSET C	C										C
PERMISSIVE	D										D
HOLD RELEASE	E										E
ZONE OFFSET	F										F

ADDRESS (C-0-0)= 4

MANUAL PLAN: (C-A-1)= 0

AUTO = 0
PLAN = 1-9
FREE = 14
FLASH = 15

MANUAL OFFSET: (C-B-1)=

AUTO = 0
OFFSET A = 1
OFFSET B = 2
OFFSET C = 3

TRANSITION TYPE (C-D-D)=

SHORTWAY = 0
DWELL > 0

FORCEOFF SHIFT FOR PEDESTRIAN (C-D-F)=

FOR OBSERVATION ONLY

MASTER PLAN (C-A-2)
CURRENT PLAN (C-A-3)
TOD PLAN (C-A-5)
MASTER CYCLE (C-A-0)
RING A CYCLE (C-B-0)
RING B CYCLE (C-D-0)
MINIMUM CYCLE (C-A-E)
MAXIMUM CYCLE (C-B-E)

SYNCHRONIZED PHASES

KEYSTROKES: C+E+PLAN

PLAN		PHASE 1	2	3	4	5	6	7	8
0									
1	SYNC 1		X				X		
2	SYNC 2		X				X		
3	SYNC 3		X				X		
4	SYNC 4		X				X		
5	SYNC 5		X				X		
6	SYNC 6		X				X		
7	SYNC 7		X				X		
8	SYNC 8		X				X		
9	SYNC 9		X				X		
A	CPEDRCL								
B	NEMA HLD								
C	SCANMEM								
D	BADPROM								
E	TODFN E								
F	TODFN F								

PHASE SEQUENCES

KEYSTROKES: C+F+FUNCTION#

FUNCTION		PHASE 1	2	3	4	5	6	7	8
0	LAG 0 (FREE)		X		X		X		X
1	LAG 1								
2	LAG 2								
3	LAG 3								
4	LAG 4								
5	LAG 5								
6	LAG 6								
7	LAG 7								
8	LAG 8								
9	LAG 9								
A	COOR MAX RECALL								
B	COOR LAG RECALL								
C	SYNC PHASES								
D	HOLD								
E	NEXT PHASE								
F	FORCE OFF								

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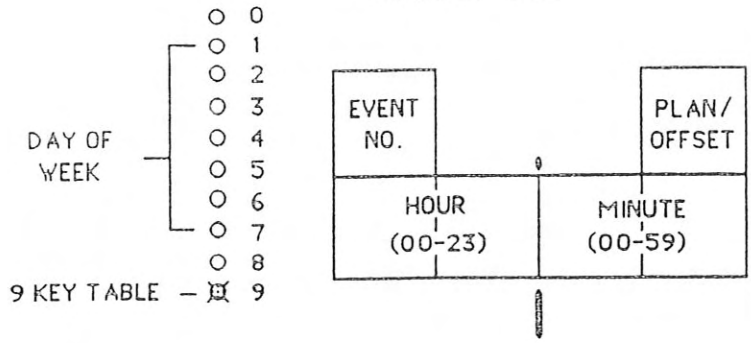
9-KEY

TIME OF DAY DISPLAYS



16 EVENT TABLE

TIME BASE COORDINATION

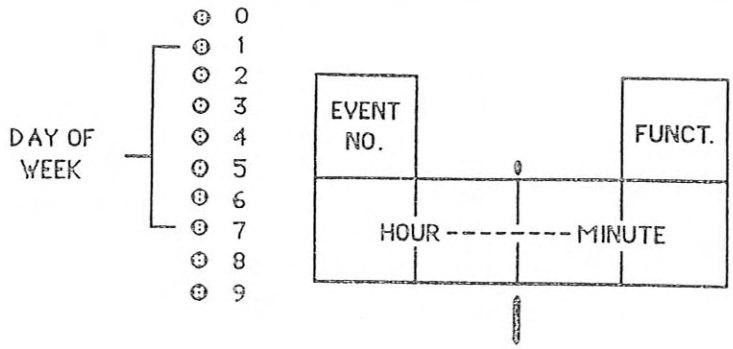
KEYSTROKES: 9+EVENT#

EVENT	TIME	PLAN	OFFSET	DAY OF WEEK S 1	M 2	T 3	W 4	T 5	F 6	S 7
0	0445	2	A		X	—	—	—	X	
1	0545	8	A		X	—	—	—	X	
2	0645	9	A		X	—	—	—	X	
3	0830	1	A		X	—	—	—	X	
4	1400	3	B	X	—	—	—	—	—	X
5	1500	5	A		X	—	—	—	X	
6	1515	6	A		X	—	—	—	X	
7	1545	7	A		X	—	—	—	X	
8	1830	5	A		X	—	—	—	X	
9	1930	8	B		X	—	—	—	X	
A	2030	1	A	X	—	—	—	—	—	X
B	2200	E	A	X	—	—	—	—	—	X
C	0730	1	A	X						X
D										
E										
F										

PLAN = 1...9 (DIAL)
E (FREE)
F (FLASH)

OFFSET = A...C

TIME OF DAY LOCAL FUNCTIONS



TIME OF DAY FUNCTIONS
KEYSTROKES: 7 + EVENT#

EVENT	TIME	FUNCT	DAY OF WEEK S	M	T	W	T	F	S
0	0645	B		X	—	—	—	X	
1	0830	B		X	—	—	—	X	
2	0645	9		X	—	—	—	X	
3	0830	9		X	—	—	—	X	
4									
5									
6									
7									
8									
9									
A									
B									
C									
D									
E									
F									

FUNCTION BY PHASE
KEYSTROKES: D-F-EVENT#

	1	2	3	4	5	6	7	8
0				X	X			
1								
2					X			
3								
4								
5								
6								
7								
8								
9								
A								
B								
C								
D								
E								
F								

TIME OF DAY LOCAL FUNCTION CODES

0 - PERMIT	7 - RED REST	E - 1-LOCAL OVERRIDE	F - TOD OUTPUTS
1 - RED LOCK	8 - DBL ENTRY	2-PHASE BANK 2	1 - TOD OUT 1
2 - YELLOW OCK	9 - VEH MAX RCL	3-PHASE BANK 3	2 - TOD OUT 2
3 - VEH RECALL	A - SOFT RECALL	4-DISABLE DET OFF	3 - TOD OUT 3
4 - PED RECALL	B - MAX II EXT	7-DET COUNT	4 - TOD OUT 4
5 - RESERVED	C - COND SERVE	8-SPLIT MONITOR	
6 - REST IN WALK	D - TOD LAG Ø		

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PHASE TIMING

KEYSTROKES: F+PHASE+INTERVAL

INTERVAL		PHASE 1	2	3	4	5	6	7	8	PREEMPT	E	
WALK	0				7		7			RR1 DELAY		0
FLASH D/W	1				15		10			RR1 CLEAR		1
MIN GREEN	2		30		3	5	30			EVA DELAY		2
TYPE 3 DET	3									EVA CLEAR		3
ADD/VEH	4									EVB DELAY		4
VEH EXTEN *	5		4		3	1	4			EVB CLEAR		5
MAX GAP *	6		4		3	1	4			EVC DELAY		6
MIN GAP *	7		4		3	1	4			EVC CLEAR		7
MAX EXTEN	8		60		30	10	60			EVD DELAY		8
MAX 2	9				35	20				EVD CLEAR		9
	A									RR2 DELAY		A
CALLTO PHASE	B									RR2 CLEAR		B
REDUCE BY	C									EV CLR TMR		C
REDUCE EVERY	D									EV DLY TMR		D
YELLOW	E		5		4	4	5			RR CLR TMR		E
RED CLEAR	F		2		1	1	2			RR DLY TMR		F

MAX INITIAL (F-0-E) = _____

RED REVERT (F-0-F) = _____

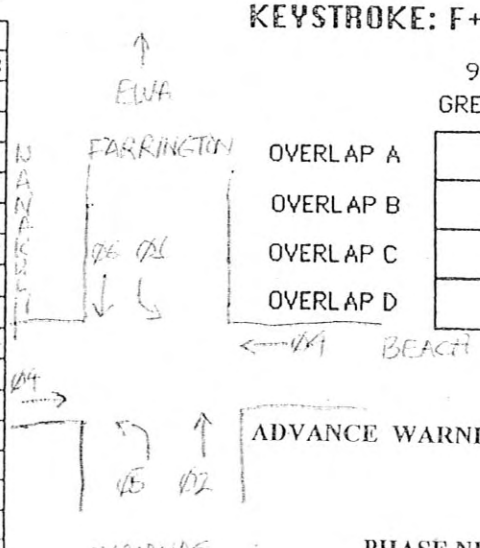
* MUST BE SAME FOR NON-DENSITY OPERATION

ALL RED START (F-C-0)= _____

PHASE FUNCTION FLAGS

KEYSTROKES: F+F+FUNCTION#

FUNCTION		PHASE 1	2	3	4	5	6	7	8
PERMIT	0		X		X	X	X		
RED LOCK	1								
YELLOW LOCK	2								
VEH RECALL	3		X			X	X		
PED RECALL	4						X		
PEDS	5								
REST IN WALK	6								
RED REST	7								
DOUBLE ENTRY	8								
MAX RECALL	9								
SOFT RECALL	A								
MAX 2	B								
COND SERVE	C								
MAN CONT RECALL	D								
STARTUP	E		X				X		
FIRST PHASES	F				X				



OVERLAP TIMING

KEYSTROKE: F+ COLOR CODE+OVERLAP

	9 GREEN	C YELLO	D RED
OVERLAP A			
OVERLAP B			
OVERLAP C			
OVERLAP D			

		C	D
PHASE NUMBER 1-8	1		
TIME AFTER START OF GREEN (0-25.5 SEC)	2		
TIME BEFORE YELLOW (0-25.5 SEC)	3		

INTERSECTION: FARRINGTON at HALEAKALA

by: _____ Date: 4-5-94

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BASE DISPLAY

COORDINATION — 0

DEMAND (VEH & PEDS) — 1 2 3 4 5 6 7 8

PREEMPTION — 9

A		b
PHASE	INTVL	PHASE	INTVL

RING A | RING B

1	2	3	4	RING A
5	6	7	8	RING B

PHASES

INTERVALS

0 - WALK
1 - FLASH DONT WALK
2 - MINIMUM GREEN
3 -
4 - VARIABLE INITIAL
5 - EXTENSION
6 -
7 - REDUCED GAP
8 - RED REST
9 - PREEMPTION
A - STOP TIME
B - RED REVERT
C - GAP TERMINATION
D - MAX TERMINATION
E - FORCEOFF
F - RED CLEARANCE

OVERLAP LOAD SWITCH ASSIGNMENT D-0-

OVERLAP A		(0-8)
OVERLAP B		(0-8)
OVERLAP C		(0-8)
OVERLAP D		(0-8)

bAdE	EPROM ERROR, SEE C-E-D WATCHDOG STOPS IF F-C-F = 0
bAdA	TURN STOPTIME SW ON THEN OFF TO REINITIALIZE

CONFIGURATION DATA

NOTE: "E" KEY ENABLED (F-9-E ≠ 0)

KEYSTROKES: E+E+INTERVAL

INTERVAL		PHASE 1	2	3	4	5	6	7	8
0	EXCLU PH								
1	RR1 GRN CL								
2	RR2 GRN CL								
3	RR2 LTD								
4	PROT/PERM					X			
5	OLA GOMIT								
6	OLB GOMIT								
7	OLC GOMIT								
8	OLD GOMIT								
9	OV FL YEL								
A	EMVEH A								
B	EMVEH B								
C	EMVEH C								
D	EMVEH D								
E	EXTRA	X							
F	IC SELECT		X						

EXTRA (E+E+E)

1-TBC TYPE 1
3-DAYLIGHT SAV
4-EV ADVANCE
5-RESERVED
6-SPECIAL EVENT
7-PRETIMED
8-SPLIT RING

IC SELECT (E+E+F)

2-DUPLEX LOCAL
3-7 WIRE IN
4-FLH/FREE
6-SIMPLEX MASTER
7-7 WIRE OUT
8-OFFSET INTERRUPTER

ASSIGN5 (E+F+F)

1-RT OVERLAP
2-TOD OUTPUTS
3-STEADY EV BEACON
4-FLASH EV BEACON
5-RESERVED
6-PHASES 3 & 7 PED
7-ADVANCE WARNING BEACON
8-SPECIAL EVENT

KEYSTROKES: E+F+INTERVAL

INTERVAL		PHASE 1	2	3	4	5	6	7	8
0									
1	RR OLAP A								
2	RR OLAP B								
3	RR OLAP C								
4	RR OLAP D								
5	PED2P								
6	PED6P						X		
7	PED4P				X				
8	PED8P								
9	FLH YELO								
A	OVERLAP A								
B	OVERLAP B								
C	OVERLAP C								
D	OVERLAP D								
E	RESTRICT								
F	ASSIGN5								

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PHASE TIMING

KEYSTROKES: F+PHASE+INTERVAL

INTERVAL		PHASE 1	2	3	4	5	6	7	8	PREEMPT	E	
WALK	0				7		7			RR1 DELAY		0
FLASH D/W	1				20		10			RR1 CLEAR		1
MIN GREEN	2		30		5	8	30			EVA DELAY		2
TYPE 3 DET	3									EVA CLEAR		3
ADD/VEH	4									EVB DELAY		4
VEH EXTEN *	5		4		3	1	4			EVB CLEAR		5
MAX GAP *	6		4		3	1	4			EVC DELAY		6
MIN GAP *	7		4		3	1	4			EVC CLEAR		7
MAX EXTEN	8		60		35	15	60			EVD DELAY		8
MAX 2	9				35	45				EVD CLEAR		9
	A									RR2 DELAY		A
CALLTO PHASE	B									RR2 CLEAR		B
REDUCE BY	C									EV CLR TMR		C
REDUCE EVERY	D									EV DLY TMR		D
YELLOW	E		5		4	4	5			RR CLR TMR		E
RED CLEAR	F		2		1	1	2			RR DLY TMR		F

MAX INITIAL (F-0-E) = _____

RED REVERT (F-0-F) = _____

ALL RED START (F-C-0)= _____

* MUST BE SAME FOR NON-DENSITY OPERATION

PHASE FUNCTION FLAGS

KEYSTROKES: F+F+FUNCTION#

FUNCTION		PHASE 1	2	3	4	5	6	7	8
PERMIT	0		X		X	X	X		
RED LOCK	1								
YELLOW LOCK	2								
VEH RECALL	3		X			X	X		
PED RECALL	4						X		
PEDS	5								
REST IN WALK	6								
RED REST	7								
DOUBLE ENTRY	8								
MAX RECALL	9								
SOFT RECALL	A								
MAX 2	B								
COND SERVE	C								
MAN CONT RECALL	D								
STARTUP	E		X				X		
FIRST PHASES	F				X				

TO MAKLAW

Farrington

4P

6P

Halcoketa

OVERLAP TIMING

KEYSTROKE: F+ COLOR CODE+OVERLAP

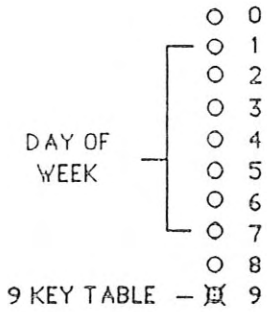
	9 GREEN	C YELLO	D RED
OVERLAP A			
OVERLAP B			
OVERLAP C			
OVERLAP D			

ADVANCE WARNING CIRCUIT CONTROL

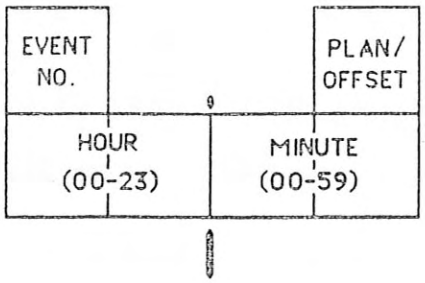
		C	D
PHASE NUMBER 1-8	1		
TIME AFTER START OF GREEN (0-25.5 SEC)	2		
TIME BEFORE YELLOW (0-25.5 SEC)	3		

TO MAKLAW

9-KEY



TIME OF DAY DISPLAYS



16 EVENT TABLE

TIME BASE COORDINATION

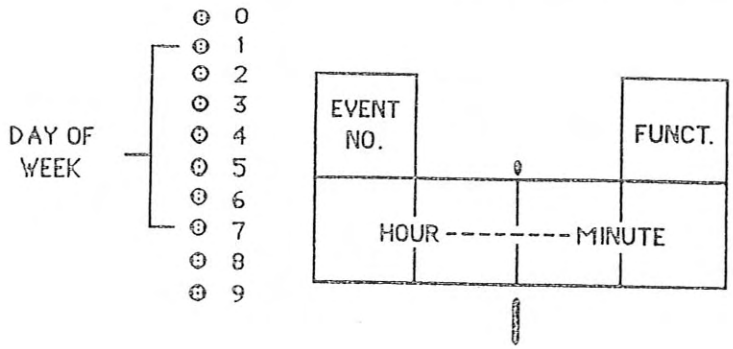
KEYSTROKES: 9+EVENT#

EVENT	TIME	PLAN	OFFSET	DAY OF WEEK S 1	M 2	T 3	W 4	T 5	F 6	S 7
0	0445	2	A		X	—	—	—	X	
1	0545	8	A		X	—	—	—	X	
2	0645	9	A		X	—	—	—	X	
3	0830	1	A		X	—	—	—	X	
4	1400	8	B	X	X	—	—	—	X	X
5	1500	5	A		X	—	—	—	X	
6	1515	6	A		X	—	—	—	X	
7	1545	7	A		X	—	—	—	X	
8	1830	5	A		X	—	—	—	X	
9	1930	8	B		X	—	—	—	X	
A	2030	1	A	X	—	—	—	—	—	X
B	2200	E	A	X	—	—	—	—	—	X
C	0730	1	A	X						X
D										
E										
F										

PLAN = 1...9 (DIAL)
E (FREE)
F (FLASH)

OFFSET = A...C

TIME OF DAY LOCAL FUNCTIONS



TIME OF DAY FUNCTIONS
KEYSTROKES: 7 + EVENT#

EVENT	TIME	FUNCT	S 1	M 2	T 3	W 4	T 5	F 6	S 7
0	0645	B		X	—	—	—	X	
1	0745	B		X	—	—	—	X	
2									
3									
4									
5									
6									
7									
8									
9									
A									
B									
C									
D									
E									
F									

FUNCTION BY PHASE
KEYSTROKES: D-F-EVENT#

EVENT	1	2	3	4	5	6	7	8
0				X	X			
1								
2								
3								
4								
5								
6								
7								
8								
9								
A								
B								
C								
D								
E								
F								

TIME OF DAY LOCAL FUNCTION CODES

0 - PERMIT
1 - RED LOCK
2 - YELLOW OCK
3 - VEH RECALL
4 - PED RECALL
5 - RESERVED
6 - REST IN WALK
7 - RED REST
8 - DBL ENTRY
9 - VEH MAX RCL
A - SOFT RECALL
B - MAX II EXT
C - COND SERVE
D - TOD LAG Ø

E - 1-LOCAL OVERRIDE
2-PHASE BANK 2
3-PHASE BANK 3
4-DISABLE DET OFF
7-DET COUNT
8-SPLIT MONITOR

F - TOD OUTPUTS
1 - TOD OUT 1
2 - TOD OUT 2
3 - TOD OUT 3
4 - TOD OUT 4

200

VERSION 1.F
OCT. 1991

COORDINATION TIMING

KEYSTROKES: C+PLAN+FEATURE

FEATURE		PLAN 1	2	3	4	5	6	7	8	9	
		sh 90									
CYCLE	0	120	120	120	160	200	220	240	150	160	0
FORCE1	1										1
FORCE2	2	0	0	0	0	0	0	0		0	2
FORCE3	3										3
FORCE4	4	28	28	28	28	35	35	35	35	38	4
FORCE5	5	43	43	43	43	51	51	51	51	62	5
FORCE6	6	0	0	0	0	0	0	0		0	6
FORCE7	7										7
FORCE8	8										8
RING OFFSET	9										9
OFFSET A	A	0	46	0	54	70	70	70	46	155	A
OFFSET B	B								0		B
OFFSET C	C										C
PERMISSIVE	D										D
HOLD RELEASE	E	255									E
ZONE OFFSET	F										F

ADDRESS (C-0-0)= 2

MANUAL PLAN: (C-A-1)= Ø

AUTO = 0
PLAN = 1-9
FREE = 14
FLASH = 15

MANUAL OFFSET: (C-B-1)=

AUTO = 0
OFFSET A = 1
OFFSET B = 2
OFFSET C = 3

TRANSITION TYPE (C-D-D)=

SHORTWAY = 0
DWELL > 0

FORCEOFF SHIFT FOR PEDESTRIAN (C-D-F)

FOR OBSERVATION ONLY

MASTER PLAN (C-A-2)
CURRENT PLAN (C-A-3)
TOD PLAN (C-A-5)
MASTER CYCLE (C-A-0)
RING A CYCLE (C-B-0)
RING B CYCLE (C-D-0)
MINIMUM CYCLE (C-A-E)
MAXIMUM CYCLE (C-B-E)

SYNCHRONIZED PHASES

KEYSTROKES: C+E+PLAN

PLAN		PHASE 1	2	3	4	5	6	7	8
0									
1	SYNC 1		X			X			
2	SYNC 2		X			X			
3	SYNC 3		X			X			
4	SYNC 4		X			X			
5	SYNC 5		X			X			
6	SYNC 6		X			X			
7	SYNC 7		X			X			
8	SYNC 8		X			X			
9	SYNC 9		X			X			
A	CPEDRCL								
B	NEMA HLD								
C	SCANMEM								
D	BADPROM								
E	TODFN E								
F	TODFN F								

PHASE SEQUENCES

KEYSTROKES: C+F+FUNCTION#

Ø5 has "left turn yield on green" sign

FUNCTION		PHASE 1	2	3	4	5	6	7	8
0	LAG 0 (FREE)								
1	LAG 1								
2	LAG 2								
3	LAG 3								
4	LAG 4								
5	LAG 5								
6	LAG 6								
7	LAG 7								
8	LAG 8								
9	LAG 9								
A	COOR MAX RECALL								
B	COOR LAG RECALL								
C	SYNC PHASES								
D	HOLD								
E	NEXT PHASE								
F	FORCE OFF								

BI TRAN SYSTEMS, INC.

INTERSECTION: FARRINGTON at NANAIKAIONO X-WALK

by: _____ Date: 4.29.94

PROGRAM **200**

VERSION 1.F
OCT. 1991

BASE DISPLAY

COORDINATION — 0
DEMAND (VEH & PEDS) — 1, 2, 3, 4, 5, 6, 7, 8
PREEMPTION — 9

A		b	
PHASE	INTVL	PHASE	INTVL

RING A | RING B

1	2	3	4	RING A
5	6	7	8	RING B

PHASES

INTERVALS

0 - WALK
1 - FLASH DONT WALK
2 - MINIMUM GREEN
3 -
4 - VARIABLE INITIAL
5 - EXTENSION
6 -
7 - REDUCED GAP
8 - RED REST
9 - PREEMPTION
A - STOP TIME
B - RED REVERT
C - GAP TERMINATION
D - MAX TERMINATION
E - FORCEOFF
F - RED CLEARANCE

OVERLAP LOAD SWITCH ASSIGNMENT D-0-

OVERLAP A		(0-8)
OVERLAP B		(0-8)
OVERLAP C		(0-8)
OVERLAP D		(0-8)

bAdE EPROM ERROR, SEE C-E-D
WATCHDOG STOPS IF F-C-F = 0

bAdA TURN STOPTIME SW ON THEN OFF TO REINITIALIZE

CONFIGURATION DATA

NOTE: "E" KEY ENABLED (F-9-E ≠ 0)

KEYSTROKES: E+E+INTERVAL

INTERVAL		PHASE 1	2	3	4	5	6	7	8
0	EXCLU PH								
1	RR1 GRN CL								
2	RR2 GRN CL								
3	RR2 LTD								
4	PROT/PERM								
5	OLA GOMIT								
6	OLB GOMIT								
7	OLC GOMIT								
8	OLD GOMIT								
9	OV FL YEL								
A	EMVEH A								
B	EMVEH B								
C	EMVEH C								
D	EMVEH D								
E	EXTRA	X							
F	IC SELECT		X						

EXTRA (E+E+E)

1-TBC TYPE 1
3-DAYLIGHT SAV
4-EV ADVANCE
5-RESERVED
6-SPECIAL EVENT
7-PRETIMED
8-SPLIT RING

IC SELECT (E+E+F)

2-DUPLEX LOCAL
3-7 WIRE IN
4-FLH/FREE
6-SIMPLEX MASTER
7-7 WIRE OUT
8-OFFSET INTERRUPTER

ASSIGN5 (E+F+F)

1-RT OVERLAP
2-TOD OUTPUTS
3-STEADY EV BEACON
4-FLASH EV BEACON
5-RESERVED
6-PHASES 3 & 7 PED
7-ADVANCE WARNING BEACON
8-SPECIAL EVENT

KEYSTROKES: E+F+INTERVAL

INTERVAL		PHASE 1	2	3	4	5	6	7	8
0									
1	RR OLAP A								
2	RR OLAP B								
3	RR OLAP C								
4	RR OLAP D								
5	PED2P								
6	PED6P								
7	PED4P				X				
8	PED8P								
9	FLH YELO								
A	OVERLAP A								
B	OVERLAP B								
C	OVERLAP C								
D	OVERLAP D								
E	RESTRICT								
F	ASSIGN5								

BI TRAN SYSTEMS, INC.

200

VERSION 1.F
OCT. 1991

PHASE TIMING

KEYSTROKES: F+PHASE+INTERVAL

INTERVAL		PHASE 1	2 (FARRINGTON)	3	4 (PED PHASE)	5	6	7	8	PREEMPT		
											E	
WALK	0				10					RR1 DELAY		0
FLASH D/W	1				15					RR1 CLEAR		1
MIN GREEN	2		60		5					EVA DELAY		2
TYPE 3 DET	3									EVA CLEAR		3
ADD/VEH	4									EVB DELAY		4
VEH EXTEN *	5		5							EVB CLEAR		5
MAX GAP *	6		5							EVC DELAY		6
MIN GAP *	7		5							EVC CLEAR		7
MAX EXTEN	8		10							EVD DELAY		8
MAX 2	9									EVD CLEAR		9
	A									RR2 DELAY		A
CALLTO PHASE	B									RR2 CLEAR		B
REDUCE BY	C									EV CLR TMR		C
REDUCE EVERY	D									EV DLY TMR		D
YELLOW	E		4		4					RR CLR TMR		E
RED CLEAR	F		3		1					RR DLY TMR		F

MAX INITIAL (F-0-E) = _____

RED REVERT (F-0-F) = _____

ALL RED START (F-C-0)= _____

* MUST BE SAME FOR NON-DENSITY OPERATION

PHASE FUNCTION FLAGS

KEYSTROKES: F+F+FUNCTION#

FUNCTION		PHASE 1	2	3	4	5	6	7	8
PERMIT	0		X		X				
RED LOCK	1								
YELLOW LOCK	2								
VEH RECALL	3		X						
PED RECALL	4								
PEDS	5								
REST IN WALK	6								
RED REST	7								
DOUBLE ENTRY	8								
MAX RECALL	9		X						
SOFT RECALL	A								
MAX 2	B								
COND SERVE	C								
MAN CONT RECALL	D								
STARTUP	E								
FIRST PHASES	F								

OVERLAP TIMING

KEYSTROKE: F+ COLOR CODE+OVERLAP

	9 GREEN	C YELLO	D RED
OVERLAP A			
OVERLAP B			
OVERLAP C			
OVERLAP D			

ADVANCE WARNING CIRCUIT CONTROL

		C	D
PHASE NUMBER 1-8	1		
TIME AFTER START OF GREEN (0-25.5 SEC)	2		
TIME BEFORE YELLOW (0-25.5 SEC)	3		

FARRINGTON / NANAIKAPONO X WALK

2

200

VERSION 1.F
OCT. 1991

COORDINATION TIMING

KEYSTROKES: C+PLAN+FEATURE

FEATURE		PLAN 1	2	3	4	5	6 (220)	7	8	9	
CYCLE	0	90	120	120		200	~~220~~	240	150	160	0
FORCE1	1										1
FORCE2	2	Ø	Ø	Ø		Ø	Ø	Ø		Ø	2
FORCE3	3										3
FORCE4	4	32	32	32		32	32	32	32	32	4
FORCE5	5										5
FORCE6	6										6
FORCE7	7										7
FORCE8	8										8
RING OFFSET	9										9
OFFSET A	A	Ø	46	15		80	80	80	46	140	A
OFFSET B	B								10		B
OFFSET C	C										C
PERMISSIVE	D										D
HOLD RELEASE	E	255									E
ZONE OFFSET	F										F

ADDRESS (C-0-0)= 3

MANUAL PLAN: (C-A-1)= Ø
- AUTO = 0
- PLAN = 1-9
- FREE = 14
- FLASH = 15

MANUAL OFFSET: (C-B-1)=
- AUTO = 0
- OFFSET A = 1
- OFFSET B = 2
- OFFSET C = 3

TRANSITION TYPE (C-D-D)=
- SHORTWAY = 0
- DWELL > 0

FORCEOFF SHIFT FOR PEDESTRIAN (C-D-F)=

FOR OBSERVATION ONLY

MASTER PLAN	(C-A-2)
CURRENT PLAN	(C-A-3)
TOD PLAN	(C-A-5)
MASTER CYCLE	(C-A-0)
RING A CYCLE	(C-B-0)
RING B CYCLE	(C-D-0)
MINIMUM CYCLE	(C-A-E)
MAXIMUM CYCLE	(C-B-E)

SYNCHRONIZED PHASES

KEYSTROKES: C+E+PLAN

PLAN		PHASE 1	2	3	4	5	6	7	8
0									
1	SYNC 1		X				X		
2	SYNC 2								
3	SYNC 3								
4	SYNC 4								
5	SYNC 5								
6	SYNC 6								
7	SYNC 7								
8	SYNC 8								
9	SYNC 9		X				X		
A	CPEDRCL								
B	NEMA HLD								
C	SCANMEM								
D	BADPROM								
E	TODFN E								
F	TODFN F								

PHASE SEQUENCES

KEYSTROKES: C+F+FUNCTION#

FUNCTION		PHASE 1	2	3	4	5	6	7	8
0	LAG 0 (FREE)		X		X		X		X
1	LAG 1								
2	LAG 2								
3	LAG 3								
4	LAG 4								
5	LAG 5								
6	LAG 6								
7	LAG 7								
8	LAG 8								
9	LAG 9		X		X		X		X
A	COOR MAX RECALL								
B	COOR LAG RECALL								
C	SYNC PHASES								
D	HOLD								
E	NEXT PHASE								
F	FORCE OFF								

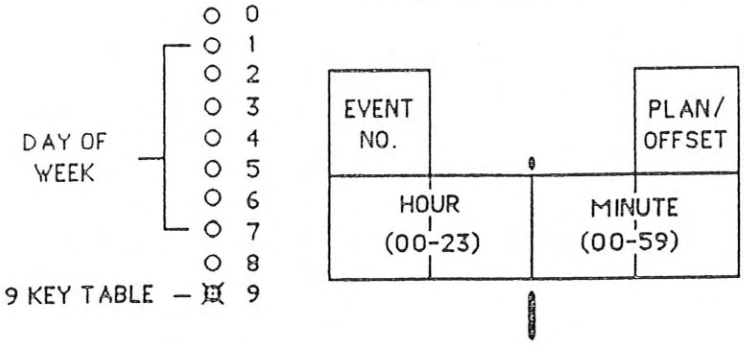
BI TRAN SYSTEMS, INC.

FARRINGTON/NANAIKAPONO
X WALK

3

9-KEY

TIME OF DAY DISPLAYS



16 EVENT TABLE

TIME BASE COORDINATION

KEYSTROKES: 9+EVENT#

EVENT	TIME	PLAN	OFFSET	DAY OF WEEK S 1	M 2	T 3	W 4	T 5	F 6	S 7
0	0445	2	A		X	X	X	X	X	
1	0545	8	A							
2	0645	9	A							
3	0830	1	A							
4	1400	8	B	X						X
5	1500	5	A							
6	1515	6	A							
7	1545	7	A							
8	1830	5	A							
9	1930	8	B							
A	2030	1	A	X						X
B	2200	E	A	X	X	X	X	X	X	X
C	0730	1	A	X						X
D										
E										
F										

PLAN = 1...9 (DIAL)
E (FREE)
F (FLASH)

OFFSET = A...C

BI TRAN SYSTEMS, INC.

FARRINGTON/
NANAIKAPONO X WALK

4

APPENDIX B TRAFFIC COUNT DATA

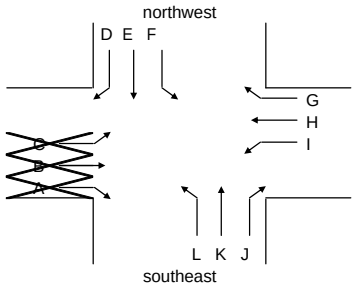
AM COUNT SHEET

Intersection: Farrington Hwy & Haleakala Ave

Date: 8 Apr 2009

By: G. Kandathil

Weather: clear & hot



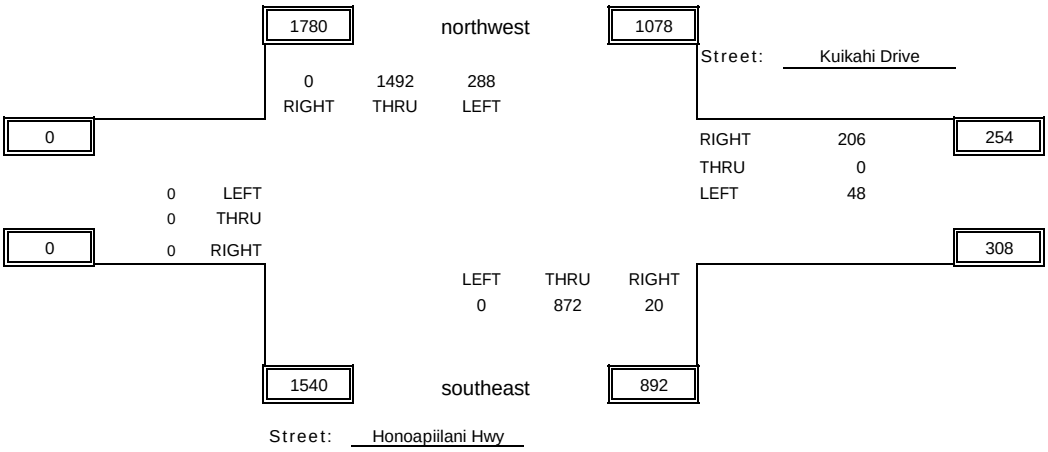
Street: Kuikahi Drive

Street: Honoapiilani Hwy

TIME	NEBR A	NEBT B	NEBL C	SEBR D	SEBT E	SEBL F	SWBR G	SWBT H	SWBL I	NWBR J	NWBT K	NWBL L	Total Mvmt	Total Hour
6:00 AM - 6:15 AM					442	13	27		15	17	103		617	2754
6:15 AM - 6:30 AM					468	23	29		8	2	131		661	2874
6:30 AM - 6:45 AM					515	32	18		3	0	190		758	2991
6:45 AM - 7:00 AM					410	50	34		8	2	214		718	2926
7:00 AM - 7:15 AM					396	76	44		14	5	202		737	
7:15 AM - 7:30 AM					380	68	64		16	5	245		778	
7:30 AM - 7:45 AM					306	94	64		10	8	211		693	
7:45 AM - 8:00 AM													0	
Phf	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.724	0.947	0.805	#DIV/0!	0.750	1.000	0.890	#DIV/0!	Peak	Phf
6:45 AM - 7:45 AM	0	0	0	0	1492	288	206	0	48	20	872	0	2926	0.965

Peak Hour

6:45 AM - 7:45 AM



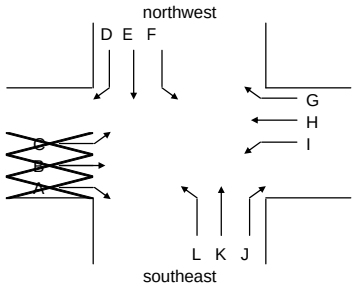
AM COUNT SHEET

Intersection: Farrington Hwy & Haleakala Ave

Date: 8 Apr 2009

By: G. Kandathil

Weather: clear & hot



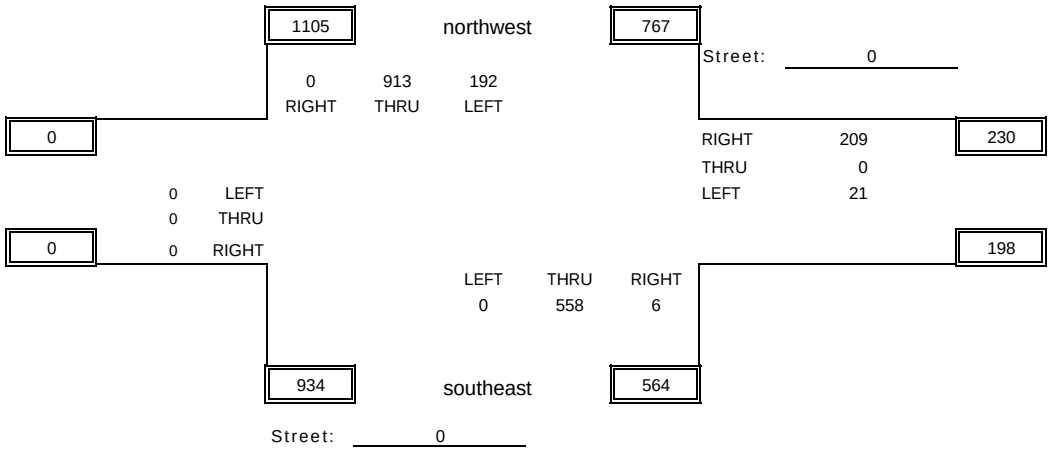
Street: _____

Street: _____

TIME	NEBR A	NEBT B	NEBL C	SEBR D	SEBT E	SEBL F	SWBR G	SWBT H	SWBL I	NWBR J	NWBT K	NWBL L	Total Mvmt	Total Hour
12:30 PM - 12:45 PM					237	31	44		3	3	152		470	1899
12:45 PM - 1:00 PM					232	54	34		5	1	165		491	1823
1:00 PM - 1:15 PM					218	68	67		7	2	106		468	1644
1:15 PM - 1:30 PM					226	39	64		6	0	135		470	1617
1:30 PM - 1:45 PM					165	29	84		5	0	111		394	
1:45 PM - 2:00 PM					139	24	24		7	1	117		312	
2:00 PM - 2:15 PM					171	26	18		5	0	221		441	
2:15 PM - 2:30 PM													0	
Phf	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.010	0.706	0.622	#DIV/0!	0.750	0.750	1.033	#DIV/0!	Peak	Phf
12:30 PM - 1:30 PM	0	0	0	0	913	192	209	0	21	6	558	0	1899	0.967

Peak Hour

12:30 PM - 1:30 PM



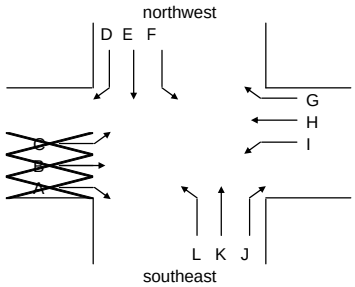
AM COUNT SHEET

Intersection: Farrington Hwy & Haleakala Ave

Date: 8 Apr 2009

By: G. Kandathil

Weather: clear & hot



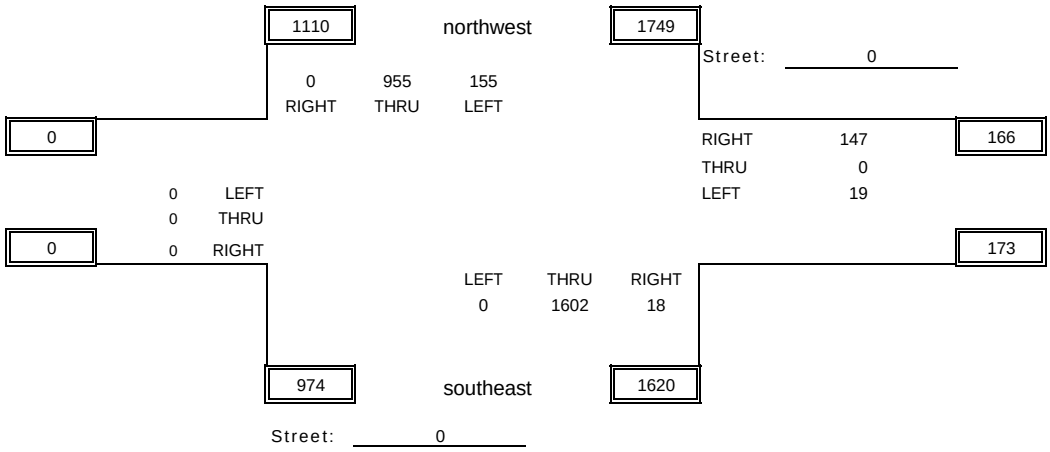
Street: _____

Street: _____

TIME	NEBR A	NEBT B	NEBL C	SEBR D	SEBT E	SEBL F	SWBR G	SWBT H	SWBL I	NWBR J	NWBT K	NWBL L	Total Mvmt	Total Hour
2:30 PM - 2:45 PM					242	32	35		6	6	350		671	2831
2:45 PM - 3:00 PM					272	23	33		20	15	376		739	2876
3:00 PM - 3:15 PM					214	31	49		8	4	388		694	2845
3:15 PM - 3:30 PM					246	31	37		3	6	404		727	2896
3:30 PM - 3:45 PM					228	44	40		5	4	395		716	2860
3:45 PM - 4:00 PM					236	40	41		7	6	378		708	
4:00 PM - 4:15 PM					245	40	29		4	2	425		745	
4:15 PM - 4:30 PM					208	34	56		8	7	378		691	
Phf	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.971	0.881	0.750	#DIV/0!	0.594	0.750	0.991	#DIV/0!	Peak	Phf
3:15 PM - 4:15 PM	0	0	0	0	955	155	147	0	19	18	1602	0	2896	0.980

Peak Hour

3:15 PM - 4:15 PM



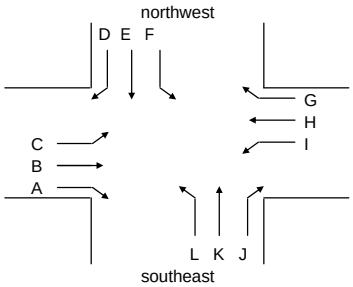
AM COUNT SHEET

Intersection: Farrington Hwy & Nanakuli Ave

Date: 8 Apr 2009

By: temporary staff (2)

Weather: clear & hot



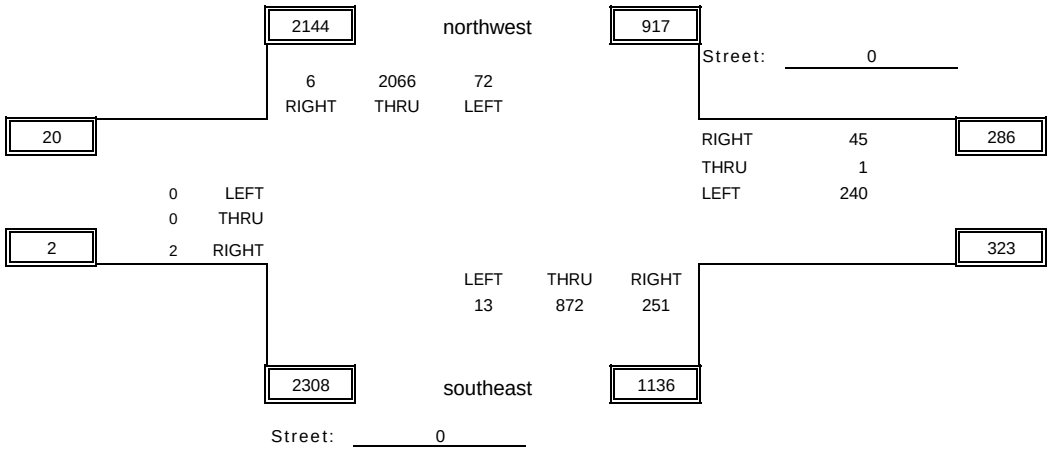
Street: _____

Street: _____

	NEBR	NEBT	NEBL	SEBR	SEBT	SEBL	SWBR	SWBT	SWBL	NWBR	NWBT	NWBL		
TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
6:00 AM - 6:15 AM	2	1	0	1	418	7	4	1	44	11	119	0	608	2988
6:15 AM - 6:30 AM	0	0	0	2	500	7	5	0	54	22	146	0	736	3284
6:30 AM - 6:45 AM	0	79	0	1	458	3	6	3	51	27	194	0	822	3497
6:45 AM - 7:00 AM	0	0	0	1	468	14	10	1	54	54	220	0	822	3568
7:00 AM - 7:15 AM	0	0	0	0	581	18	7	0	60	61	177	0	904	
7:15 AM - 7:30 AM	0	0	0	3	515	16	15	0	53	82	264	1	949	
7:30 AM - 7:45 AM	2	0	0	2	502	24	13	0	73	54	211	12	893	
7:45 AM - 8:00 AM													0	
Phf	#DIV/0!	0.000	#DIV/0!	0.500	0.889	1.000	0.750	0.083	1.000	0.765	0.826	3.250	Peak	Phf
6:45 AM - 7:45 AM	2	0	0	6	2066	72	45	1	240	251	872	13	3568	0.987

Peak Hour

6:45 AM - 7:45 AM



PARSONS
BRINCKERHOFF

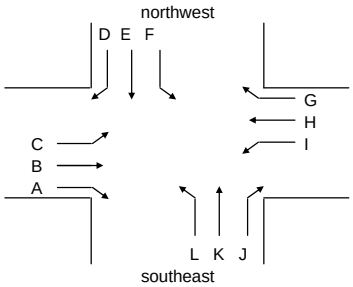
AM COUNT SHEET

Intersection: Farrington Hwy & Nanakuli Ave

Date: 8 Apr 2009

By: temporary staff (2)

Weather: clear & hot



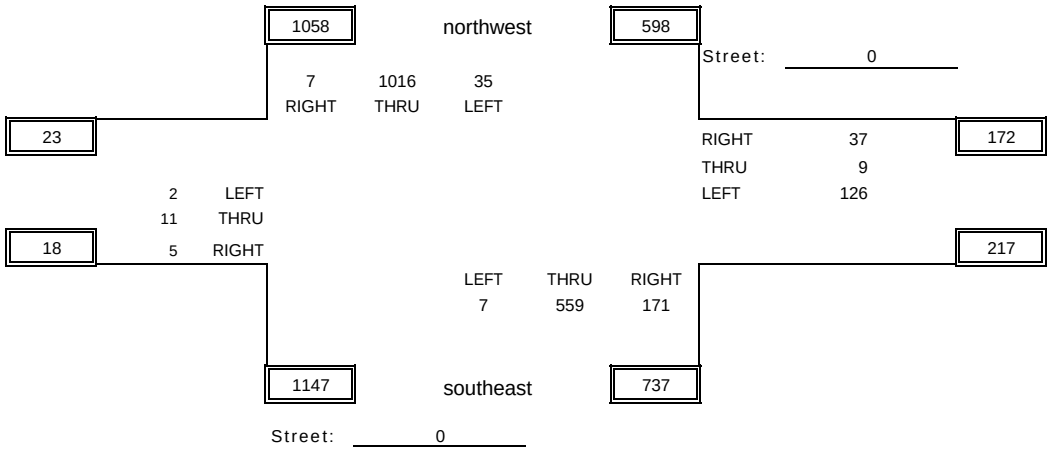
Street: _____

Street: _____

TIME	NEBR A	NEBT B	NEBL C	SEBR D	SEBT E	SEBL F	SWBR G	SWBT H	SWBL I	NWBR J	NWBT K	NWBL L	Total Mvmt	Total Hour
12:30 PM - 12:45 PM	1	0	1	2	237	8	5	1	28	49	180	1	513	1985
12:45 PM - 1:00 PM	2	3	0	0	274	10	11	2	28	47	163	1	541	1969
1:00 PM - 1:15 PM	2	3	0	2	246	12	9	3	39	44	87	2	449	1834
1:15 PM - 1:30 PM	0	5	1	3	259	5	12	3	31	31	129	3	482	2022
1:30 PM - 1:45 PM	0	2	3	2	226	5	12	1	55	52	139	0	497	
1:45 PM - 2:00 PM	2	2	0	2	185	7	4	1	27	33	143	0	406	
2:00 PM - 2:15 PM	1	1	0	0	267	8	5	2	28	61	261	3	637	
2:15 PM - 2:30 PM													0	
Phf	0.625	0.550	0.167	0.583	0.981	0.729	0.771	0.750	0.573	0.822	0.977	0.583	Peak	Phf
12:30 PM - 1:30 PM	5	11	2	7	1016	35	37	9	126	171	559	7	1985	0.917

Peak Hour

12:30 PM - 1:30 PM



PARSONS
BRINCKERHOFF

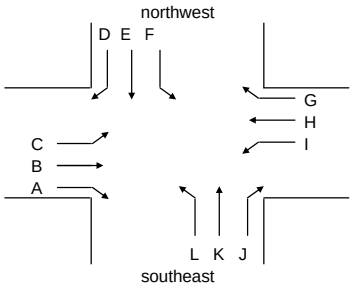
AM COUNT SHEET

Intersection: Farrington Hwy & Nanakuli Ave

Date: 8 Apr 2009

By: temporary staff (2)

Weather: clear & hot



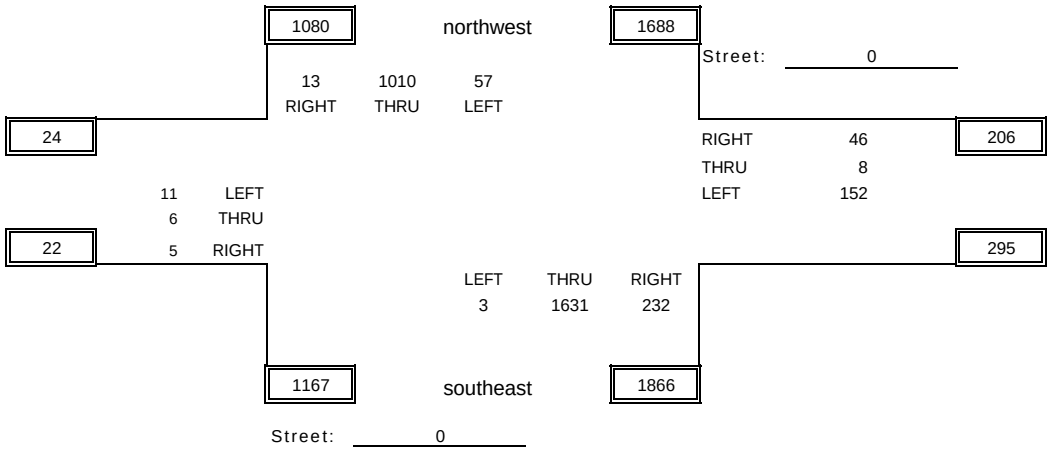
Street: _____

Street: _____

TIME	NEBR A	NEBT B	NEBL C	SEBR D	SEBT E	SEBL F	SWBR G	SWBT H	SWBL I	NWBR J	NWBT K	NWBL L	Total Mvmt	Total Hour
2:30 PM - 2:45 PM	1	2	2	4	243	12	15	3	32	47	358	2	721	3048
2:45 PM - 3:00 PM	1	11	12	6	289	7	17	2	52	33	348	0	778	3086
3:00 PM - 3:15 PM	2	4	5	2	226	5	6	1	42	61	394	0	748	3131
3:15 PM - 3:30 PM	3	0	4	7	241	9	10	1	46	63	416	1	801	3174
3:30 PM - 3:45 PM	0	0	3	2	208	17	11	0	26	74	418	0	759	3207
3:45 PM - 4:00 PM	1	1	3	2	298	17	15	6	42	42	395	1	823	
4:00 PM - 4:15 PM	1	5	1	2	263	14	10	1	38	53	402	1	791	
4:15 PM - 4:30 PM	0	0	1	2	259	10	9	2	33	64	454	0	834	
Phf	0.417	0.136	0.550	0.464	0.847	0.838	0.767	0.333	0.826	0.784	0.975	0.750	Peak	Phf
3:15 PM - 4:15 PM	5	6	11	13	1010	57	46	8	152	232	1631	3	3174	0.991

Peak Hour

3:15 PM - 4:15 PM



PARSONS
BRINCKERHOFF

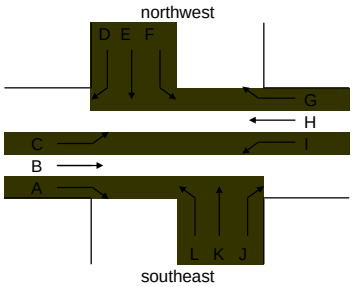
AM COUNT SHEET

Intersection: Ped Crossing on Farr Hwy b/t Haleakala Ave & Nanakuli Ave

Date: 2 Jun 2009

By: G. Kandathil

Weather: clear & hot



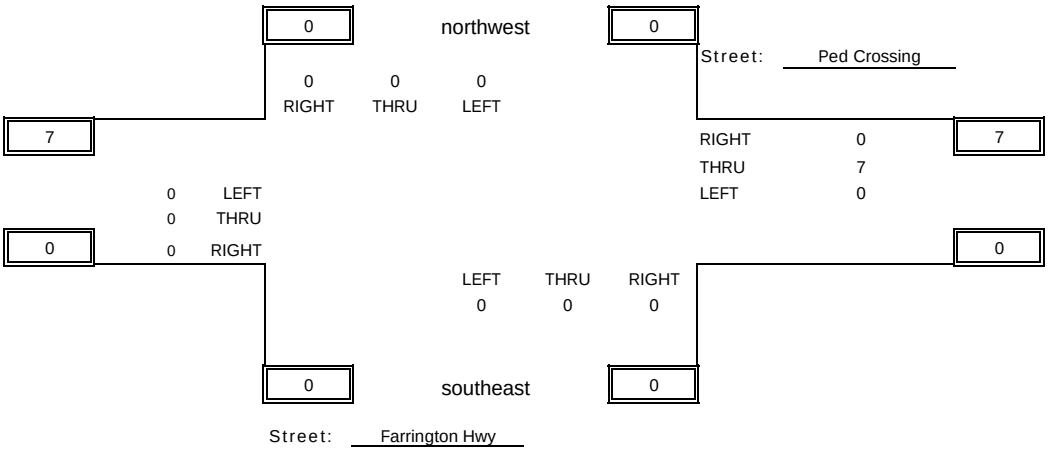
Street: Ped Crossing

Street: Farrington Hwy

TIME	NEBR A	NEBT B	NEBL C	SEBR D	SEBT E	SEBL F	SWBR G	SWBT H	SWBL I	NWBR J	NWBT K	NWBL L	Total Mvmt	Total Hour
6:30 AM - 6:45 AM		0						0					0	0
6:45 AM - 7:00 AM		0						0					0	0
7:00 AM - 7:15 AM		0						0					0	2
7:15 AM - 7:30 AM		0						0					0	7
7:30 AM - 7:45 AM		0						0					0	
7:45 AM - 8:00 AM		0						2					2	
8:00 AM - 8:15 AM		0						5					5	
8:15 AM - 8:30 AM		0						0					0	
Phf	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.875	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	Peak	Phf
	0	0	0	0	0	0	0	7	0	0	0	0	7	#DIV/0!

Peak Hour

12:00 AM # 12:00 AM



PARSONS BRINCKERHOFF

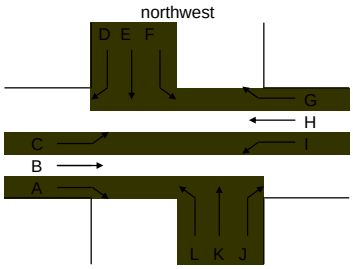
AM COUNT SHEET

Intersection: Ped Crossing on Farr Hwy b/t Haleakala Ave & Nanakuli Ave

Date: 2 Jun 2009

By: G. Kandathil

Weather: clear & hot



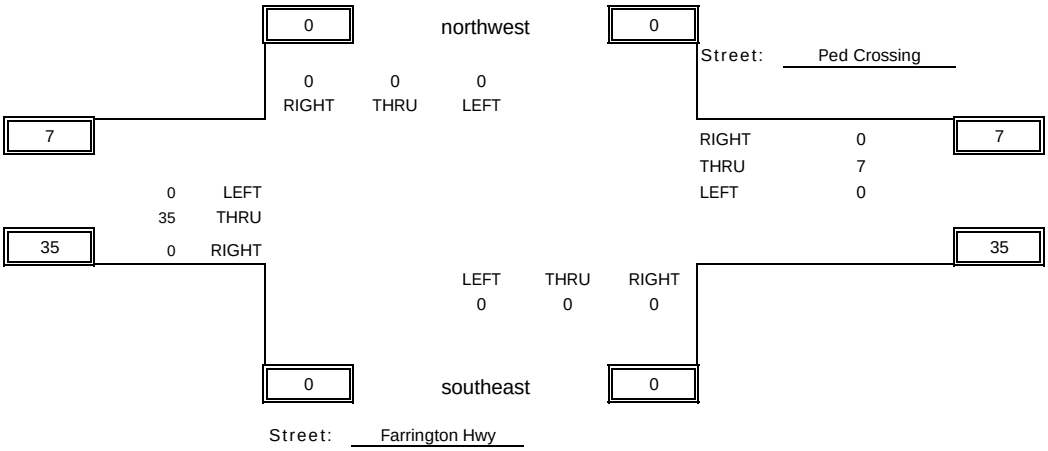
Street: Ped Crossing

Street: Farrington Hwy

TIME	NEBR A	NEBT B	NEBL C	SEBR D	SEBT E	SEBL F	SWBR G	SWBT H	SWBL I	NWBR J	NWBT K	NWBL L	Total Mvmt	Total Hour
2:00 PM - 2:15 PM		0						0					0	38
2:15 PM - 2:30 PM		0						0					0	42
2:30 PM - 2:45 PM		1						3					4	42
2:45 PM - 3:00 PM		31						3					34	45
3:00 PM - 3:15 PM		3						1					4	
3:15 PM - 3:30 PM		0						0					0	
3:30 PM - 3:45 PM		4						3					7	
3:45 PM - 4:00 PM		0						1					1	
4:00 PM - 4:15 PM		0						0					0	
4:15 PM - 4:30 PM		0						4					4	
4:30 PM - 4:45 PM		0						0					0	
4:45 PM - 5:00 PM		0						0					0	
Phf	#DIV/0!	0.282	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.583	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	Peak	Phf
	0	35	0	0	0	0	0	7	0	0	0	0	42	0.309

Peak Hour

12:00 AM # 12:00 AM



PARSONS BRINCKERHOFF

Charter School Peak-Hour Access and Egress Vehicle Counts

Time	Honolulu-side Entrance/Exit				Waianae-side Entrance/Exit			
	Entering		Exiting		Entering		Exiting	
	From North	From South	To North	To South	From North	From South	To North	To South
6:30 - 6:45	7	3	1	1	0	0	0	1
6:45 - 7:00	12	10	2	2	1	0	0	0
7:00 - 7:15	17	1	5	7	3	0	0	0
7:15 - 7:30	3	4	1	5	0	0	2	0
7:30 - 7:45	15	7	8	9	5	2	2	2
7:45 - 8:00	30	22	11	7	5	0	0	1
8:00 - 8:15	20	10	8	9	7	2	5	5
8:15 - 8:30	7	3	3	19	2	0	4	4
2:30 - 2:45	14	5	0	0	5	0	2	5
2:45 - 3:00	11	5	20	19	2	0	5	6
3:00 - 3:15	9	2	4	15	1	2	1	0
3:15 - 3:30	11	8	11	12	3	0	1	2
3:30 - 3:45	13	7	13	8	2	0	3	0
3:45 - 4:00	26	7	13	20	1	0	3	8
4:00 - 4:15	7	7	10	8	0	0	0	0
4:15 - 4:30	4	1	5	14	1	0	0	2

APPENDIX C ACCIDENT ANALYSIS

(Rev. 11/68)

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
MEMORANDUM

HWY-TS 2.1870

TO: HWY-DS **DATE:** April 30, 2009

FROM: HWY-T A. Yalutt

SUBJECT: TRAFFIC ACCIDENT ANALYSIS FOR FARRINGTON HIGHWAY INTERSECTION IMPROVEMENTS AT HALEAKALA AVENUE AND NANAKULI AVENUE, PROJECT NO. 93A-01-05, AND FARRINGTON HIGHWAY, MILEPOST 4.0 – 6.5.

The Traffic Branch has conducted a traffic accident analysis for the subject locations under its Highway Safety Improvement Program (HSIP) of Title 23, United States Code, and Section 148. This traffic accident analysis is protected under Title 23, U.S.C., Sections 402(k) and 409, and is intended for highway safety and educational purposes only.

The scope of this project, which includes installing left turn auxiliary lanes from Farrington Highway onto Haleakala Avenue and Nanakuli Avenue with left turn protective phases and installing a left turn auxiliary lane from Farrington Highway onto Nanakuli Beach Park Road, should decrease the number and severity of the accidents at these intersections.

The Traffic Branch has identified reinforcing the State milepost reference system as a priority. Milepost reference markers at every 1/2 of a mile should be installed at appropriate locations throughout the limits of this project. Proper locations should be verified with HWY-TD.

Please be reminded that the installation of milled centerline and shoulder rumble strips is a Highways initiative to proactively reduce the frequency and severity of accidents. We recommend considering the installation of this safety measure throughout the project limits.

If there are any questions, please call the Traffic Safety Section at 692-7685.

bc: HWY-TD

JH:mh

APPENDIX D LEVEL OF SERVICE DEFINITIONS

The Highway Capacity Manual defines six Intersection Levels of Service (LOS), labeled A through F, from free flow to congested conditions.

Levels of Service for signalized intersections is defined in terms of control delay, which is a measure of driver discomfort, frustration, fuel consumption, and increased travel time. The delay experienced by a motorist is made up of a number of factors that relate to control, geometrics, traffic, and incidents. Total delay is the difference between the travel time actually experienced and the reference travel time that would result during base conditions: in the absence of traffic control, geometric delay, any incidents, and any other vehicles. Specifically, LOS criteria for traffic signals are stated in terms of the average control delay per vehicle, typically for a 15-minute analysis period. Delay is a complex measure and depends on a number of variables, including the quality of progression, the cycle length, the green ratio, and the v/c ratio for the lane group.

LEVEL-OF-SERVICE A: Low control delay, up to 10 s/veh. This LOS occurs when progression is extremely favorable and most vehicles arrive during the green phase. Many vehicles do not stop at all. Short cycle lengths may tend to contribute to low delay values.

LEVEL-OF-SERVICE B: Control delay greater than 10 and up to 20 s/veh. This level generally occurs with good progression, short cycle lengths, or both. More vehicles stop than with LOS A, causing higher levels of delay.

LEVEL-OF-SERVICE C: Control delay greater than 20 and up to 35 s/veh. These higher delays may result from only fair progression, longer cycle lengths, or both. Individual cycle failures may begin to appear at this level. Cycle failure occurs when a given green phase does not serve queued vehicles, and overflows occur. The number of vehicles stopping is significant at this level, though many still pass through the intersection without stopping.

LEVEL-OF-SERVICE D: Control delay greater than 35 and up to 55 s/veh. At LOS D, the influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, and high v/c

ratios. Many vehicles stop, and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.

LEVEL-OF-SERVICE E: Control delay greater than 55 and up to 80 s/veh. These high delay values generally indicate poor progression, long cycle lengths, and high v/c ratios. Individual cycle failures are frequent.

LEVEL-OF-SERVICE F: Control delay in excess of 80 s/veh. This level, considered unacceptable to most drivers, often occurs with oversaturation, that is when arrival flow rates exceed the capacity of lane groups. It may also occur at high v/c ratios with many individual cycle failures. Poor progression and long cycle lengths may also contribute significantly to high delay levels.

For unsignalized intersections, the Highway Capacity Manual evaluates gaps in the major street traffic flow and calculates available gaps for left-turns across oncoming traffic and for the left and right-turns onto the major roadway from the minor street. Average control delay, based on these factors, is still used to define the levels of service.

LEVEL-OF-SERVICE A: Low control delay, up to 10 s/veh.

LEVEL-OF-SERVICE B: Control delay greater than 10 and up to 15 s/veh.

LEVEL-OF-SERVICE C: Control delay greater than 15 and up to 25 s/veh.

LEVEL-OF-SERVICE D: Control delay greater than 25 and up to 35 s/veh.

LEVEL-OF-SERVICE E: Control delay greater than 35 and up to 50 s/veh.

LEVEL-OF-SERVICE F: Control delay in excess of 50 s/veh.

APPENDIX E SYNCHRO REPORTS – EXISTING CONDITIONS

HCM Signalized Intersection Capacity Analysis
1: Farrington Hwy & Haleakala Ave (AM)

2/17/2010

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	288	1492	872	20	48	206
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0		5.0	
Lane Util. Factor		0.95	0.95		1.00	
Frpb, ped/bikes		1.00	0.99		0.95	
Flpb, ped/bikes		1.00	1.00		1.00	
Frt		1.00	1.00		0.89	
Flt Protected		0.99	1.00		0.99	
Satd. Flow (prot)		3461	3463		1563	
Flt Permitted		0.61	1.00		0.99	
Satd. Flow (perm)		2122	3463		1563	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	313	1622	948	22	52	224
RTOR Reduction (vph)	0	0	0	0	105	0
Lane Group Flow (vph)	0	1935	970	0	171	0
Confl. Peds. (#/hr)	14			54		23
Bus Blockages (#/hr)	0	6	6	0	1	0
Turn Type	pm+pt					
Protected Phases	1	6	2		8	
Permitted Phases	6					
Actuated Green, G (s)		117.3	117.3		21.0	
Effective Green, g (s)		117.3	117.3		21.0	
Actuated g/C Ratio		0.79	0.79		0.14	
Clearance Time (s)		5.0	5.0		5.0	
Vehicle Extension (s)		3.0	3.0		3.0	
Lane Grp Cap (vph)		1678	2739		221	
v/s Ratio Prot			0.28		c0.11	
v/s Ratio Perm		c0.91				
v/c Ratio		1.15	0.35		0.78	
Uniform Delay, d1		15.5	4.5		61.4	
Progression Factor		1.00	1.00		1.00	
Incremental Delay, d2		76.2	0.1		15.5	
Delay (s)		91.7	4.6		76.9	
Level of Service		F	A		E	
Approach Delay (s)		91.7	4.6		76.9	
Approach LOS		F	A		E	

Intersection Summary			
HCM Average Control Delay	63.9	HCM Level of Service	E
HCM Volume to Capacity ratio	1.10		
Actuated Cycle Length (s)	148.3	Sum of lost time (s)	10.0
Intersection Capacity Utilization	105.2%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
2: Farrington Hwy & Nanakuli Ave (AM)

2/17/2010

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	72	1462	6	13	872	251	0	0	2	240	1	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0			5.0	5.0
Lane Util. Factor		0.95			0.95			1.00			1.00	1.00
Frpb, ped/bikes		1.00			1.00			1.00			1.00	0.96
Flpb, ped/bikes		1.00			1.00			1.00			1.00	1.00
Frt		1.00			0.97			0.86			1.00	0.85
Flt Protected		1.00			1.00			1.00			0.95	1.00
Satd. Flow (prot)		3486			3379			1611			1774	1516
Flt Permitted		0.72			0.91			1.00			0.73	1.00
Satd. Flow (perm)		2510			3084			1611			1353	1516
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	78	1589	7	14	948	273	0	0	2	261	1	49
RTOR Reduction (vph)	0	0	0	0	8	0	0	2	0	0	0	29
Lane Group Flow (vph)	0	1674	0	0	1227	0	0	0	0	0	262	20
Confl. Peds. (#/hr)			1									15
Bus Blockages (#/hr)	0	6	0	0	6	0	0	0	0	0	0	0
Turn Type	pm+pt			Perm			Perm			Perm		Perm
Protected Phases	1	6			2			4			8	
Permitted Phases	6			2			4			8		8
Actuated Green, G (s)		115.1			115.1			32.9			32.9	32.9
Effective Green, g (s)		115.1			115.1			32.9			32.9	32.9
Actuated g/C Ratio		0.73			0.73			0.21			0.21	0.21
Clearance Time (s)		5.0			5.0			5.0			5.0	5.0
Vehicle Extension (s)		3.0			3.0			3.0			3.0	3.0
Lane Grp Cap (vph)		1828			2247			335			282	316
v/s Ratio Prot								0.00				
v/s Ratio Perm		c0.67			0.40						c0.19	0.01
v/c Ratio		0.92			0.55			0.00			0.93	0.06
Uniform Delay, d1		17.5			9.7			49.5			61.4	50.2
Progression Factor		1.00			1.00			1.00			1.00	1.00
Incremental Delay, d2		7.6			0.3			0.0			34.9	0.1
Delay (s)		25.1			9.9			49.5			96.3	50.3
Level of Service		C			A			D			F	D
Approach Delay (s)		25.1			9.9			49.5			89.0	
Approach LOS		C			A			D			F	

Intersection Summary			
HCM Average Control Delay	25.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.92		
Actuated Cycle Length (s)	158.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	107.7%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	0	1477	872	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0			
Lane Util. Factor		0.95	0.95			
Frt		1.00	1.00			
Flt Protected		1.00	1.00			
Satd. Flow (prot)		3539	3539			
Flt Permitted		1.00	1.00			
Satd. Flow (perm)		3539	3539			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	1605	948	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	1605	948	0	0	0
Turn Type						
Protected Phases		2	6			
Permitted Phases						
Actuated Green, G (s)		127.0	127.0			
Effective Green, g (s)		127.0	127.0			
Actuated g/C Ratio		0.79	0.79			
Clearance Time (s)		5.0	5.0			
Lane Grp Cap (vph)		2809	2809			
v/s Ratio Prot		c0.45	0.27			
v/s Ratio Perm						
v/c Ratio		0.57	0.34			
Uniform Delay, d1		6.2	4.6			
Progression Factor		1.00	1.00			
Incremental Delay, d2		0.9	0.3			
Delay (s)		7.1	5.0			
Level of Service		A	A			
Approach Delay (s)		7.1	5.0		0.0	
Approach LOS		A	A		A	

Intersection Summary			
HCM Average Control Delay	6.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	160.0	Sum of lost time (s)	33.0
Intersection Capacity Utilization	45.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
1: Farrington Hwy & Haleakala Ave (MD)

2/17/2010

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	192	913	558	6	21	209
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0		5.0	
Lane Util. Factor		0.95	0.95		1.00	
Frpb, ped/bikes		1.00	1.00		0.97	
Flpb, ped/bikes		1.00	1.00		1.00	
Frt		1.00	1.00		0.88	
Flt Protected		0.99	1.00		1.00	
Satd. Flow (prot)		3491	3512		1570	
Flt Permitted		0.72	1.00		1.00	
Satd. Flow (perm)		2519	3512		1570	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	209	992	607	7	23	227
RTOR Reduction (vph)	0	0	1	0	201	0
Lane Group Flow (vph)	0	1201	613	0	49	0
Confl. Peds. (#/hr)	6			66		24
Bus Blockages (#/hr)	0	2	2	0	1	0
Turn Type	pm+pt					
Protected Phases	1	6	2		8	
Permitted Phases	6					
Actuated Green, G (s)		54.2	54.2		8.2	
Effective Green, g (s)		54.2	54.2		8.2	
Actuated g/C Ratio		0.75	0.75		0.11	
Clearance Time (s)		5.0	5.0		5.0	
Vehicle Extension (s)		3.0	3.0		3.0	
Lane Grp Cap (vph)		1886	2629		178	
v/s Ratio Prot			0.17		c0.03	
v/s Ratio Perm		c0.48				
v/c Ratio		0.64	0.23		0.27	
Uniform Delay, d1		4.4	2.8		29.4	
Progression Factor		1.00	1.00		1.00	
Incremental Delay, d2		0.7	0.0		0.8	
Delay (s)		5.1	2.8		30.2	
Level of Service		A	A		C	
Approach Delay (s)		5.1	2.8		30.2	
Approach LOS		A	A		C	

Intersection Summary			
HCM Average Control Delay	7.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	72.4	Sum of lost time (s)	10.0
Intersection Capacity Utilization	76.8%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	35	1016	7	7	559	171	2	11	5	126	9	37
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0			5.0	5.0
Lane Util. Factor		0.95			0.95			1.00			1.00	1.00
Frpb, ped/bikes		1.00			0.99			1.00			1.00	0.98
Flpb, ped/bikes		1.00			1.00			1.00			1.00	1.00
Frt		1.00			0.97			0.96			1.00	0.85
Flt Protected		1.00			1.00			0.99			0.96	1.00
Satd. Flow (prot)		3516			3381			1787			1780	1554
Flt Permitted		0.91			0.94			0.96			0.73	1.00
Satd. Flow (perm)		3210			3190			1730			1354	1554
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	38	1104	8	8	608	186	2	12	5	137	10	40
RTOR Reduction (vph)	0	0	0	0	19	0	0	4	0	0	0	32
Lane Group Flow (vph)	0	1150	0	0	783	0	0	15	0	0	147	8
Confl. Peds. (#/hr)						3						11
Bus Blockages (#/hr)	0	2	0	0	2	0	0	0	0	0	0	0
Turn Type	pm+pt			Perm			Perm			Perm		Perm
Protected Phases	1	6			2			4			8	
Permitted Phases	6			2			4			8		8
Actuated Green, G (s)		28.1			28.1			9.4			9.4	9.4
Effective Green, g (s)		28.1			28.1			9.4			9.4	9.4
Actuated g/C Ratio		0.59			0.59			0.20			0.20	0.20
Clearance Time (s)		5.0			5.0			5.0			5.0	5.0
Vehicle Extension (s)		3.0			3.0			3.0			3.0	3.0
Lane Grp Cap (vph)		1899			1887			342			268	308
v/s Ratio Prot												
v/s Ratio Perm		c0.36			0.25			0.01			c0.11	0.01
v/c Ratio		0.61			0.41			0.04			0.55	0.03
Uniform Delay, d1		6.2			5.3			15.4			17.1	15.4
Progression Factor		1.00			1.00			1.00			1.00	1.00
Incremental Delay, d2		0.6			0.1			0.1			2.3	0.0
Delay (s)		6.7			5.4			15.5			19.4	15.4
Level of Service		A			A			B			B	B
Approach Delay (s)		6.7			5.4			15.5			18.6	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM Average Control Delay	7.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	47.5	Sum of lost time (s)	10.0
Intersection Capacity Utilization	77.7%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	0	965	559	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		11.0	5.0			
Lane Util. Factor		0.95	0.95			
Frt		1.00	1.00			
Flt Protected		1.00	1.00			
Satd. Flow (prot)		3539	3539			
Flt Permitted		1.00	1.00			
Satd. Flow (perm)		3539	3539			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	1049	608	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	1049	608	0	0	0
Turn Type						
Protected Phases		6	2			
Permitted Phases						
Actuated Green, G (s)		51.0	57.0			
Effective Green, g (s)		51.0	57.0			
Actuated g/C Ratio		0.57	0.63			
Clearance Time (s)		11.0	5.0			
Lane Grp Cap (vph)		2005	2241			
v/s Ratio Prot		c0.30	0.17			
v/s Ratio Perm						
v/c Ratio		0.52	0.27			
Uniform Delay, d1		12.0	7.3			
Progression Factor		1.00	1.00			
Incremental Delay, d2		1.0	0.3			
Delay (s)		13.0	7.6			
Level of Service		B	A			
Approach Delay (s)		13.0	7.6		0.0	
Approach LOS		B	A		A	

Intersection Summary			
HCM Average Control Delay	11.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	39.0
Intersection Capacity Utilization	35.8%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
1: Farrington Hwy & Haleakala Ave (PM)

2/17/2010

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	155	955	1602	18	19	147
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0		5.0	
Lane Util. Factor		0.95	0.95		1.00	
Frpb, ped/bikes		1.00	0.99		0.93	
Flpb, ped/bikes		1.00	1.00		1.00	
Frt		1.00	1.00		0.88	
Flt Protected		0.99	1.00		0.99	
Satd. Flow (prot)		3501	3499		1507	
Flt Permitted		0.50	1.00		0.99	
Satd. Flow (perm)		1755	3499		1507	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	168	1038	1741	20	21	160
RTOR Reduction (vph)	0	0	0	0	92	0
Lane Group Flow (vph)	0	1206	1761	0	89	0
Confl. Peds. (#/hr)	6			66		24
Bus Blockages (#/hr)	0	2	2	0	1	0
Turn Type	pm+pt					
Protected Phases	1	6	2		8	
Permitted Phases	6					
Actuated Green, G (s)		200.2	200.2		18.4	
Effective Green, g (s)		200.2	200.2		18.4	
Actuated g/C Ratio		0.88	0.88		0.08	
Clearance Time (s)		5.0	5.0		5.0	
Vehicle Extension (s)		3.0	3.0		3.0	
Lane Grp Cap (vph)		1537	3064		121	
v/s Ratio Prot			0.50		c0.06	
v/s Ratio Perm		c0.69				
v/c Ratio		0.90dl	0.57		0.74	
Uniform Delay, d1		5.6	3.6		102.7	
Progression Factor		1.00	1.00		1.00	
Incremental Delay, d2		2.7	0.8		20.6	
Delay (s)		8.3	4.3		123.3	
Level of Service		A	A		F	
Approach Delay (s)		8.3	4.3		123.3	
Approach LOS		A	A		F	

Intersection Summary			
HCM Average Control Delay	12.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	228.6	Sum of lost time (s)	10.0
Intersection Capacity Utilization	104.3%	ICU Level of Service	G
Analysis Period (min)	15		

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
2: Farrington Hwy & Nanakuli Ave (PM)

2/17/2010

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	57	1010	13	3	1631	232	11	6	5	152	8	46
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0			5.0			5.0	5.0
Lane Util. Factor		0.95			0.95			1.00			1.00	1.00
Frpb, ped/bikes		1.00			0.99			1.00			1.00	0.95
Flpb, ped/bikes		1.00			1.00			1.00			1.00	1.00
Frt		1.00			0.98			0.97			1.00	0.85
Flt Protected		1.00			1.00			0.98			0.95	1.00
Satd. Flow (prot)		3509			3440			1766			1778	1511
Flt Permitted		0.56			0.95			0.68			0.75	1.00
Satd. Flow (perm)		1960			3280			1233			1394	1511
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	62	1098	14	3	1773	252	12	7	5	165	9	50
RTOR Reduction (vph)	0	0	0	0	3	0	0	4	0	0	0	28
Lane Group Flow (vph)	0	1174	0	0	2025	0	0	20	0	0	174	22
Confl. Peds. (#/hr)						3						11
Bus Blockages (#/hr)	0	2	0	0	2	0	0	0	0	0	0	0
Turn Type	pm+pt			Perm			Perm			Perm		Perm
Protected Phases	1	6			2			4			8	
Permitted Phases	6			2			4			8		8
Actuated Green, G (s)		195.1			195.1			32.4			32.4	32.4
Effective Green, g (s)		195.1			195.1			32.4			32.4	32.4
Actuated g/C Ratio		0.82			0.82			0.14			0.14	0.14
Clearance Time (s)		5.0			5.0			5.0			5.0	5.0
Vehicle Extension (s)		3.0			3.0			3.0			3.0	3.0
Lane Grp Cap (vph)		1610			2694			168			190	206
v/s Ratio Prot												
v/s Ratio Perm		0.60			c0.62			0.02			c0.12	0.01
v/c Ratio		0.73			0.75			0.12			0.92	0.10
Uniform Delay, d1		9.4			9.9			90.0			101.2	89.8
Progression Factor		1.00			1.00			1.00			1.00	1.00
Incremental Delay, d2		1.7			2.0			0.3			41.9	0.2
Delay (s)		11.1			11.9			90.3			143.1	90.1
Level of Service		B			B			F			F	F
Approach Delay (s)		11.1			11.9			90.3			131.3	
Approach LOS		B			B			F			F	

Intersection Summary			
HCM Average Control Delay	19.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	237.5	Sum of lost time (s)	10.0
Intersection Capacity Utilization	95.6%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	0	983	1617	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0			
Lane Util. Factor		0.95	0.95			
Frpb, ped/bikes		1.00	1.00			
Flpb, ped/bikes		1.00	1.00			
Frt		1.00	1.00			
Flt Protected		1.00	1.00			
Satd. Flow (prot)		3539	3539			
Flt Permitted		1.00	1.00			
Satd. Flow (perm)		3539	3539			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	1068	1758	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	1068	1758	0	0	0
Confl. Peds. (#/hr)					8	
Turn Type						
Protected Phases		2	6			
Permitted Phases						
Actuated Green, G (s)		207.0	207.0			
Effective Green, g (s)		207.0	207.0			
Actuated g/C Ratio		0.86	0.86			
Clearance Time (s)		5.0	5.0			
Lane Grp Cap (vph)		3052	3052			
v/s Ratio Prot		0.30	c0.50			
v/s Ratio Perm						
v/c Ratio		0.35	0.58			
Uniform Delay, d1		3.2	4.5			
Progression Factor		1.00	1.00			
Incremental Delay, d2		0.3	0.8			
Delay (s)		3.6	5.3			
Level of Service		A	A			
Approach Delay (s)		3.6	5.3		0.0	
Approach LOS		A	A		A	

Intersection Summary			
HCM Average Control Delay	4.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	240.0	Sum of lost time (s)	33.0
Intersection Capacity Utilization	48.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

INITIAL QUEUE DELAY WORKSHEET

General Information

Project Description: Existing (2009) queue delay calculation at Farr Hwy & Kanakuli Ave

Input Parameters

Period (i) _____

Duration, T: 0.25 h

Cycle length, C: 240 s

	SEB	NWB	NB	SB
Lane group			Source	
Initial queue, Q_b (veh)		630 veh/lane	field observation	
Green ratio, g/C		0.82	Synchro	
v/c ratio, X X = v/c		0.75	Synchro	
Adjusted lane group capacity, c (veh/h)		2688	Synchro	
Duration of unmet demand in T (h) $t = \min\left\{T, \frac{Q_b}{c[1 - \min(1,X)]}\right\}$		0.20	assumption	
Case				

Cases I and II ($Q_b = 0$)

Initial queue delay, $d_3 = 0$, and uniform delay, d_1, is as shown on Capacity and LOS Worksheet

* **Case III ($Q_b > 0$) ($X \le 1.0$) ($t < T$)**

Initial queue delay, d_3 (s) $d_3 = \frac{1800\, Q_b t}{cT}$		337.5 sec/veh		
Uniform delay, d_1 (s) $d_1 = 0.50C(1 - g/C)\frac{T}{T} + \frac{0.5C(1 - g/C)^2}{1 - g/C \min(1, X)}\left[\frac{(T - t)}{T}\right] \cdot PF$				

Case IV ($Q_b > 0$) ($X \le 1.0$) ($t = T$)

Delay parameter, u $u = 1 - \frac{cT}{Q_b}\left[1 - \min(1,X)\right]$				
Initial queue delay, d_3 (s) $d_3 = \frac{1800\, Q_b (1 + u)}{c}$				
Uniform delay, d_1 (s) $d_1 = 0.50C(1 - g/C)$				

Case V ($Q_b > 0$) ($X > 1.0$) ($t = T$)

Initial queue delay, d_3 (s) $d_3 = \frac{3600\, Q_b}{c}$				
Uniform delay, d_1 (s) $d_1 = 0.50C\,(1 - g/C)$				

Farrington Highway/Nanakuli Avenue PM Peak Hour Delay Re-calculations (2009)

Movement	Delay	Added Delay	Total Delay	Volume	
Farr Hwy inbound left/through/right	17.6		17.6	1080	19008
Farr Hwy outbound left/through/right	12.4	337.5	349.9	1866	652913.4
Nanakuli Ave mauka left/through/right	76.6		76.6	22	1685.2
Nanakuli Ave makai left/through	145.5		145.5	160	23280
Nanakuli Ave makai right	39.2		39.2	46	1803.2
				3174	698689.8
				Total Intersection Delay	220.1291

Farrington Highway/Nanakuli Avenue PM Peak Hour Delay Re-calculations (2012)

Movement	Delay	Added Delay	Total Delay	Volume	
Farr Hwy inbound left	129.8		129.8	3	389.4
Farr Hwy inbound through/right	8.7		8.7	1937	16851.9
Farr Hwy outbound left	120.7		120.7	59	7121.3
Farr Hwy outbound through/right	25.9	337.5	363.4	1064	386657.6
Nanakuli Ave mauka left/through/right	72.2		72.2	22	1588.4
Nanakuli Ave makai left/through	139.4		139.4	166	23140.4
Nanakuli Ave makai right	39.9		39.9	48	1915.2
				3299	437664.2
				Total Intersection Delay	132.6657

Farrington Highway/Nanakuli Avenue PM Peak Hour Delay Re-calculations (2030)

Movement	Delay	Added Delay	Total Delay	Volume	
Farr Hwy inbound left	130.3		130.3	74	9642.2
Farr Hwy inbound through/right	7.9		7.9	1330	10507
Farr Hwy outbound left	119		119	4	476
Farr Hwy outbound through/right	21.8	337.5	359.3	2422	870224.6
Nanakuli Ave mauka left/through/right	79		79	29	2291
Nanakuli Ave makai left/through	177.1		177.1	208	36836.8
Nanakuli Ave makai right	48		48	60	2880
				4127	932857.6
				Total Intersection Delay	226.0377

APPENDIX F SYNCHRO REPORTS – 2012 VOLUMES WITH SHORT-TERM IMPROVEMENTS

HCM Signalized Intersection Capacity Analysis
1: Farrington Hwy & Haleakala Ave (AM)

2/17/2010

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	288	1492	872	20	48	206
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0		5.0	
Lane Util. Factor	1.00	0.95	0.95		1.00	
Frpb, ped/bikes	1.00	1.00	1.00		0.97	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	1.00		0.89	
Flt Protected	0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1770	3497	3471		1587	
Flt Permitted	0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1770	3497	3471		1587	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	104%	104%	104%	104%	104%	104%
Adj. Flow (vph)	326	1687	986	23	54	233
RTOR Reduction (vph)	0	0	1	0	100	0
Lane Group Flow (vph)	326	1687	1008	0	187	0
Confl. Peds. (#/hr)	14			54		23
Bus Blockages (#/hr)	0	6	6	0	1	0
Turn Type	Prot					
Protected Phases	1	6	2		8	
Permitted Phases						
Actuated Green, G (s)	19.8	60.3	35.5		15.7	
Effective Green, g (s)	19.8	60.3	35.5		15.7	
Actuated g/C Ratio	0.23	0.70	0.41		0.18	
Clearance Time (s)	5.0	5.0	5.0		5.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	408	2452	1433		290	
v/s Ratio Prot	c0.18	c0.48	0.29		c0.12	
v/s Ratio Perm						
v/c Ratio	0.80	0.69	0.70		0.65	
Uniform Delay, d1	31.2	7.4	20.9		32.6	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	10.5	0.8	1.6		4.9	
Delay (s)	41.7	8.2	22.5		37.4	
Level of Service	D	A	C		D	
Approach Delay (s)		13.7	22.5		37.4	
Approach LOS		B	C		D	

Intersection Summary			
HCM Average Control Delay	18.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	86.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	73.4%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	72	1462	6	13	872	251	0	0	2	240	1	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		4.0	5.0			5.0			5.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	1.00
Frpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	0.96
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Frt	1.00	1.00		1.00	0.97			0.86			1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.95	1.00
Satd. Flow (prot)	1770	3494		1770	3379			1611			1774	1527
Flt Permitted	0.95	1.00		0.95	1.00			1.00			0.73	1.00
Satd. Flow (perm)	1770	3494		1770	3379			1611			1353	1527
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	104%	104%	104%	104%	104%	104%	104%	104%	104%	104%	104%	104%
Adj. Flow (vph)	81	1653	7	15	986	284	0	0	2	271	1	51
RTOR Reduction (vph)	0	0	0	0	15	0	0	1	0	0	0	27
Lane Group Flow (vph)	81	1660	0	15	1255	0	0	1	0	0	272	24
Confl. Peds. (#/hr)			1									15
Bus Blockages (#/hr)	0	6	0	0	6	0	0	0	0	0	0	0
Turn Type	Prot			Prot			Perm			Perm		Perm
Protected Phases	1	6		5	2			4			8	
Permitted Phases							4			8		8
Actuated Green, G (s)	11.2	74.2		2.8	64.8			31.0			31.0	31.0
Effective Green, g (s)	11.2	74.2		2.8	64.8			31.0			31.0	31.0
Actuated g/C Ratio	0.09	0.61		0.02	0.53			0.25			0.25	0.25
Clearance Time (s)	5.0	5.0		4.0	5.0			5.0			5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	3.0
Lane Grp Cap (vph)	162	2125		41	1795			409			344	388
v/s Ratio Prot	c0.05	c0.48		0.01	0.37			0.00				
v/s Ratio Perm											c0.20	0.02
v/c Ratio	0.50	0.78		0.37	0.70			0.00			0.79	0.06
Uniform Delay, d1	52.7	17.8		58.7	21.3			33.9			42.5	34.5
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Incremental Delay, d2	2.4	1.9		5.5	1.2			0.0			11.7	0.1
Delay (s)	55.2	19.8		64.2	22.5			34.0			54.2	34.6
Level of Service	E	B		E	C			C			D	C
Approach Delay (s)		21.4			23.0			34.0			51.1	
Approach LOS		C			C			C			D	

Intersection Summary			
HCM Average Control Delay	24.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	122.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	77.8%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	0	1477	872	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0			
Lane Util. Factor		0.95	0.95			
Frpb, ped/bikes		1.00	1.00			
Flpb, ped/bikes		1.00	1.00			
Frt		1.00	1.00			
Flt Protected		1.00	1.00			
Satd. Flow (prot)		3539	3539			
Flt Permitted		1.00	1.00			
Satd. Flow (perm)		3539	3539			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	104%	104%	104%	104%	104%	104%
Adj. Flow (vph)	0	1670	986	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	1670	986	0	0	0
Confl. Peds. (#/hr)					2	
Turn Type						
Protected Phases		2	6			
Permitted Phases						
Actuated Green, G (s)		34.5	34.5			
Effective Green, g (s)		34.5	34.5			
Actuated g/C Ratio		0.74	0.74			
Clearance Time (s)		5.0	5.0			
Vehicle Extension (s)		3.0	3.0			
Lane Grp Cap (vph)		2626	2626			
v/s Ratio Prot		c0.47	0.28			
v/s Ratio Perm						
v/c Ratio		0.64	0.38			
Uniform Delay, d1		2.9	2.1			
Progression Factor		1.00	1.00			
Incremental Delay, d2		0.5	0.1			
Delay (s)		3.4	2.2			
Level of Service		A	A			
Approach Delay (s)		3.4	2.2		0.0	
Approach LOS		A	A		A	

Intersection Summary			
HCM Average Control Delay	3.0	HCM Level of Service	A
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	46.5	Sum of lost time (s)	12.0
Intersection Capacity Utilization	46.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
1: Farrington Hwy & Haleakala Ave (MD)

2/17/2010

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	192	913	558	6	21	209
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0		5.0	
Lane Util. Factor	1.00	0.95	0.95		1.00	
Frpb, ped/bikes	1.00	1.00	1.00		0.98	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	1.00		0.88	
Flt Protected	0.95	1.00	1.00		1.00	
Satd. Flow (prot)	1770	3525	3515		1581	
Flt Permitted	0.95	1.00	1.00		1.00	
Satd. Flow (perm)	1770	3525	3515		1581	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	104%	104%	104%	104%	104%	104%
Adj. Flow (vph)	217	1032	631	7	24	236
RTOR Reduction (vph)	0	0	1	0	199	0
Lane Group Flow (vph)	217	1032	637	0	61	0
Confl. Peds. (#/hr)	6			66		24
Bus Blockages (#/hr)	0	2	2	0	1	0
Turn Type	Prot					
Protected Phases	1	6	2		8	
Permitted Phases						
Actuated Green, G (s)	10.2	30.1	14.9		7.4	
Effective Green, g (s)	10.2	30.1	14.9		7.4	
Actuated g/C Ratio	0.21	0.63	0.31		0.16	
Clearance Time (s)	5.0	5.0	5.0		5.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	380	2234	1103		246	
v/s Ratio Prot	0.12	c0.29	c0.18		c0.04	
v/s Ratio Perm						
v/c Ratio	0.57	0.46	0.58		0.25	
Uniform Delay, d1	16.7	4.5	13.7		17.6	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	2.1	0.2	0.7		0.5	
Delay (s)	18.8	4.7	14.4		18.1	
Level of Service	B	A	B		B	
Approach Delay (s)		7.1	14.4		18.1	
Approach LOS		A	B		B	

Intersection Summary			
HCM Average Control Delay	10.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	47.5	Sum of lost time (s)	15.0
Intersection Capacity Utilization	57.9%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	35	1016	7	7	559	171	2	11	5	126	9	37
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		4.0	5.0			5.0			5.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	1.00
Frpb, ped/bikes	1.00	1.00		1.00	0.99			1.00			1.00	0.98
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Frt	1.00	1.00		1.00	0.96			0.96			1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.96	1.00
Satd. Flow (prot)	1770	3521		1770	3381			1778			1780	1553
Flt Permitted	0.95	1.00		0.95	1.00			0.97			0.73	1.00
Satd. Flow (perm)	1770	3521		1770	3381			1727			1351	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	104%	104%	104%	104%	104%	104%	104%	104%	104%	104%	104%	104%
Adj. Flow (vph)	40	1149	8	8	632	193	2	12	6	142	10	42
RTOR Reduction (vph)	0	0	0	0	26	0	0	5	0	0	0	34
Lane Group Flow (vph)	40	1157	0	8	799	0	0	15	0	0	152	8
Confl. Peds. (#/hr)						3						11
Bus Blockages (#/hr)	0	2	0	0	2	0	0	0	0	0	0	0
Turn Type	Prot			Prot			Perm			Perm		Perm
Protected Phases	1	6		5	2			4			8	
Permitted Phases							4			8		8
Actuated Green, G (s)	1.7	27.1		0.5	24.9			10.1			10.1	10.1
Effective Green, g (s)	1.7	27.1		0.5	24.9			10.1			10.1	10.1
Actuated g/C Ratio	0.03	0.52		0.01	0.48			0.20			0.20	0.20
Clearance Time (s)	5.0	5.0		4.0	5.0			5.0			5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	3.0
Lane Grp Cap (vph)	58	1846		17	1628			337			264	303
v/s Ratio Prot	c0.02	c0.33		0.00	0.24							
v/s Ratio Perm								0.01			c0.11	0.01
v/c Ratio	0.69	0.63		0.47	0.49			0.05			0.58	0.03
Uniform Delay, d1	24.7	8.7		25.5	9.1			16.9			18.9	16.8
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Incremental Delay, d2	29.0	0.7		19.2	0.2			0.1			3.0	0.0
Delay (s)	53.7	9.4		44.6	9.3			16.9			21.9	16.9
Level of Service	D	A		D	A			B			C	B
Approach Delay (s)		10.9			9.7			16.9			20.8	
Approach LOS		B			A			B			C	

Intersection Summary			
HCM Average Control Delay	11.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	51.7	Sum of lost time (s)	10.0
Intersection Capacity Utilization	54.5%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	0	965	559	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		11.0	5.0			
Lane Util. Factor		0.95	0.95			
Frt		1.00	1.00			
Flt Protected		1.00	1.00			
Satd. Flow (prot)		3539	3539			
Flt Permitted		1.00	1.00			
Satd. Flow (perm)		3539	3539			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	104%	104%	104%	104%	104%	104%
Adj. Flow (vph)	0	1091	632	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	1091	632	0	0	0
Turn Type						
Protected Phases		6	2			
Permitted Phases						
Actuated Green, G (s)		51.0	57.0			
Effective Green, g (s)		51.0	57.0			
Actuated g/C Ratio		0.57	0.63			
Clearance Time (s)		11.0	5.0			
Lane Grp Cap (vph)		2005	2241			
v/s Ratio Prot		c0.31	0.18			
v/s Ratio Perm						
v/c Ratio		0.54	0.28			
Uniform Delay, d1		12.2	7.4			
Progression Factor		1.00	1.00			
Incremental Delay, d2		1.1	0.3			
Delay (s)		13.3	7.7			
Level of Service		B	A			
Approach Delay (s)		13.3	7.7		0.0	
Approach LOS		B	A		A	

Intersection Summary			
HCM Average Control Delay	11.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	39.0
Intersection Capacity Utilization	36.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
1: Farrington Hwy & Haleakala Ave (PM)

2/17/2010

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	155	955	1602	18	19	147
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0		5.0	
Lane Util. Factor	1.00	0.95	0.95		1.00	
Frpb, ped/bikes	1.00	1.00	0.99		0.93	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	1.00		0.88	
Flt Protected	0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1770	3525	3500		1507	
Flt Permitted	0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1770	3525	3500		1507	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	104%	104%	104%	104%	104%	104%
Adj. Flow (vph)	175	1080	1811	20	21	166
RTOR Reduction (vph)	0	0	0	0	127	0
Lane Group Flow (vph)	175	1080	1831	0	60	0
Confl. Peds. (#/hr)	6			66		24
Bus Blockages (#/hr)	0	2	2	0	1	0
Turn Type	Prot					
Protected Phases	1	6	2		8	
Permitted Phases						
Actuated Green, G (s)	27.0	200.3	168.3		15.2	
Effective Green, g (s)	27.0	200.3	168.3		15.2	
Actuated g/C Ratio	0.12	0.89	0.75		0.07	
Clearance Time (s)	5.0	5.0	5.0		5.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	212	3131	2612		102	
v/s Ratio Prot	c0.10	0.31	c0.52		c0.04	
v/s Ratio Perm						
v/c Ratio	0.83	0.34	0.70		0.59	
Uniform Delay, d1	96.9	2.0	15.2		102.1	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	22.3	0.3	1.6		8.4	
Delay (s)	119.2	2.3	16.8		110.6	
Level of Service	F	A	B		F	
Approach Delay (s)		18.6	16.8		110.6	
Approach LOS		B	B		F	

Intersection Summary			
HCM Average Control Delay	22.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	225.5	Sum of lost time (s)	15.0
Intersection Capacity Utilization	84.3%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	57	1010	13	3	1631	232	11	6	5	152	8	46
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0			5.0			5.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	1.00
Frpb, ped/bikes	1.00	1.00		1.00	0.99			1.00			1.00	0.95
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Frt	1.00	1.00		1.00	0.98			0.97			1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00			0.98			0.95	1.00
Satd. Flow (prot)	1770	3518		1770	3441			1760			1778	1512
Flt Permitted	0.95	1.00		0.95	1.00			0.68			0.75	1.00
Satd. Flow (perm)	1770	3518		1770	3441			1228			1389	1512
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	104%	104%	104%	104%	104%	104%	104%	104%	104%	104%	104%	104%
Adj. Flow (vph)	64	1142	15	3	1844	262	12	7	6	172	9	52
RTOR Reduction (vph)	0	0	0	0	4	0	0	5	0	0	0	28
Lane Group Flow (vph)	64	1157	0	3	2102	0	0	20	0	0	181	24
Confl. Peds. (#/hr)						3						11
Bus Blockages (#/hr)	0	2	0	0	2	0	0	0	0	0	0	0
Turn Type	Prot			Prot			Perm			Perm		Perm
Protected Phases	1	6		5	2			4			8	
Permitted Phases							4			8		8
Actuated Green, G (s)	13.7	186.1		0.8	173.2			33.0			33.0	33.0
Effective Green, g (s)	13.7	186.1		0.8	173.2			33.0			33.0	33.0
Actuated g/C Ratio	0.06	0.79		0.00	0.74			0.14			0.14	0.14
Clearance Time (s)	5.0	5.0		5.0	5.0			5.0			5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	3.0
Lane Grp Cap (vph)	103	2787		6	2537			173			195	212
v/s Ratio Prot	c0.04	0.33		0.00	c0.61							
v/s Ratio Perm								0.02			c0.13	0.02
v/c Ratio	0.62	0.41		0.50	0.83			0.11			0.93	0.11
Uniform Delay, d1	108.1	7.6		116.9	20.8			88.2			99.8	88.1
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Incremental Delay, d2	11.1	0.5		53.4	3.3			0.3			44.0	0.2
Delay (s)	119.2	8.0		170.2	24.1			88.5			143.8	88.4
Level of Service	F	A		F	C			F			F	F
Approach Delay (s)		13.8			24.3			88.5			131.4	
Approach LOS		B			C			F			F	

Intersection Summary			
HCM Average Control Delay	28.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	234.9	Sum of lost time (s)	15.0
Intersection Capacity Utilization	79.8%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	0	983	1617	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0			
Lane Util. Factor		0.95	0.95			
Frpb, ped/bikes		1.00	1.00			
Flpb, ped/bikes		1.00	1.00			
Frt		1.00	1.00			
Flt Protected		1.00	1.00			
Satd. Flow (prot)		3539	3539			
Flt Permitted		1.00	1.00			
Satd. Flow (perm)		3539	3539			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	104%	104%	104%	104%	104%	104%
Adj. Flow (vph)	0	1111	1828	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	1111	1828	0	0	0
Confl. Peds. (#/hr)					8	
Turn Type						
Protected Phases		2	6			
Permitted Phases						
Actuated Green, G (s)		207.0	207.0			
Effective Green, g (s)		207.0	207.0			
Actuated g/C Ratio		0.86	0.86			
Clearance Time (s)		5.0	5.0			
Lane Grp Cap (vph)		3052	3052			
v/s Ratio Prot		0.31	c0.52			
v/s Ratio Perm						
v/c Ratio		0.36	0.60			
Uniform Delay, d1		3.3	4.7			
Progression Factor		1.00	1.00			
Incremental Delay, d2		0.3	0.9			
Delay (s)		3.6	5.6			
Level of Service		A	A			
Approach Delay (s)		3.6	5.6		0.0	
Approach LOS		A	A		A	

Intersection Summary			
HCM Average Control Delay	4.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	240.0	Sum of lost time (s)	33.0
Intersection Capacity Utilization	50.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

APPENDIX G SYNCHRO REPORTS – 2030 VOLUMES WITH MID-RANGE IMPROVEMENTS

HCM Signalized Intersection Capacity Analysis
1: Farrington Hwy & Haleakala Ave (AM)

2/17/2010

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	374	1940	1134	26	62	268
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0		5.0	
Lane Util. Factor	1.00	0.95	0.95		1.00	
Frpb, ped/bikes	1.00	1.00	0.99		0.96	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	1.00		0.89	
Flt Protected	0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1770	3497	3466		1570	
Flt Permitted	0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1770	3497	3466		1570	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	100%	100%	100%	100%	100%	100%
Adj. Flow (vph)	407	2109	1233	28	67	291
RTOR Reduction (vph)	0	0	1	0	98	0
Lane Group Flow (vph)	407	2109	1260	0	260	0
Confl. Peds. (#/hr)	14			54		23
Bus Blockages (#/hr)	0	6	6	0	1	0
Turn Type	Prot					
Protected Phases	1	6	2		8	
Permitted Phases						
Actuated Green, G (s)	20.2	93.0	67.8		26.1	
Effective Green, g (s)	20.2	93.0	67.8		26.1	
Actuated g/C Ratio	0.16	0.72	0.53		0.20	
Clearance Time (s)	5.0	5.0	5.0		5.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	277	2519	1820		317	
v/s Ratio Prot	c0.23	c0.60	0.36		c0.17	
v/s Ratio Perm						
v/c Ratio	1.47	0.84	0.69		0.82	
Uniform Delay, d1	54.4	12.7	22.9		49.3	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	229.9	2.6	1.2		15.1	
Delay (s)	284.3	15.3	24.0		64.4	
Level of Service	F	B	C		E	
Approach Delay (s)		58.8	24.0		64.4	
Approach LOS		E	C		E	

Intersection Summary			
HCM Average Control Delay	48.7	HCM Level of Service	D
HCM Volume to Capacity ratio	0.92		
Actuated Cycle Length (s)	129.1	Sum of lost time (s)	10.0
Intersection Capacity Utilization	87.2%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	94	1901	8	17	1134	326	3	0	0	312	1	59
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		4.0	5.0			5.0			5.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	1.00
Frpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	0.96
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Frt	1.00	1.00		1.00	0.97			1.00			1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00			0.95			0.95	1.00
Satd. Flow (prot)	1770	3494		1770	3380			1770			1774	1522
Flt Permitted	0.95	1.00		0.95	1.00			0.25			0.73	1.00
Satd. Flow (perm)	1770	3494		1770	3380			462			1351	1522
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Adj. Flow (vph)	102	2066	9	18	1233	354	3	0	0	339	1	64
RTOR Reduction (vph)	0	0	0	0	14	0	0	0	0	0	0	27
Lane Group Flow (vph)	102	2075	0	18	1573	0	0	3	0	0	340	37
Confl. Peds. (#/hr)			1									15
Bus Blockages (#/hr)	0	6	0	0	6	0	0	0	0	0	0	0
Turn Type	Prot			Prot			Perm			Perm		Perm
Protected Phases	1	6		5	2			4			8	
Permitted Phases							4			8		8
Actuated Green, G (s)	13.2	87.6		3.2	76.6			35.0			35.0	35.0
Effective Green, g (s)	13.2	87.6		3.2	76.6			35.0			35.0	35.0
Actuated g/C Ratio	0.09	0.63		0.02	0.55			0.25			0.25	0.25
Clearance Time (s)	5.0	5.0		4.0	5.0			5.0			5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	3.0
Lane Grp Cap (vph)	167	2189		41	1852			116			338	381
v/s Ratio Prot	c0.06	c0.59		0.01	0.47							
v/s Ratio Perm								0.01			c0.25	0.02
v/c Ratio	0.61	0.95		0.44	0.85			0.03			1.01	0.10
Uniform Delay, d1	60.8	24.0		67.4	26.7			39.5			52.4	40.3
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Incremental Delay, d2	6.5	9.6		7.3	3.9			0.1			50.4	0.1
Delay (s)	67.3	33.6		74.8	30.6			39.6			102.8	40.4
Level of Service	E	C		E	C			D			F	D
Approach Delay (s)		35.2			31.1			39.6			93.0	
Approach LOS		D			C			D			F	

Intersection Summary			
HCM Average Control Delay	39.2	HCM Level of Service	D
HCM Volume to Capacity ratio	0.97		
Actuated Cycle Length (s)	139.8	Sum of lost time (s)	15.0
Intersection Capacity Utilization	85.2%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	0	1921	1134	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0			
Lane Util. Factor		0.95	0.95			
Frpb, ped/bikes		1.00	1.00			
Flpb, ped/bikes		1.00	1.00			
Frt		1.00	1.00			
Flt Protected		1.00	1.00			
Satd. Flow (prot)		3539	3539			
Flt Permitted		1.00	1.00			
Satd. Flow (perm)		3539	3539			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	100%	100%	100%	100%	100%	100%
Adj. Flow (vph)	0	2088	1233	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	2088	1233	0	0	0
Confl. Peds. (#/hr)					2	
Turn Type						
Protected Phases		2	6			
Permitted Phases						
Actuated Green, G (s)		55.6	55.6			
Effective Green, g (s)		55.6	55.6			
Actuated g/C Ratio		0.82	0.82			
Clearance Time (s)		5.0	5.0			
Vehicle Extension (s)		3.0	3.0			
Lane Grp Cap (vph)		2911	2911			
v/s Ratio Prot		c0.59	0.35			
v/s Ratio Perm						
v/c Ratio		0.72	0.42			
Uniform Delay, d1		2.6	1.6			
Progression Factor		1.00	1.00			
Incremental Delay, d2		0.9	0.1			
Delay (s)		3.5	1.7			
Level of Service		A	A			
Approach Delay (s)		3.5	1.7		0.0	
Approach LOS		A	A		A	

Intersection Summary			
HCM Average Control Delay	2.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	67.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	57.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
1: Farrington Hwy & Haleakala Ave (MD)

2/17/2010

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	250	1187	725	23	27	272
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0		5.0	
Lane Util. Factor	1.00	0.95	0.95		1.00	
Frpb, ped/bikes	1.00	1.00	1.00		0.97	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	1.00		0.88	
Flt Protected	0.95	1.00	1.00		1.00	
Satd. Flow (prot)	1770	3525	3494		1578	
Flt Permitted	0.95	1.00	1.00		1.00	
Satd. Flow (perm)	1770	3525	3494		1578	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	100%	100%	100%	100%	100%	100%
Adj. Flow (vph)	272	1290	788	25	29	296
RTOR Reduction (vph)	0	0	3	0	230	0
Lane Group Flow (vph)	272	1290	810	0	95	0
Confl. Peds. (#/hr)	6			66		24
Bus Blockages (#/hr)	0	2	2	0	1	0
Turn Type	Prot					
Protected Phases	1	6	2		8	
Permitted Phases						
Actuated Green, G (s)	10.3	34.8	19.5		8.6	
Effective Green, g (s)	10.3	34.8	19.5		8.6	
Actuated g/C Ratio	0.19	0.65	0.37		0.16	
Clearance Time (s)	5.0	5.0	5.0		5.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	341	2297	1276		254	
v/s Ratio Prot	c0.15	0.37	c0.23		c0.06	
v/s Ratio Perm						
v/c Ratio	0.80	0.56	0.63		0.37	
Uniform Delay, d1	20.6	5.1	14.0		20.0	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	12.2	0.3	1.0		0.9	
Delay (s)	32.8	5.4	15.0		20.9	
Level of Service	C	A	B		C	
Approach Delay (s)		10.2	15.0		20.9	
Approach LOS		B	B		C	

Intersection Summary			
HCM Average Control Delay	12.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	53.4	Sum of lost time (s)	15.0
Intersection Capacity Utilization	67.6%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	46	1321	9	9	727	222	3	14	7	164	12	48
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		4.0	5.0			5.0			5.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	1.00
Frpb, ped/bikes	1.00	1.00		1.00	0.99			1.00			1.00	0.98
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Frt	1.00	1.00		1.00	0.96			0.96			1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00			0.99			0.96	1.00
Satd. Flow (prot)	1770	3521		1770	3380			1775			1780	1549
Flt Permitted	0.95	1.00		0.95	1.00			0.97			0.72	1.00
Satd. Flow (perm)	1770	3521		1770	3380			1724			1344	1549
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Adj. Flow (vph)	50	1436	10	10	790	241	3	15	8	178	13	52
RTOR Reduction (vph)	0	0	0	0	25	0	0	6	0	0	0	41
Lane Group Flow (vph)	50	1446	0	10	1006	0	0	20	0	0	191	11
Confl. Peds. (#/hr)						3						11
Bus Blockages (#/hr)	0	2	0	0	2	0	0	0	0	0	0	0
Turn Type	Prot			Prot			Perm			Perm		Perm
Protected Phases	1	6		5	2			4			8	
Permitted Phases							4			8		8
Actuated Green, G (s)	3.3	37.8		0.7	34.2			14.7			14.7	14.7
Effective Green, g (s)	3.3	37.8		0.7	34.2			14.7			14.7	14.7
Actuated g/C Ratio	0.05	0.56		0.01	0.51			0.22			0.22	0.22
Clearance Time (s)	5.0	5.0		4.0	5.0			5.0			5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	3.0
Lane Grp Cap (vph)	87	1981		18	1720			377			294	339
v/s Ratio Prot	c0.03	c0.41		0.01	0.30							
v/s Ratio Perm								0.01			c0.14	0.01
v/c Ratio	0.57	0.73		0.56	0.58			0.05			0.65	0.03
Uniform Delay, d1	31.3	10.9		33.1	11.5			20.7			23.9	20.7
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Incremental Delay, d2	8.9	1.4		32.3	0.5			0.1			4.9	0.0
Delay (s)	40.1	12.3		65.4	12.0			20.8			28.8	20.7
Level of Service	D	B		E	B			C			C	C
Approach Delay (s)		13.2			12.6			20.8			27.1	
Approach LOS		B			B			C			C	

Intersection Summary			
HCM Average Control Delay	14.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	67.2	Sum of lost time (s)	15.0
Intersection Capacity Utilization	63.8%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	0	1254	726	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		11.0	5.0			
Lane Util. Factor		0.95	0.95			
Frt		1.00	1.00			
Flt Protected		1.00	1.00			
Satd. Flow (prot)		3539	3539			
Flt Permitted		1.00	1.00			
Satd. Flow (perm)		3539	3539			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	100%	100%	100%	100%	100%	100%
Adj. Flow (vph)	0	1363	789	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	1363	789	0	0	0
Turn Type						
Protected Phases		6	2			
Permitted Phases						
Actuated Green, G (s)		51.0	57.0			
Effective Green, g (s)		51.0	57.0			
Actuated g/C Ratio		0.57	0.63			
Clearance Time (s)		11.0	5.0			
Lane Grp Cap (vph)		2005	2241			
v/s Ratio Prot		c0.39	0.22			
v/s Ratio Perm						
v/c Ratio		0.68	0.35			
Uniform Delay, d1		13.7	7.8			
Progression Factor		1.00	1.00			
Incremental Delay, d2		1.9	0.4			
Delay (s)		15.6	8.2			
Level of Service		B	A			
Approach Delay (s)		15.6	8.2		0.0	
Approach LOS		B	A		A	

Intersection Summary			
HCM Average Control Delay	12.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	39.0
Intersection Capacity Utilization	43.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
1: Farrington Hwy & Haleakala Ave (PM)

2/17/2010

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	202	1242	2083	23	25	191
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0		5.0	
Lane Util. Factor	1.00	0.95	0.95		1.00	
Frpb, ped/bikes	1.00	1.00	0.99		0.93	
Flpb, ped/bikes	1.00	1.00	1.00		1.00	
Frt	1.00	1.00	1.00		0.88	
Flt Protected	0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1770	3525	3500		1505	
Flt Permitted	0.95	1.00	1.00		0.99	
Satd. Flow (perm)	1770	3525	3500		1505	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	100%	100%	100%	100%	100%	100%
Adj. Flow (vph)	220	1350	2264	25	27	208
RTOR Reduction (vph)	0	0	0	0	120	0
Lane Group Flow (vph)	220	1350	2289	0	115	0
Confl. Peds. (#/hr)	6			66		24
Bus Blockages (#/hr)	0	2	2	0	1	0
Turn Type	Prot					
Protected Phases	1	6	2		8	
Permitted Phases						
Actuated Green, G (s)	31.9	200.2	163.3		21.7	
Effective Green, g (s)	31.9	200.2	163.3		21.7	
Actuated g/C Ratio	0.14	0.86	0.70		0.09	
Clearance Time (s)	5.0	5.0	5.0		5.0	
Vehicle Extension (s)	3.0	3.0	3.0		3.0	
Lane Grp Cap (vph)	243	3043	2465		141	
v/s Ratio Prot	c0.12	0.38	c0.65		c0.08	
v/s Ratio Perm						
v/c Ratio	0.91	0.44	0.93		0.82	
Uniform Delay, d1	98.5	3.5	29.3		103.2	
Progression Factor	1.00	1.00	1.00		1.00	
Incremental Delay, d2	33.4	0.5	7.7		29.4	
Delay (s)	131.9	4.0	37.0		132.6	
Level of Service	F	A	D		F	
Approach Delay (s)		21.9	37.0		132.6	
Approach LOS		C	D		F	

Intersection Summary			
HCM Average Control Delay	36.7	HCM Level of Service	D
HCM Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	231.9	Sum of lost time (s)	15.0
Intersection Capacity Utilization	99.4%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	74	1313	17	4	2120	302	7	8	14	198	10	60
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0			5.0			5.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	1.00
Frpb, ped/bikes	1.00	1.00		1.00	0.99			1.00			1.00	0.95
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Frt	1.00	1.00		1.00	0.98			0.94			1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00			0.99			0.95	1.00
Satd. Flow (prot)	1770	3518		1770	3441			1723			1778	1512
Flt Permitted	0.95	1.00		0.95	1.00			0.68			0.72	1.00
Satd. Flow (perm)	1770	3518		1770	3441			1193			1348	1512
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Adj. Flow (vph)	80	1427	18	4	2304	328	8	9	15	215	11	65
RTOR Reduction (vph)	0	0	0	0	4	0	0	13	0	0	0	28
Lane Group Flow (vph)	80	1445	0	4	2628	0	0	19	0	0	226	37
Confl. Peds. (#/hr)						3						11
Bus Blockages (#/hr)	0	2	0	0	2	0	0	0	0	0	0	0
Turn Type	Prot			Prot			Perm			Perm		Perm
Protected Phases	1	6		5	2			4			8	
Permitted Phases							4			8		8
Actuated Green, G (s)	15.9	186.5		0.8	171.4			35.0			35.0	35.0
Effective Green, g (s)	15.9	186.5		0.8	171.4			35.0			35.0	35.0
Actuated g/C Ratio	0.07	0.79		0.00	0.72			0.15			0.15	0.15
Clearance Time (s)	5.0	5.0		5.0	5.0			5.0			5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	3.0
Lane Grp Cap (vph)	119	2765		6	2485			176			199	223
v/s Ratio Prot	c0.05	0.41		0.00	c0.76							
v/s Ratio Perm								0.02			c0.17	0.02
v/c Ratio	0.67	0.52		0.67	1.06			0.11			1.14	0.17
Uniform Delay, d1	108.2	9.2		118.1	32.9			87.6			101.2	88.4
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	1.00
Incremental Delay, d2	13.9	0.7		145.1	35.6			0.3			105.1	0.4
Delay (s)	122.1	9.9		263.3	68.5			87.9			206.2	88.7
Level of Service	F	A		F	E			F			F	F
Approach Delay (s)		15.8			68.8			87.9			180.0	
Approach LOS		B			E			F			F	

Intersection Summary			
HCM Average Control Delay	58.1	HCM Level of Service	E
HCM Volume to Capacity ratio	1.04		
Actuated Cycle Length (s)	237.3	Sum of lost time (s)	15.0
Intersection Capacity Utilization	95.1%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations						
Volume (vph)	0	1278	2102	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0			
Lane Util. Factor		0.95	0.95			
Frpb, ped/bikes		1.00	1.00			
Flpb, ped/bikes		1.00	1.00			
Frt		1.00	1.00			
Flt Protected		1.00	1.00			
Satd. Flow (prot)		3539	3539			
Flt Permitted		1.00	1.00			
Satd. Flow (perm)		3539	3539			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	100%	100%	100%	100%	100%	100%
Adj. Flow (vph)	0	1389	2285	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	1389	2285	0	0	0
Confl. Peds. (#/hr)					8	
Turn Type						
Protected Phases		2	6			
Permitted Phases						
Actuated Green, G (s)		207.0	207.0			
Effective Green, g (s)		207.0	207.0			
Actuated g/C Ratio		0.86	0.86			
Clearance Time (s)		5.0	5.0			
Lane Grp Cap (vph)		3052	3052			
v/s Ratio Prot		0.39	c0.65			
v/s Ratio Perm						
v/c Ratio		0.46	0.75			
Uniform Delay, d1		3.7	6.4			
Progression Factor		1.00	1.00			
Incremental Delay, d2		0.5	1.7			
Delay (s)		4.2	8.1			
Level of Service		A	A			
Approach Delay (s)		4.2	8.1		0.0	
Approach LOS		A	A		A	

Intersection Summary			
HCM Average Control Delay	6.7	HCM Level of Service	A
HCM Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	240.0	Sum of lost time (s)	33.0
Intersection Capacity Utilization	62.3%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

PRELIMINARY DRAINAGE REPORT

for

FARRINGTON HIGHWAY INTERSECTION IMPROVEMENTS AT HALEAKALA AVENUE AND NANAKULI AVENUE

FEDERAL AID PROJECT NO. 93A-01-05

DRAFT

Prepared for the
State Department of Transportation

by

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1001 Bishop Street
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Honolulu, Hawaii 96813

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1.0 INTRODUCTION

1.1 PROJECT LOCATION AND DESCRIPTION

Farrington Highway in Nanakuli, Oahu, Hawaii, is a major arterial roadway that serves as the only access to the Waianae Coast.

The State Department of Transportation plans to widen Farringtong Highway from approximately Helelua Street to Nanakuli Stream for the purpose of providing a median turn lane at Haleakala Avenue and Nanakuli Avenue. The total proposed length of improvements is approximately 0.8 miles (See Figure 1).

1.2 PURPOSE AND SCOPE

The purpose of this study is to perform a hydrologic and hydraulic evaluation of the proposed widening project and to develop appropriate design criteria for a drainage system within the project limits. The scope of work includes the following:

- evaluate hydrologic design criteria applicable to the area,
- perform hydrologic evaluation of existing tributary drainage areas adjacent to the project,
- perform hydrologic analysis of the project area itself, and
- establish a proposed roadway drainage system and evaluate its hydraulic performance.

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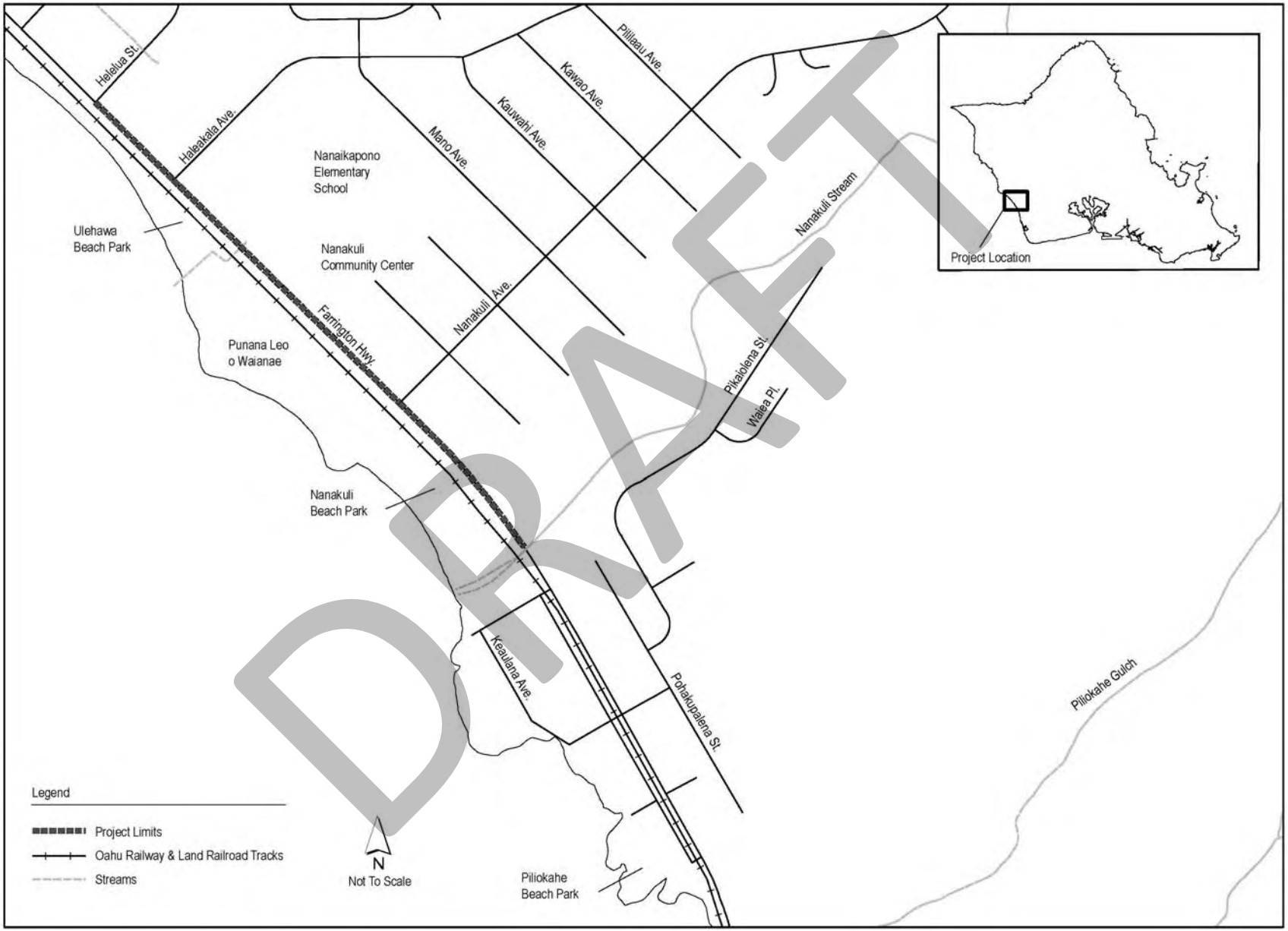

FIGURE 1 : PROJECT LOCATION MAP

2.0 HYDROLOGIC ANALYSIS

2.1 INTRODUCTION

This section discusses the guidelines and procedures used to determine the quantity of peak overland runoff which contributes to or affects drainage along the Farrington Highway corridor within the project limits.

2.2 EXISTING CONDITIONS

With the exception of a segment of sidewalk and drainage improvements along the northern side of Farrington Highway from Nanakuli Stream to approximately 300 feet west of Nanakuli Avenue, a length of approximately 1,300 feet, there is no existing drainage system along Farrington Highway within the project limits to handle the roadway's surface runoff. The existing network comprises of 14 catch basins, 2 manholes, and about 1300 feet of pipes, and intercepts the storm runoff from the adjacent developments in addition to providing drainage for parts of Farrington Highway. This network begins approximately 300 feet west of Nanakuli Avenue, and ultimately discharges into Nanakuli Stream (See Figure 2).

A drainage canal constructed as part of a drainage system for the DHHL (Department of Hawaiian Home Lands) properties in Nanakuli Valley, crosses Farrington Highway between Haleakala Avenue and Nanakuli Avenue, eventually discharging into the ocean. Based on hydrologic analysis, during a 25-Year storm, there will be a peak flow rate of approximately 1,348 cfs through the drainage canal.

A high point along Farrington Highway exists near station 163+53. Southeast of station 163+53, surface runoff from the Farrington Highway right-of-way flows into adjacent properties with eventual discharge into Nanakuli Stream. Northwest of station 163+53, surface runoff will flow in a northwesterly direction.

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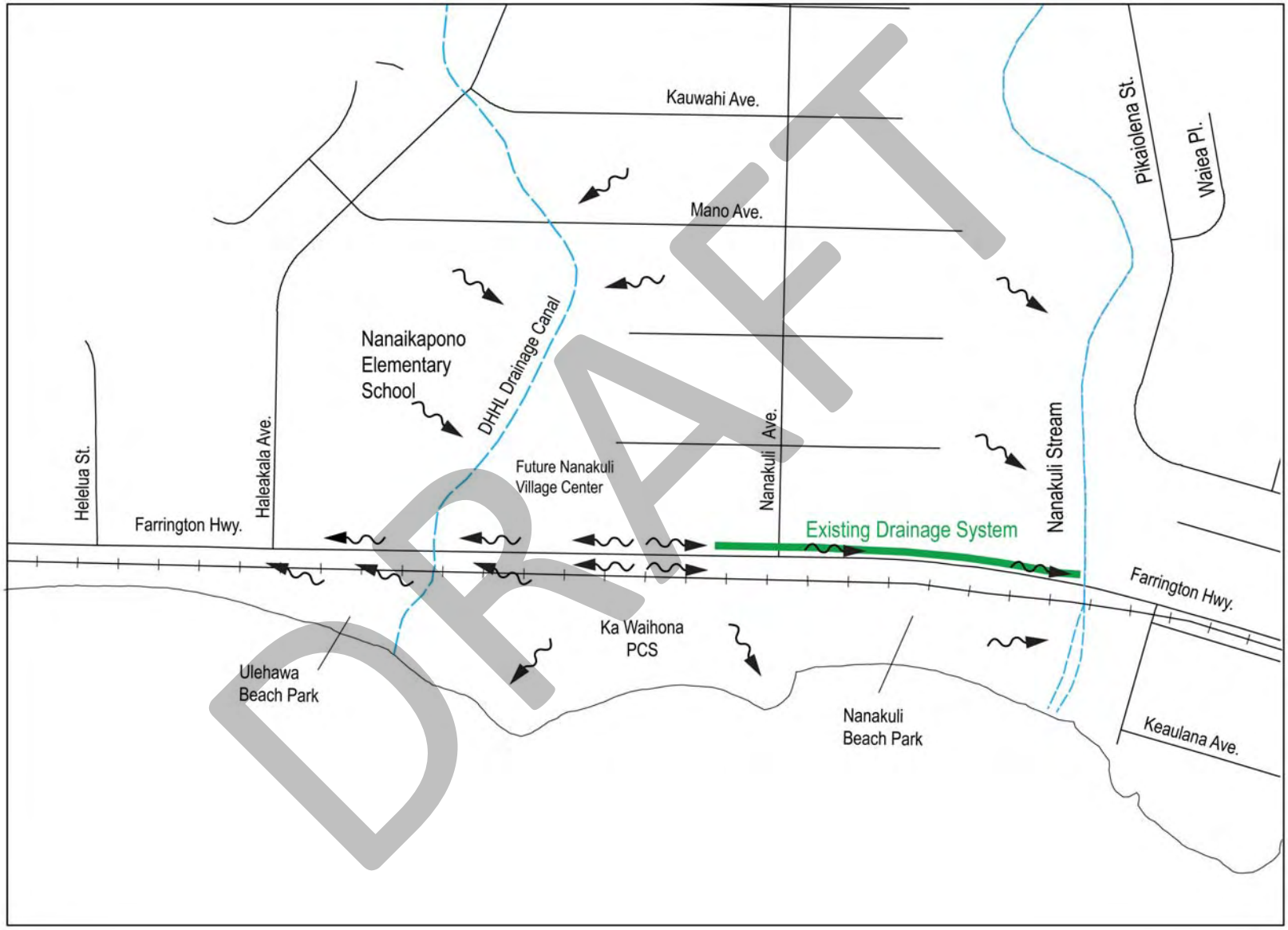

FIGURE 2 : EXISTING DRAINAGE PATTERNS

2.3 HYROLOGIC DESIGN CRITERIA

The State of Hawaii Department of Transportation (SDOT) *Design Criteria for Highway Drainage* (5/16/06) specifies the following hydrologic design criteria that are applicable to the Farrington Highway project:

- Recurrence Interval (T_m) : Roadway drainage for arterial highways – 25-year recurrence interval.
- Minimum time of concentration of 10 minutes.
- Design Discharge – with no significant off-site drainage areas, the Rational Method shall be used (maximum drainage area of 200 acres)
- Drainage Map - a drainage map showing the drainage areas (See Appendix B)

2.4 METHODOLOGIES

The *StormCAD* software, developed by Bentley, was used to determine the quantity of discharge for all drainage areas. The peak runoff calculations were estimated based on the Rational Method. *StormCAD* is based on methodologies set forth in the U.S. Federal Highways Administration's *Hydraulic Design Series No. 22, Urban Drainage Design Manual, Second Edition.*

2.5 RATIONAL METHOD

For small drainage basins with no stream gage measurements, the Rational Method is the most common hydrologic technique used for computation of peak discharges. The Rational Method was used to estimate peak discharges for drainage basins up to 200 acres. The basic equation is expressed as:

$$Q = CIA$$

where:

Q = Peak discharge (cfs)

C = Runoff coefficient (dimensionless)

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I	=	Average rainfall intensity (in/hr) for a duration equal to the time of concentration
A	=	Drainage area (acres)

The following assumptions are inherent in the estimation of peak discharges using the Rational Method:

- The peak runoff occurs when all parts of the drainage basin are contributing to the runoff,
- The precipitation is uniformly distributed over the entire drainage basin and throughout the duration of the storm, and
- A runoff coefficient can adequately account for all the abstractions and losses within the drainage basin.

Drainage areas (A) were established using topographic information and surface modeling within a CAD environment. Drainage basin boundaries were delineated based on topography and existing developments.

The system time of concentration (T_c) is defined as the hydraulically most distant point in the watershed to the point of discharge. The Rational Method is applicable only if the period of precipitation exceeds the time of concentration. Due to the short distances observed within each drainage area, the minimum design criteria of a 10 minute time of concentration was used.

The rainfall intensity (I) value was computed using rainfall isohyetals, time of concentration (T_c), and intensity correction factors. An average rainfall of 2.2 inches/hour was assumed for the 25-year storm event as determined by the State of Hawaii's *Rainfall Frequency Study for Oahu, Report R-73* (1984) (See Appendix A).

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Utilizing Plate 4 of the City and County of Honolulu's *Rules Relating to Storm Drainage Standards* design method for Rational Method computations a correction factor of 2.25 was applied to the average rainfall intensity value to determine the design rainfall intensity of 4.95 inches per hour for a 10-minute time of concentration.

Runoff coefficient values of 0.9 for paved areas, 0.7 for residential areas, and 0.55 for unpaved areas were selected.

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3.0 HYDRAULIC ANALYSIS

3.1 INTRODUCTION

This section summarizes the hydraulic computations used to analyze all proposed pipes and culverts. The design intent for the proposed drainage system on Farrington Highway was to carry storm water runoff along the Farrington Highway corridor and to discharge this runoff into the DHHL drainage canal or Nanakuli Stream.

The hydraulic analyses were performed using Bentley's *StormCAD* software (Version 8).

3.2 DESIGN CRITERIA

The hydraulic analysis was based on the requirements specified in the State of Hawaii, Department of Transportation, *Design Criteria for Highway Drainage* (5/16/06). The parameters set forth by the hydraulic design criteria include:

- A minimum time of concentration (T_c) of 10 minutes,
- Recurrence interval (T_m) of 25 years as stated in Section 2.3,
- maximum flood encroachment not to exceed 1/3 travel lane,
- no encroachment into the travel lane at sumps,
- minimum pipe slope of 0.005 ft/ft,
- minimum pipe cover of 2',
- minimum grate inlet catch of 70 percent, and
- inlets to be located at;
    - upstream corners of intersections
    - upstream of median breaks
    - upgrade of cross slope reversals

In addition to the above listed criteria, a minimum freeboard of 1 foot was maintained in all manholes, inlets, and catch basins.

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3.3 STORMCAD PROCEDURE

StormCAD has the ability to model single culverts and multiple culverts, including circular and box culverts, which are proposed for use on this project. In addition, *StormCAD* has the ability to model multiple drainage inlets and junctions along a culvert alignment, making it well suited for this application.

The required parameters for the *StormCAD* analysis include the following:

- Design discharge flow rates (inlet areas and 'C' values) at headwalls and drainage inlets,
- Drainage inlet and pipe invert elevations,
- Pipe lengths and cross-sectional properties, and
- Pipe material properties

The *StormCAD* model requires the definition of a drainage system pipe network based on inlet dimensions, including inlet types (State standard grates and catch basins), ground, and sump elevations. Pipe cross sectional properties, lengths, and orientations (angle of entry) complete the geometry information for a given analysis. The schematic drainage system layout and relevant data are provided in Appendix C.

3.4 PLAN AND DESCRIPTION OF PROPOSED IMPROVEMENTS

The proposed roadway drainage system consists of new catch basins and grated drop inlets. The proposed drainage system has three main networks (See Figure 3). The first, Drainline "A" starts at Station 140+50.00 and carries the runoff southeast into the existing DHHL drainage canal. Drainline "B" starts at Station 161+16.26 and carries the runoff northwest into the DHHL drainage canal. Drainline "C" starts at Station 164+87.88 and carries the runoff southeast into Nanakuli Stream.

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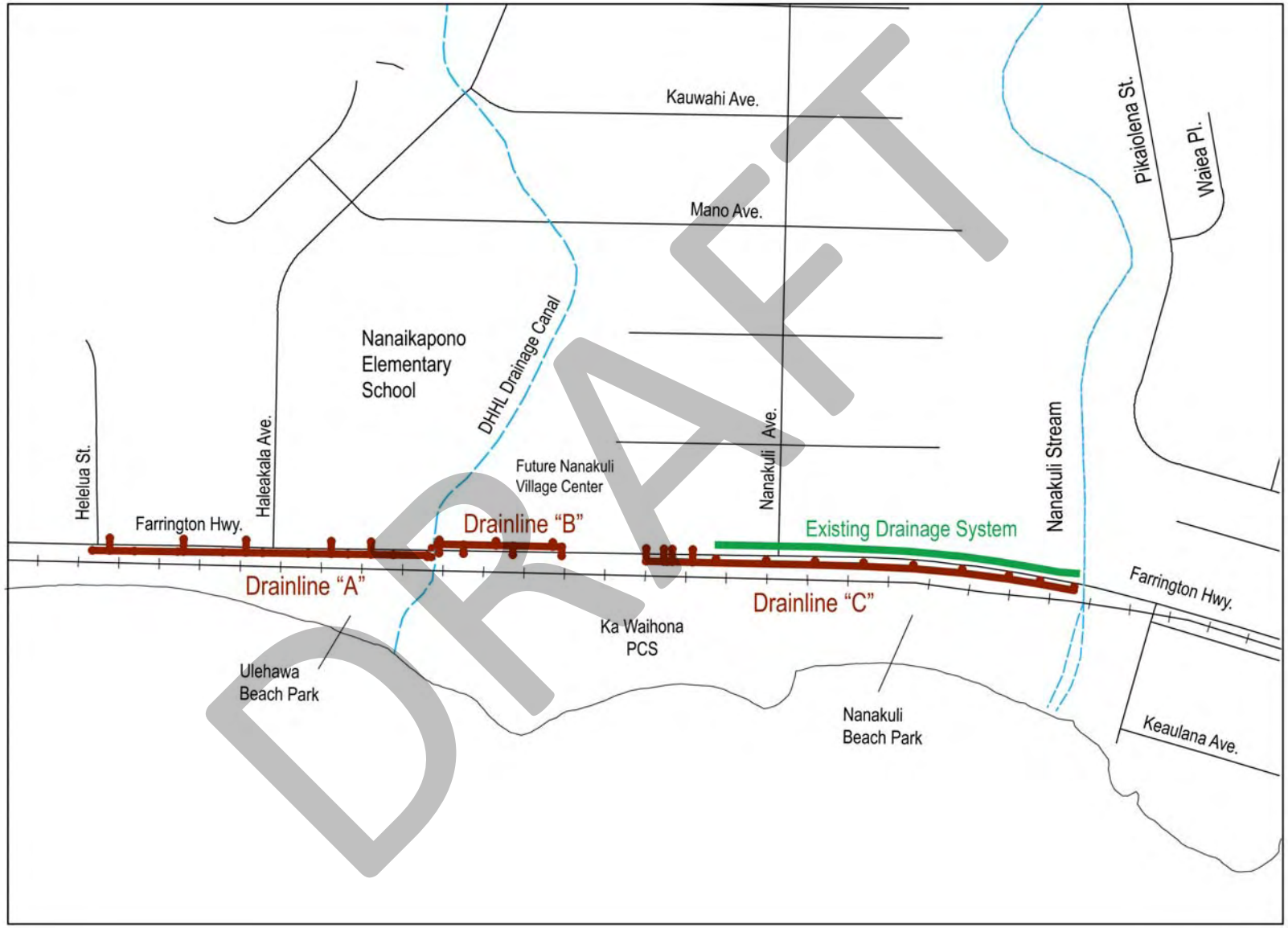

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FIGURE 3 : PROPOSED DRAINAGE SYSTEMS

During analysis it was determined that based upon grade and minimum cover constraints, Drainline "A" will require the use of a box culvert. Plans for the proposed drainage improvements and integration into the existing drainage system are provided in Appendix C.

3.5 INLET SPACING, GUTTER CAPACITY AND CONDUIT RESULTS

All inlet locations were designed to meet the allowable spread criteria, which is 5.3' from the curb face. Inlet efficiency ratings and gutter spread computations are summarized for each inlet location on the layout plans in Appendix C.

Conduit designs varied based upon cover constraints. Due to flat roadway running slopes and a shallow outfall target elevation, concrete box culverts were required for the main trunk of the Farrington Highway drainage system from station 140+00 up to station 155+50. However, from Station 155+50 to Nanakuli Stream circular conduits were determined to be adequate. A conduit summary table is provided in Appendix D.

Based on the StormCAD drainage system model, a final peak discharge of approximately 14.87 cfs was estimated for Drainline "A", and a peak discharge of 7.44 cfs was estimated for Drainline "B". Based on these results, an estimated 25-year peak discharge of 22.31 cfs is anticipated to be directed to the existing drainage canal. The peak discharge of Drainline "C" into Nanakuli Stream was estimated at 8.74 cfs.

3.6 IMPACTS OF OUTFALLS TO EXISTING STREAMS

For evaluation of impacts to existing streams, peak discharges in the existing DHHL drainage canal and Nanakuli Stream were estimated based on the SCS method and WinTR-55. Peak 25 year discharges were estimated at 1348 cfs for the existing DHHL drainage canal and ___ for Nanakuli Stream.

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As a measure of impact, HEC-RAS models were used to evaluate existing streams for increases in water surface elevation for a 25-year peak discharge. Based on these models a net increase in water surface elevation of less than 2-inches is expected for the DHHL drainage canal and ____ for Nanakuli Stream as a result of the proposed drainage improvements (See Appendix E).

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4.0 REFERENCES

City and County of Honolulu, Department of Planning and Permitting, Rules Relating to Storm Drainage Standards, January 2000.

State of Hawaii, Department of Transportation, Highways Division, Design Criteria for Highway Drainage, 5/16/06.

U.S. Department of Transportation, Federal Highway Administration, Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22, Second Edition, FHWA-NHI-01-021, August 2001.

State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development. Rainfall Frequency Study for Oahu, Report R-73, 1984.

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APPENDIX A – HYDROLOGY

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Determination of 1-hr rainfall intensity for 25 year recurrence interval per Rainfall Frequency Study for Oahu, Report R-73 dated 1984

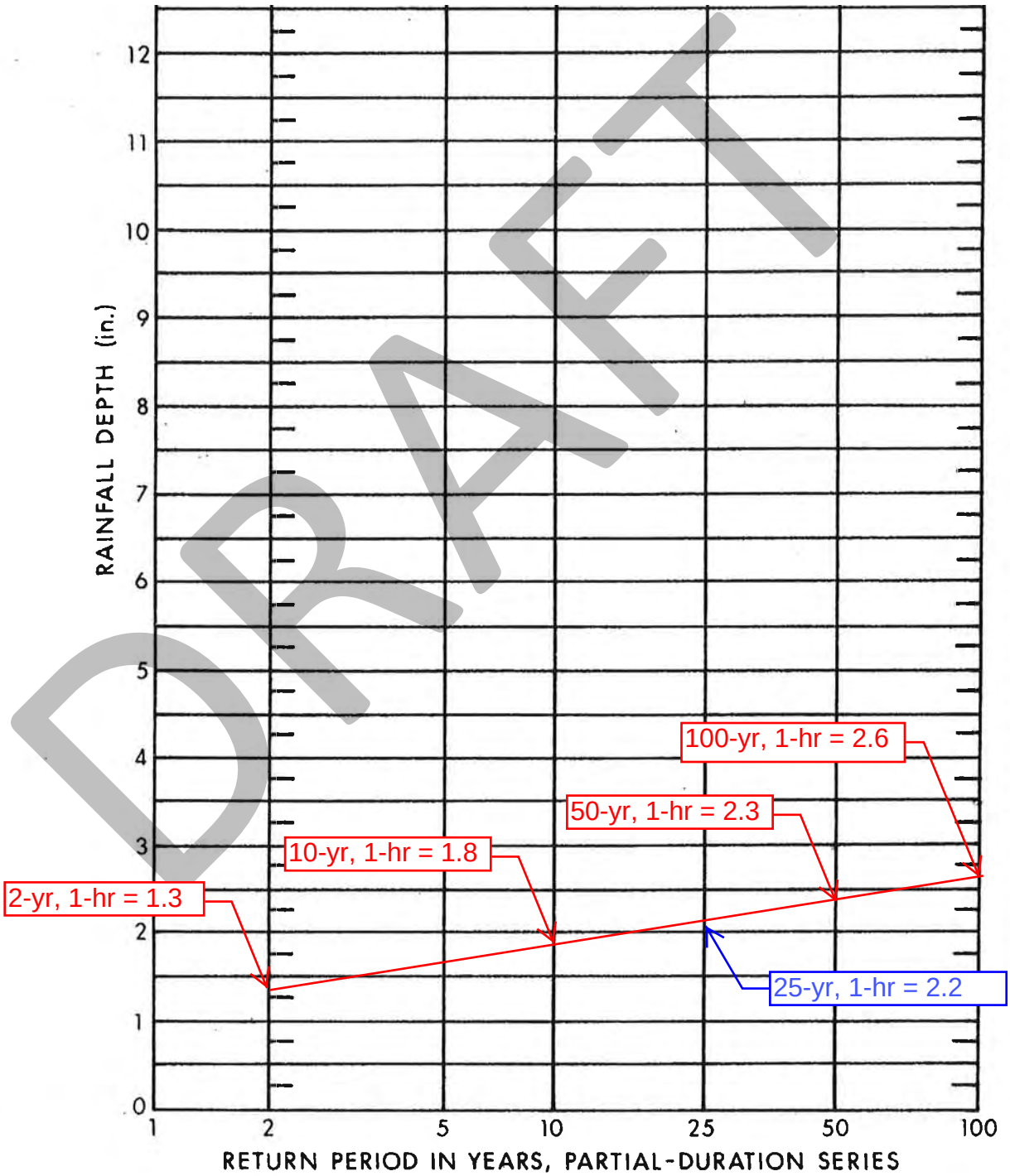

Figure 20. Return period interpolation diagram

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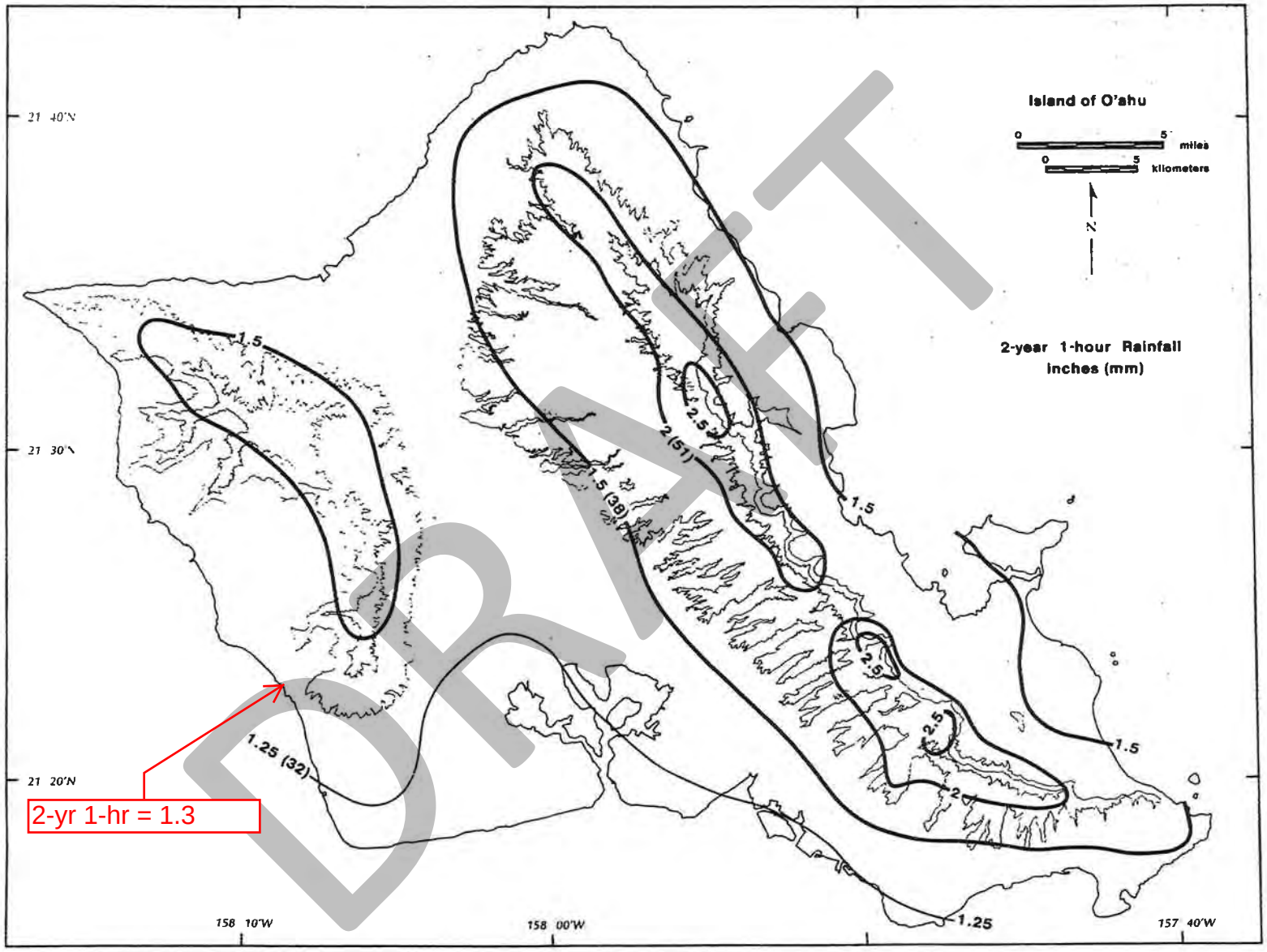

Figure 7. Map of 2-yr 1-hr rainfall, O'ahu, Hawai'i

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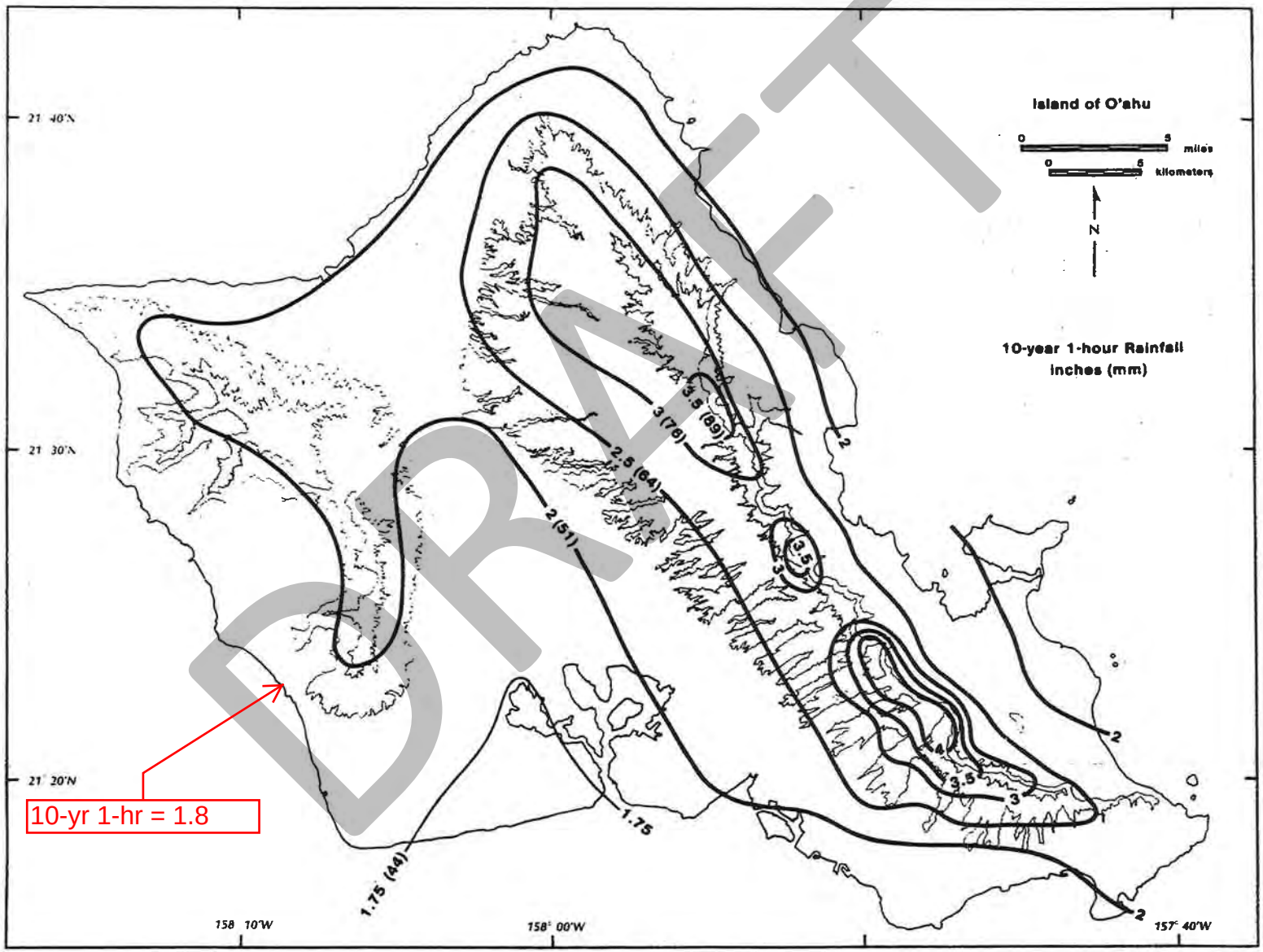

Figure 8. Map of 10-yr 1-hr rainfall, O'ahu, Hawai'i

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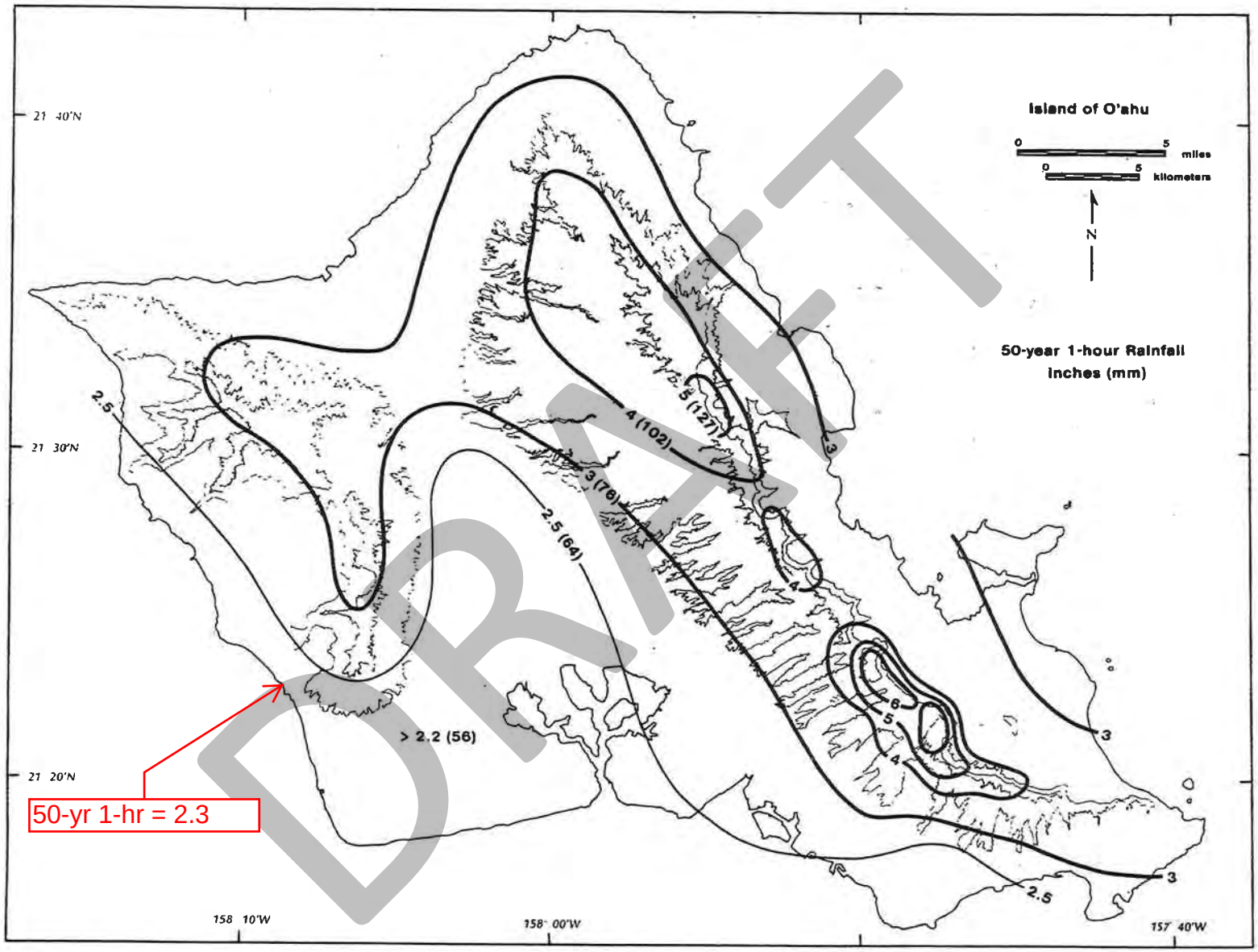

Figure 9. Map of 50-yr 1-hr rainfall, O'ahu, Hawai'i

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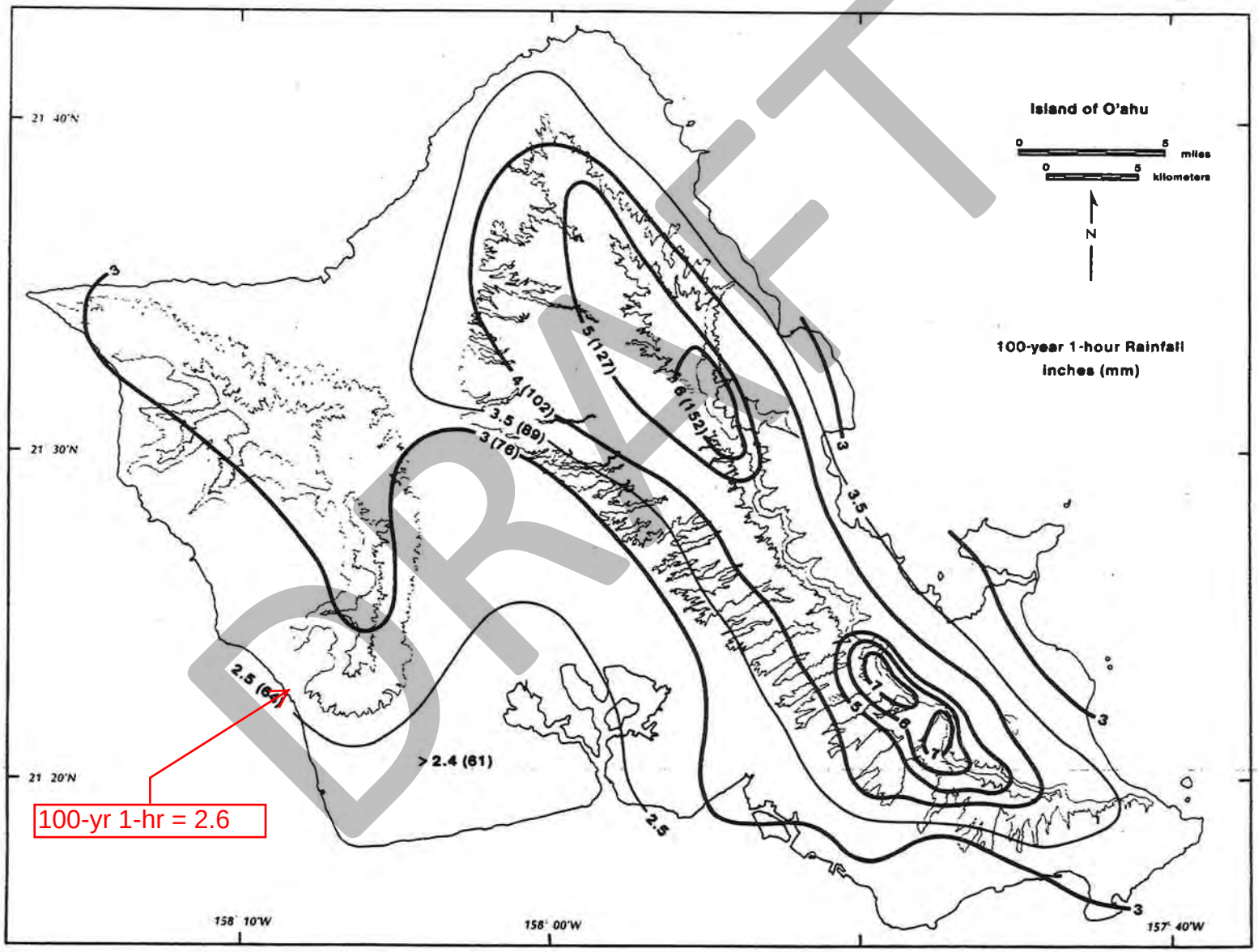

Figure 10. Map of 100-yr 1-hr rainfall, O'ahu, Hawai'i

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Determination of Correction Factor

City and County of Honolulu, Plate 4

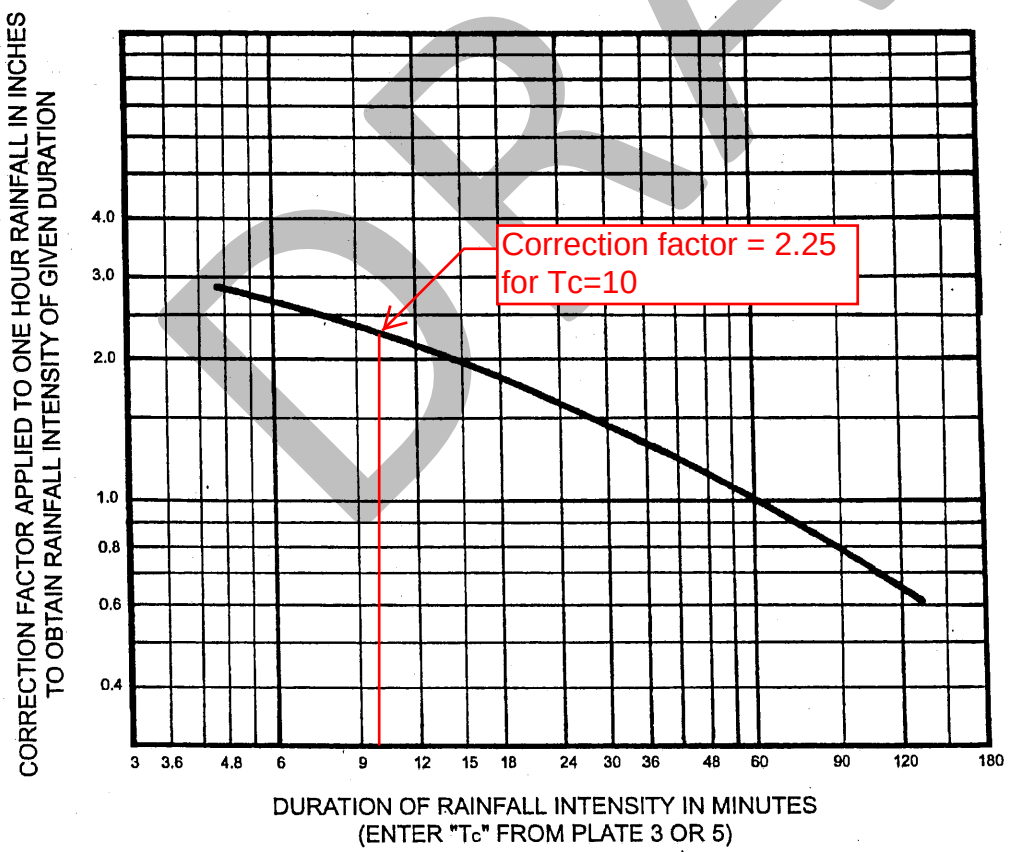

Plate 4

CORRECTION FACTOR

FOR CONVERTING 1 HR. RAINFALL
TO RAINFALL INTENSITY
OF VARIOUS DURATIONS

TO BE USED FOR AREA
LESS THAN 100 ACRES

(See Plate 6 for area
more than 100 acres)

SCS Method Computations
DHHL Drainage Canal, 25-year Peak Discharge

Land Use	Quantity	Units	Source
Undeveloped Area:	149	acres	GIS Hydrology file
Residential Area:	246	acres	GIS Hydrology file
Total Area:	395	acres	GIS Hydrology file

Soil Types in Drainage Area (from Table 14 in SCS Method Reference)

Soil Symbol	Soil Series	Soil Group
rRK	Rock Land	D
LPE	Lualualei	D
EaB	Ewa	B
LvB	Lualualei	D
MnC	Mamala	D
CR	Coral Outcrop	D

Residential Area

Average lot size ~1/2 acre (estimated using GIS Hydrology file)

Soil Types present: LPE, EaB, LvB, MnC, CR (from GIS Hydrology file)

area (ft^2) on Group B soil= 1595140.45

area (acres) on Group B soil= 36.6193859 CN=70*

area (acres) on Group D soil= 209.3806141 CN=85*

*CN numbers from Table 25 in SCS Method Reference

Undeveloped Area

Wood/Forestland-poor cover

Soil Type present: rRK

area (acres) on Group D soil= 149 CN=83*

*CN numbers from Table 25 in SCS Method Reference

Computations

Average Slope= 14.92847009 % (from area high point to

round up 15 % culvert entrance)

$CN_{\text{entire drainage area}}$= $(\Sigma(Cn_i * area_i))/(\text{total area})$

$CN_{\text{entire drainage area}}$= 82.85496003

From 25Yr 24Hr Rainfall Chart in Section 3 of SCS Method Reference,

25yr, 24hr rainfall intensity= 10 in

From Section 4 in SCS Method Reference-24Hr Type I Storm Distribution (sheet 3 of 3),

Peak Discharge (initial)= 150 $ft^3/s/in$

(corresponds to 395acres drainage area and CN=82.85)

From Table 28 in SCS Method Reference,

Slope Adjustment Factor= 0.98

(corresponds to 395acres drainage area and 15% average slope)

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From Table 24 in SCS Method Reference, 10in of rainfall corresponds to:

CN 80=7.52, CN 85=8.16

runoff depth=	7.8848	in

Peak Discharge=	[Peak Discharge (initial)]*(runoff depth)	
Peak Discharge=	1182.72	ft^3/s
Peak Discharge for 15% slope=	(Peak Discharge)*(Slope Adjustment Factor)	
Peak Discharge for 15% slope=	1159.0656	ft^3/s

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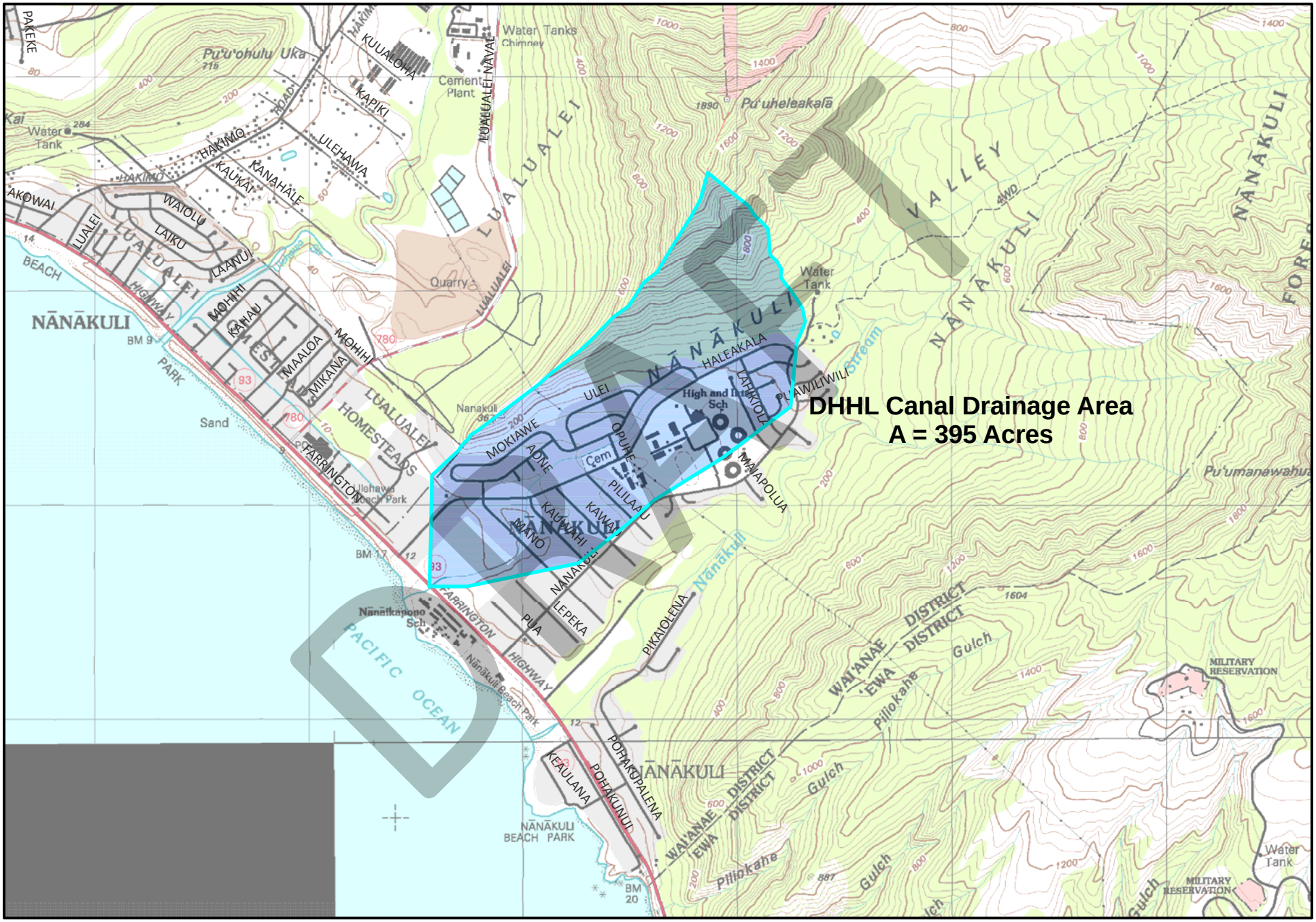
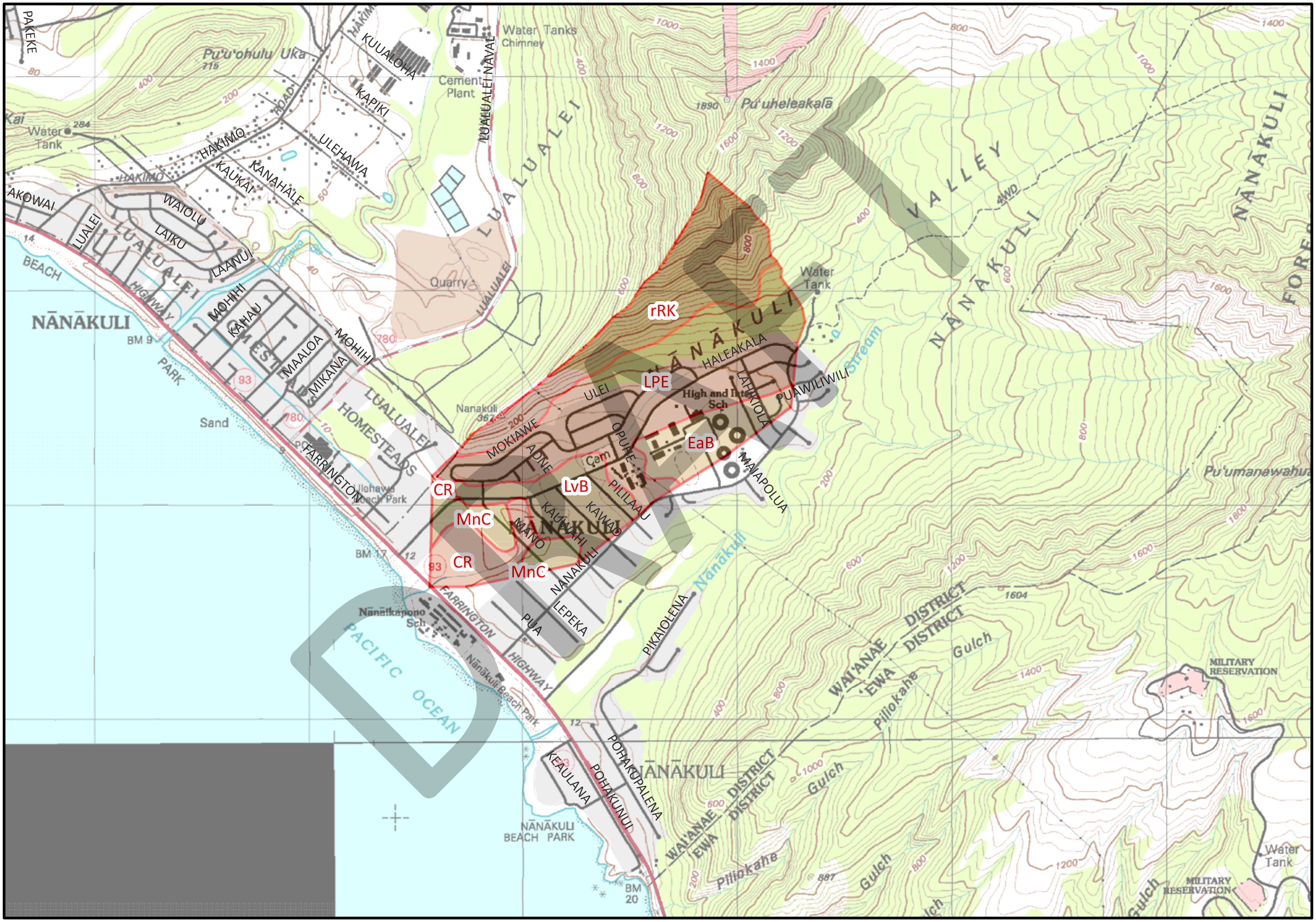


DHHL Drainage Drainage Area Map



DHHL Drainage Canal Drainage Area Soil Map

Drainage Area	Soil Type(s) present	Soil Group Type	Area (acres)	Total Area on Group B Soil (acres)	Total Area on Group D Soil (acres)	Weighted CN	Average Slope (%)	t_c (hours)	Recurrence Interval	P (in) (24-hr)	Q (cfs)
Undeveloped				0	149	83	43	0.1	25	10	
	rRK	D	149								
Residential				36.6193859	209.382844	83	3.8	0.578	25	10	
	rRK	D	0.535794								
	LPE	D	108.4912								
	EaB	B	36.61939								
	LvB	D	45.97373								
	MnC	D	23.46085								
	CR	D	30.92128								
Entire Site			395.0022								1348.55

Got soil types from GIS "Hydrology" file
Got corresponding Soil Groups from Table 14 in "SCS Method Reference"
Area calculated in GIS "Hydrology" file
Weighted CN calculated in WinTR-55
Average slope estimated in GIS "Hydrology" file
t_c calculated in WinTR-55
P determined from Section 3 of "SCS Method Reference"
Q calculated in WinTR-55

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APPENDIX B – ROADWAY DRAINAGE AREA MAPS

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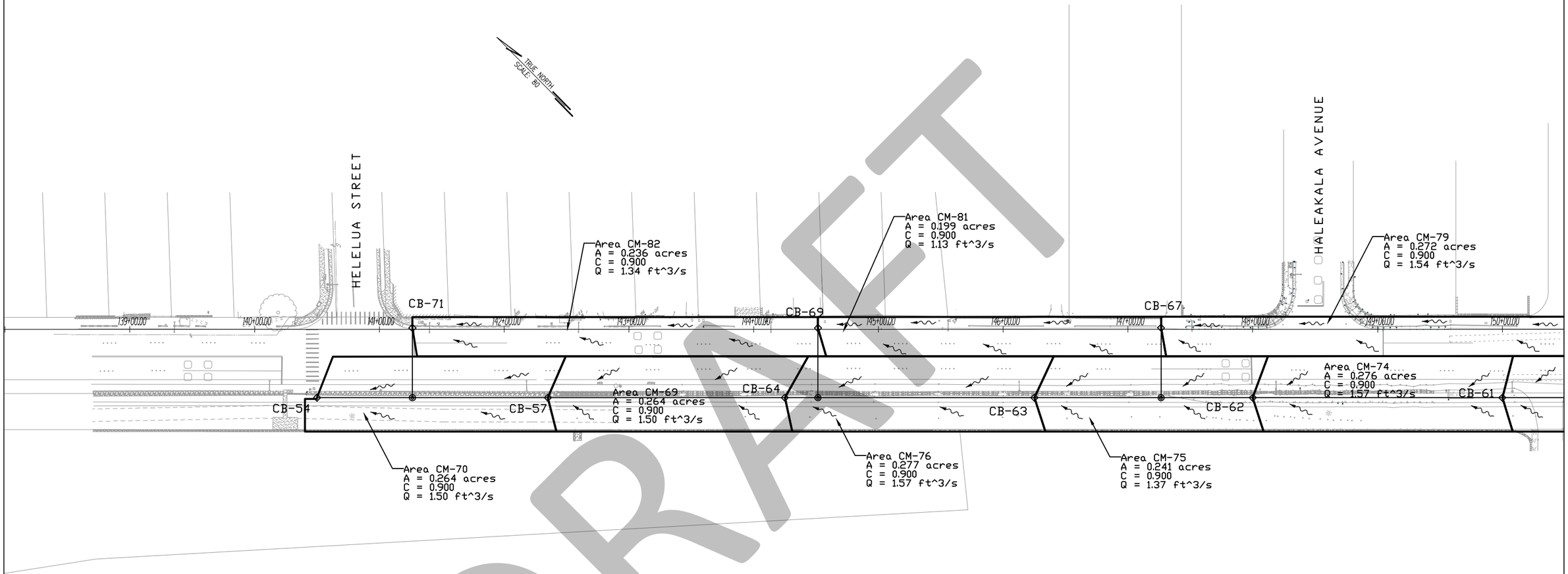
FED. ROAD DIST. NO.	STATE	FEDERAL AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
HAWAII	HAW.	93A-01-05	2010	1	3



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ORIGINAL PLAN	SURVEY PLOTTED BY	DATE
	DRAWN BY	
	TRACED BY	
NOTE BOOK	DESIGNED BY	
	QUANTITIES BY	
No.	CHECKED BY	

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

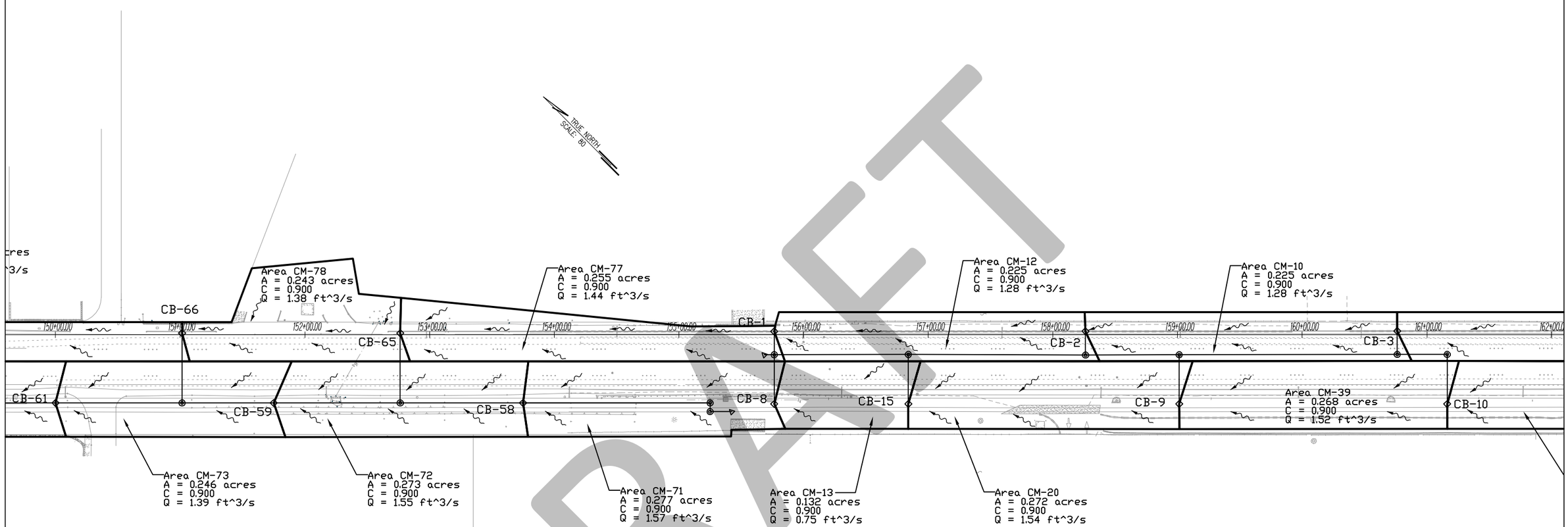
STORMCAD DRAINAGE AREAS

FARRINGTON HIGHWAY INTERSECTION IMPROVEMENTS
NANAKULI AND HALEAKALA INTERSECTIONS
Federal-Aid Project No. STP-093-1(22)

Scale: 1" = 80'

SHEET No. 1 OF 3 SHEETS

FED. ROAD DIST. NO.	STATE	FEDERAL AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
HAWAII	HAW.	93A-01-05	2010	2	3



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ORIGINAL PLAN	SURVEY PLOTTED BY	DATE
	DRAWN BY	
	TRACED BY	
NOTE BOOK	DESIGNED BY	
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No.	CHECKED BY	

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

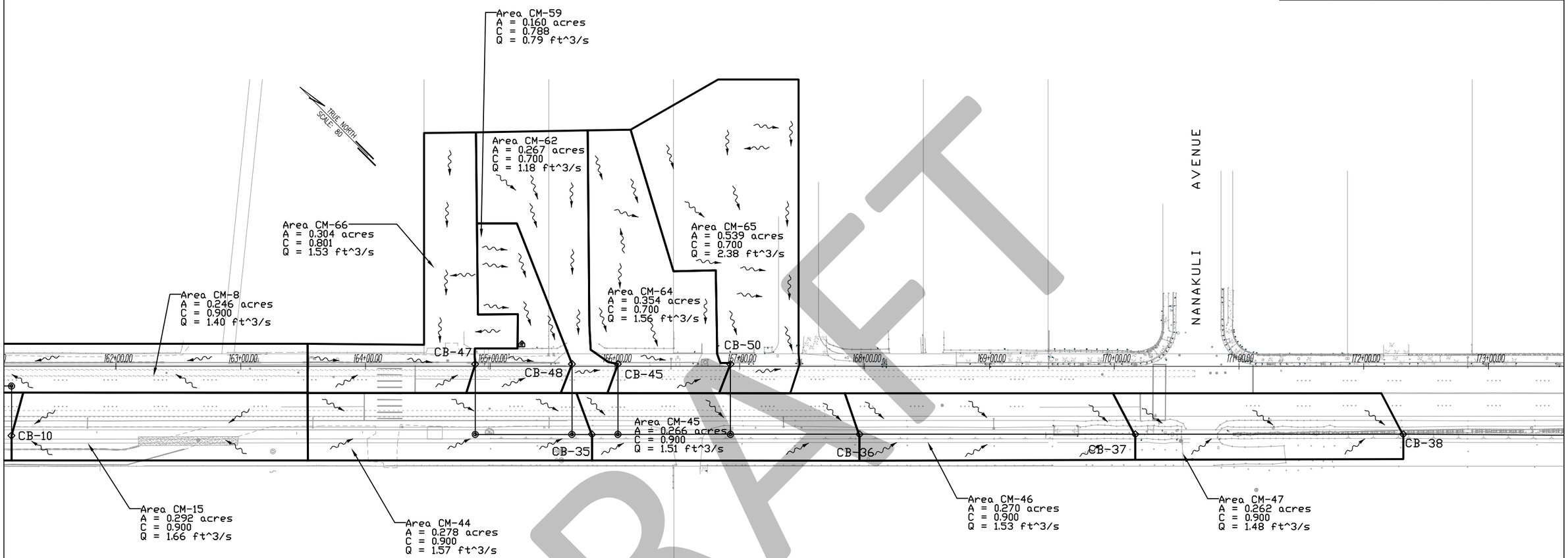
STORMCAD DRAINAGE AREAS

FARRINGTON HIGHWAY INTERSECTION IMPROVEMENTS
NANAKULI AND HALEAKALA INTERSECTIONS
Federal-Aid Project No. STP-093-1(22)

Scale: 1" = 80'

SHEET No. 2 OF 3 SHEETS

FED. ROAD DIST. NO.	STATE	FEDERAL AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
HAWAII	HAW.	93A-01-05	2010	3	3



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ORIGINAL PLAN	SURVEY PLOTTED BY	DATE
	DRAWN BY	
	TRACED BY	
NOTE BOOK	DESIGNED BY	
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No.	CHECKED BY	

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

STORMCAD DRAINAGE AREAS

FARRINGTON HIGHWAY INTERSECTION IMPROVEMENTS
NANAKULI AND HALEAKALA INTERSECTIONS
Federal-Aid Project No. STP-093-1(22)

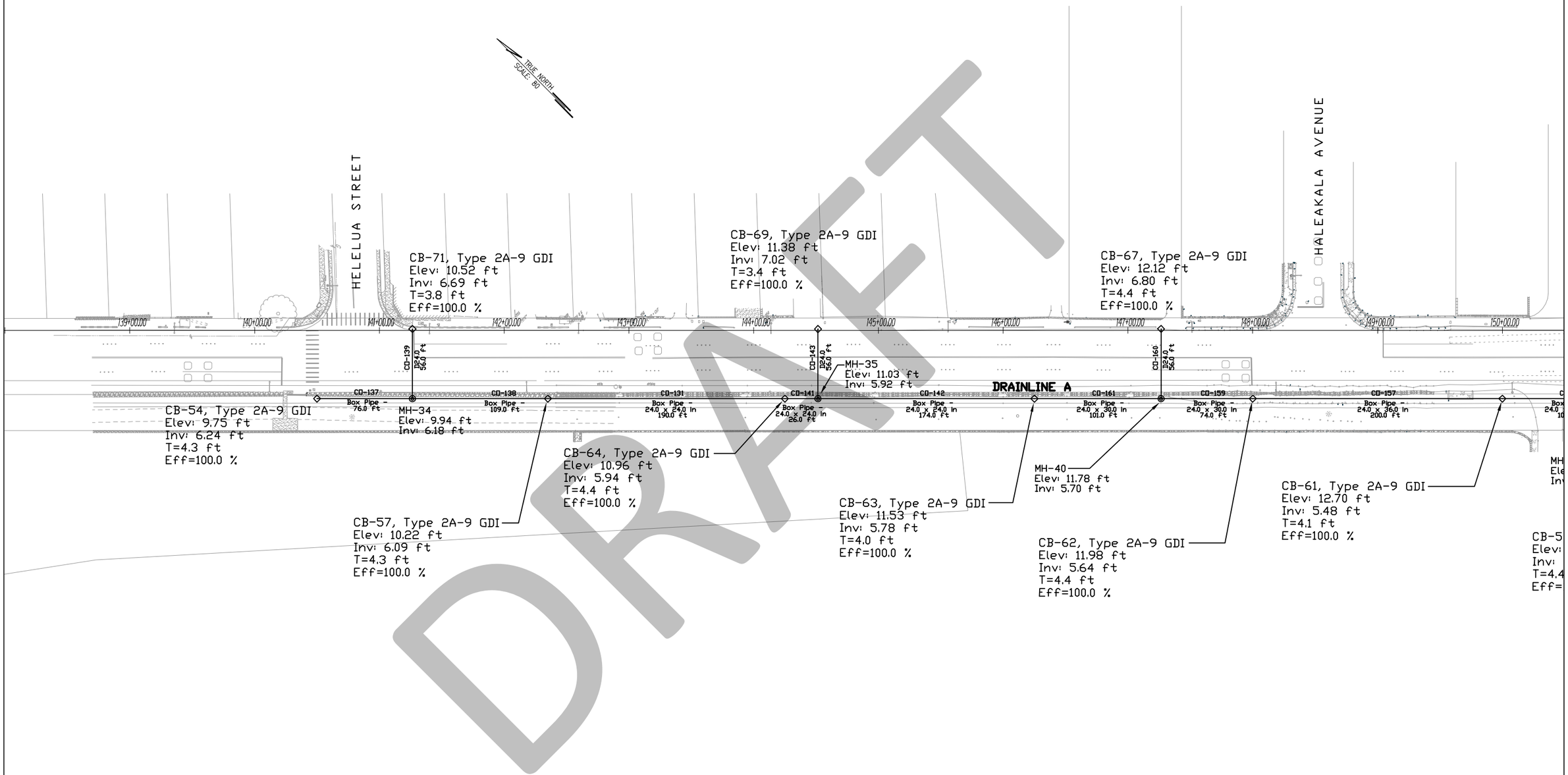
Scale: 1" = 80'

SHEET No. 3 OF 3 SHEETS

APPENDIX C – ROADWAY DRAINAGE SYSTEM LAYOUT

DRAFT

FED. ROAD DIST. NO.	STATE	FEDERAL AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
HAWAII	HAW.	93A-01-05	2010	1	4



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ORIGINAL PLAN		DATE
	SURVEY PLOTTED BY	
	DRAWN BY	
	TRACED BY	
NOTE BOOK	DESIGNED BY	
	QUANTITIES BY	
No.	CHECKED BY	

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

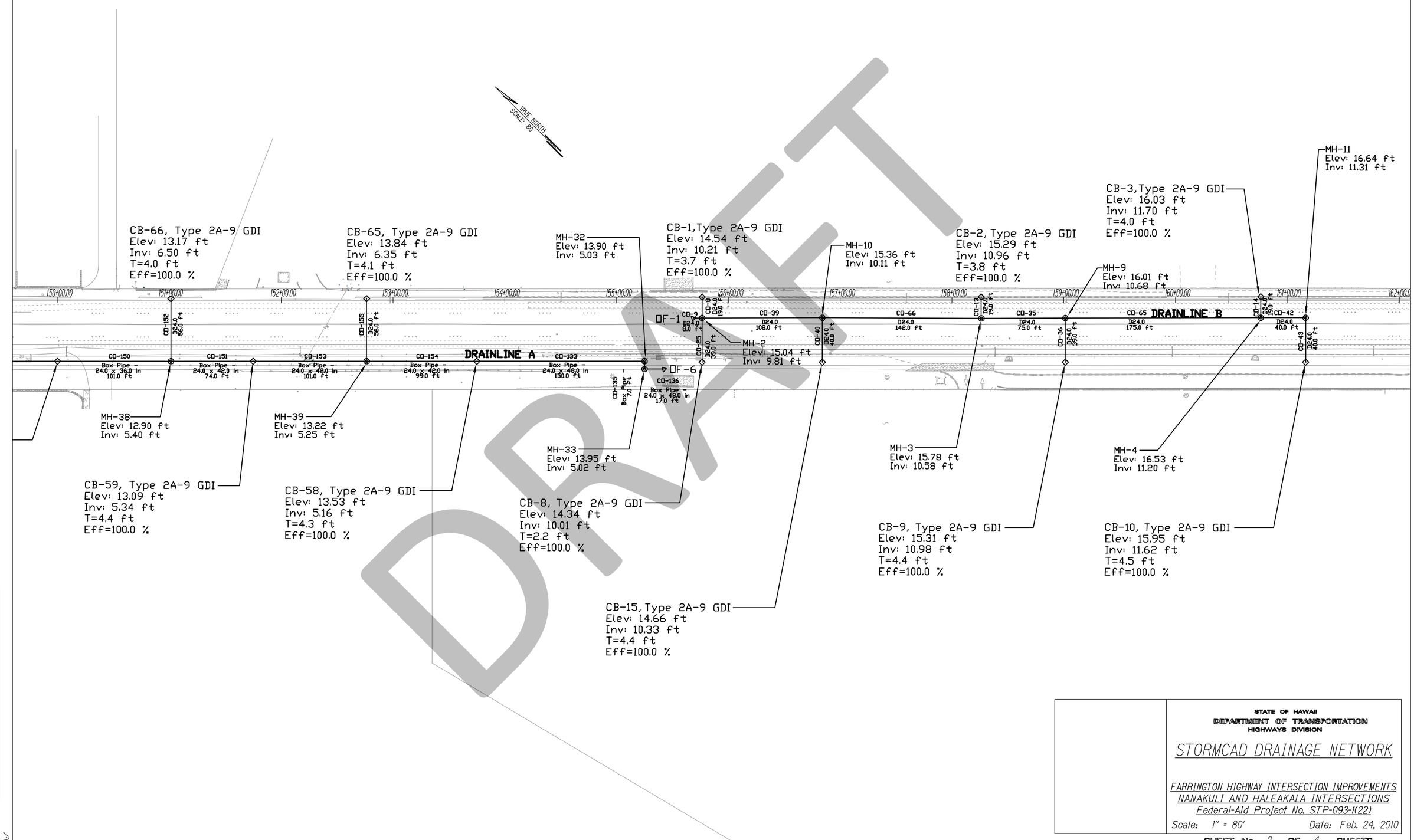
STORMCAD DRAINAGE NETWORK

FARRINGTON HIGHWAY INTERSECTION IMPROVEMENTS
NANAKULI AND HALEAKALA INTERSECTIONS
Federal-Aid Project No. STP-093-1(22)

Scale: 1" = 80' Date: Feb. 24, 2010

SHEET No. 1 OF 4 SHEETS

FED. ROAD DIST. NO.	STATE	FEDERAL AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
HAWAII	HAW.	93A-01-05	2010	2	4



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ORIGINAL PLAN	SURVEY PLOTTED BY	DATE
	DRAWN BY	
	TRACED BY	
NOTE BOOK	DESIGNED BY	
	QUANTITIES BY	
No.	CHECKED BY	

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

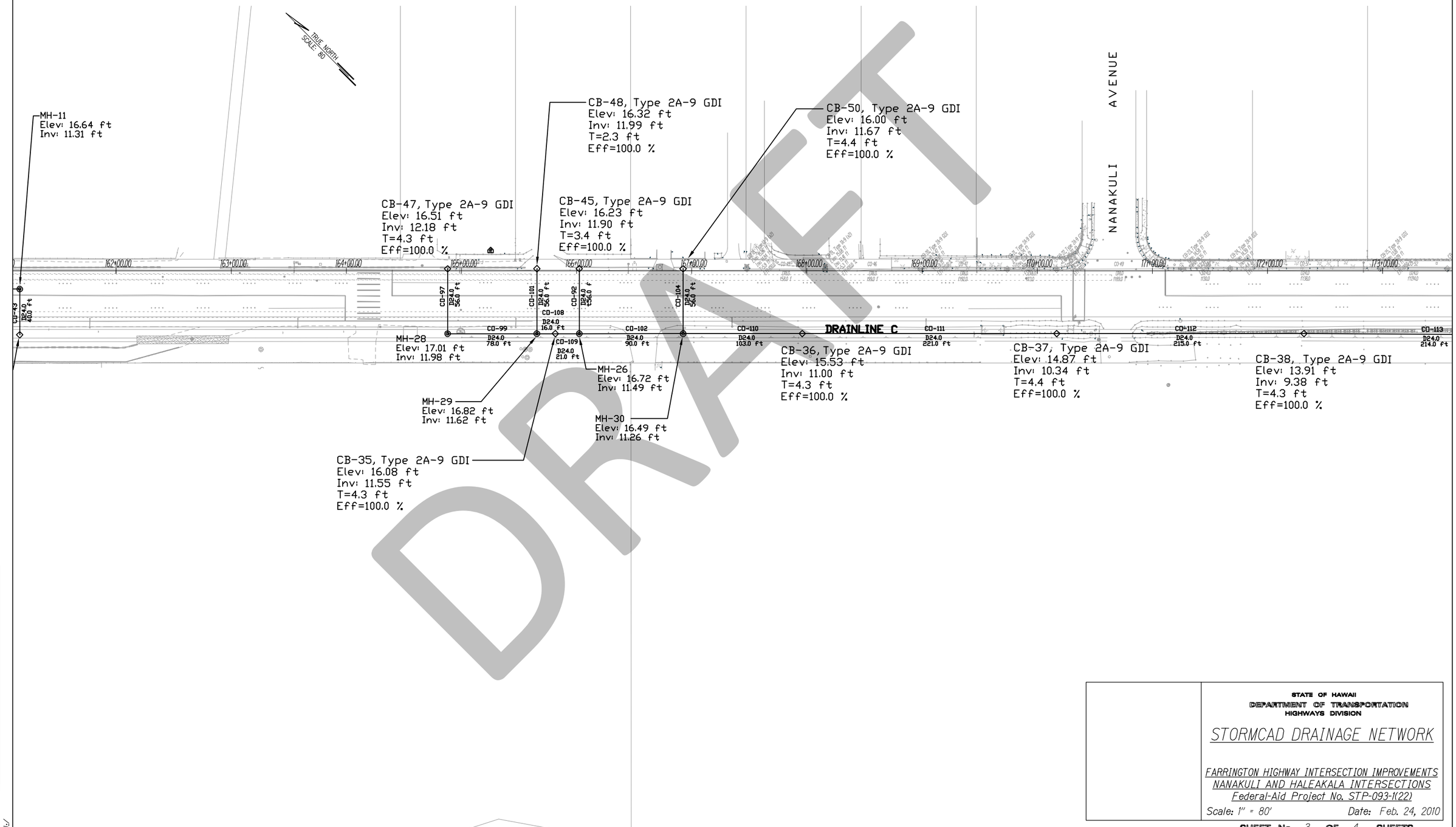
STORMCAD DRAINAGE NETWORK

FARRINGTON HIGHWAY INTERSECTION IMPROVEMENTS
NANAKULI AND HALEAKALA INTERSECTIONS
Federal-Aid Project No. STP-093-1(22)

Scale: 1" = 80' Date: Feb. 24, 2010

SHEET No. 2 OF 4 SHEETS

FED. ROAD DIST. NO.	STATE	FEDERAL AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
HAWAII	HAW.	93A-01-05	2010	3	4



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ORIGINAL PLAN	SURVEY PLOTTED BY	DATE
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STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

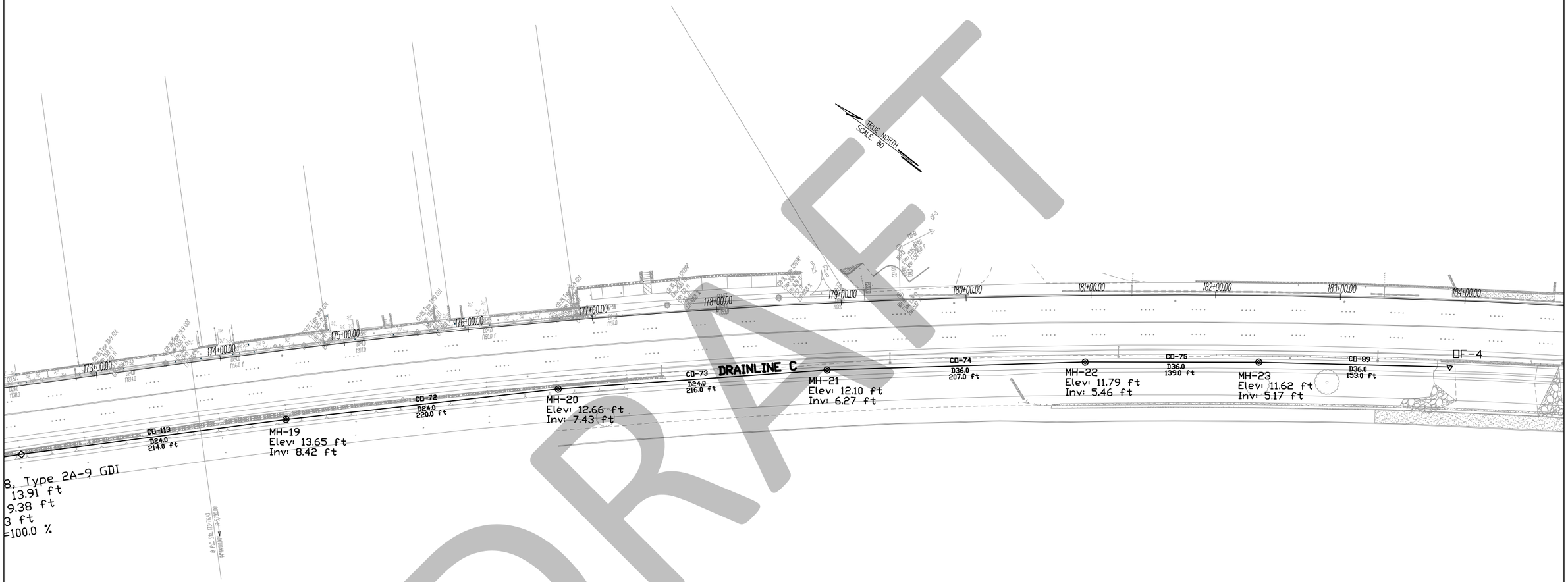
STORMCAD DRAINAGE NETWORK

FARRINGTON HIGHWAY INTERSECTION IMPROVEMENTS
NANAKULI AND HALEAKALA INTERSECTIONS
Federal-Aid Project No. STP-093-1(22)

Scale: 1" = 80' Date: Feb. 24, 2010

SHEET No. 3 OF 4 SHEETS

FED. ROAD DIST. NO.	STATE	FEDERAL AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
HAWAII	HAW.	93A-01-05	2010	4	4



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ORIGINAL PLAN		DATE
	SURVEY PLOTTED BY	
	DRAWN BY	
	TRACED BY	
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STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

STORMCAD DRAINAGE NETWORK

FARRINGTON HIGHWAY INTERSECTION IMPROVEMENTS
NANAKULI AND HALEAKALA INTERSECTIONS
Federal-Aid Project No. STP-093-1(22)

Scale: 1" = 80' Date: Feb. 24, 2010

SHEET No. 4 OF 4 SHEETS

APPENDIX D – STORMCAD SUMMARIES

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Proposed Drainage System Inlet Summary

Label	Drainline	Elevation (Ground) (ft)	Elevation (Invert) (ft)	Inlet Drainage Area (ft^2)	Inlet Drainage Area (acres)	Inlet C (composite)	Local CA (acres)	Total Inlet T_c (min)	Total Rational Flow to Inlet (ft^3/s)	Flow (Total Intercepted) (ft^3/s)	Flow (Total Bypassed) (ft^3/s)	Capture Efficiency (%)	Depth (In) (ft)	Depth (Out) (ft)	Bypass Target	Gutter Spread (ft)	Allowable Spread (ft)
CB-1	B	14.54	10.21	9809.972	0.225	0.9	0.203	10	1.03	1.01	0.02	100	0.55	0.55	CB-65	3.7	5.3
CB-2	B	15.29	10.96	9820.978	0.225	0.9	0.203	10	1.04	1.02	0.02	100	0.35	0.35	CB-1	3.8	5.3
CB-3	B	16.03	11.7	10736.112	0.246	0.9	0.222	10	1.11	1.08	0.03	100	0.36	0.36	CB-2	4	5.3
CB-8	B	14.34	10.01	5760.836	0.132	0.9	0.119	10	0.65	0.65	0	100	0.77	0.77	CB-58	2.2	5.3
CB-9	B	15.31	10.98	11666.294	0.268	0.9	0.241	10	1.27	1.21	0.05	100	0.56	0.56	CB-15	4.4	5.3
CB-10	B	15.95	11.62	12737.672	0.292	0.9	0.263	10	1.31	1.25	0.06	100	0.39	0.39	CB-9	4.5	5.3
CB-15	B	14.66	10.33	11835.052	0.272	0.9	0.245	10	1.27	1.22	0.06	100	0.76	0.76	CB-8	4.4	5.3
CB-35	C	16.08	11.55	12092.129	0.278	0.9	0.25	10	1.25	1.2	0.05	100	0.81	0.81	CB-36	4.3	5.3
CB-36	C	15.53	11	11583.919	0.266	0.9	0.239	10	1.25	1.19	0.05	100	1.02	1.02	CB-37	4.3	5.3
CB-37	C	14.87	10.34	11763.596	0.270	0.9	0.243	10	1.26	1.21	0.05	100	1	1	CB-38	4.4	5.3
CB-38	C	13.91	9.38	11398.77	0.262	0.9	0.236	10	1.23	1.18	0.05	100	1.09	1.09	N/A	4.3	5.3
CB-45	C	16.23	11.9	11624.835	0.267	0.7	0.187	10	0.93	0.92	0.01	100	0.42	0.42	CB-50	3.4	5.3
CB-47	C	16.51	12.18	13237.451	0.304	0.801	0.243	10	1.21	1.17	0.05	100	0.4	0.4	CB-48	4.3	5.3
CB-48	C	16.32	11.99	6975.165	0.160	0.788	0.126	10	0.68	0.68	0	100	0.35	0.35	CB-45	2.3	5.3
CB-50	C	16	11.67	15428.71	0.354	0.7	0.248	10	1.25	1.2	0.05	100	0.53	0.53	CB-18	4.4	5.3
CB-54	A	9.75	6.24	11519.773	0.264	0.9	0.238	10	1.24	1.19	0.05	100	1.98	1.98	N/A	4.3	5.3
CB-57	A	10.22	6.09	11513.95	0.264	0.9	0.238	10	1.24	1.19	0.05	100	2.13	2.13	CB-54	4.3	5.3
CB-58	A	13.53	5.16	12081.181	0.277	0.9	0.25	10	1.25	1.19	0.05	100	2.93	2.93	CB-59	4.3	5.3
CB-59	A	13.09	5.34	11874.935	0.273	0.9	0.245	10	1.28	1.22	0.06	100	2.77	2.77	CB-61	4.4	5.3
CB-61	A	12.7	5.48	10712.467	0.246	0.9	0.221	10	1.16	1.12	0.04	100	2.65	2.65	CB-62	4.1	5.3
CB-62	A	11.98	5.64	12023.895	0.276	0.9	0.248	10	1.28	1.22	0.06	100	2.51	2.51	CB-63	4.4	5.3
CB-63	A	11.53	5.78	10510.181	0.241	0.9	0.217	10	1.14	1.1	0.04	100	2.39	2.39	CB-64	4	5.3
CB-64	A	10.96	5.94	12049.866	0.277	0.9	0.249	10	1.28	1.22	0.06	100	2.26	2.26	CB-57	4.4	5.3
CB-65	A	13.84	6.35	11087.28	0.255	0.9	0.229	10	1.17	1.13	0.04	100	1.75	1.75	CB-66	4.1	5.3
CB-66	A	13.17	6.5	10579.636	0.243	0.9	0.219	10	1.13	1.1	0.03	100	1.62	1.62	CB-67	4	5.3
CB-67	A	12.12	6.8	11844.301	0.272	0.9	0.245	10	1.26	1.2	0.05	100	1.36	1.36	CB-69	4.4	5.3
CB-69	A	11.38	7.02	8654.027	0.199	0.9	0.179	10	0.94	0.93	0.01	100	1.18	1.18	CB-71	3.4	5.3
CB-71	A	10.52	6.69	10286.768	0.236	0.9	0.213	10	1.07	1.05	0.03	100	1.53	1.53	N/A	3.8	5.3

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Proposed Drainage System Conduit Summary

Label	Profile Description	Start Node	Stop Node	Conduit Shape	Material	Manning's n ()	Diameter (in)	Rise (in)	Span (in)	Flow (ft^3/s)	Capacity (Full Flow) (ft^3/s)	Length (ft)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Slope (Calculated) (ft/ft)	Cover (Start) (ft)	Cover (Stop) (ft)	Elevation Ground (Start) (ft)	Elevation Ground (Stop) (ft)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Velocity (Average) (ft/s)
CO-8	S1	CB-1	MH-2	Circular Pipe	Concrete	0.013	24	0	0	1.01	32.82	19	10.21	9.81	0.021	2.33	3.23	14.54	15.04	10.76	10.78	4.71
CO-9	Composite Pressure S1 S2	MH-2	OF-1	Circular Pipe	Concrete	0.013	24	0	0	7.44	107.6	8	9.81	8	0.226	3.23	4.35	15.04	14.35	10.78	10.4	19.65
CO-13	Composite S1 S2	CB-2	MH-3	Circular Pipe	Concrete	0.013	24	0	0	1.02	31.99	19	10.96	10.58	0.02	2.33	3.2	15.29	15.78	11.31	11.4	4.64
CO-14	Composite S1 S2	CB-3	MH-4	Circular Pipe	Concrete	0.013	24	0	0	1.08	36.7	19	11.7	11.2	0.026	2.33	3.33	16.03	16.53	12.06	11.79	5.19
CO-25	S1	CB-8	MH-2	Circular Pipe	Concrete	0.013	24	0	0	0.65	16.2	39	10.01	9.81	0.005	2.33	3.23	14.34	15.04	10.78	10.78	2.52
CO-35	M2	MH-9	MH-3	Circular Pipe	Concrete	0.013	24	0	0	3.54	8.26	75	10.68	10.58	0.001	3.33	3.2	16.01	15.78	11.55	11.4	2.53
CO-36	S1	CB-9	MH-9	Circular Pipe	Concrete	0.013	24	0	0	1.21	19.84	39	10.98	10.68	0.008	2.33	3.33	15.31	16.01	11.54	11.55	3.49
CO-39	M2	MH-10	MH-2	Circular Pipe	Concrete	0.013	24	0	0	5.78	11.92	108	10.11	9.81	0.003	3.25	3.23	15.36	15.04	11.09	10.78	3.76
CO-40	S1	CB-15	MH-10	Circular Pipe	Concrete	0.013	24	0	0	1.22	16.78	40	10.33	10.11	0.006	2.33	3.25	14.66	15.36	11.09	11.09	3.11
CO-42	M1	MH-11	MH-4	Circular Pipe	Concrete	0.013	24	0	0	1.25	11.86	40	11.31	11.2	0.003	3.33	3.33	16.64	16.53	11.81	11.79	2.45
CO-43	Composite S1 S2	CB-10	MH-11	Circular Pipe	Concrete	0.013	24	0	0	1.25	19.91	40	11.62	11.31	0.008	2.33	3.33	15.95	16.64	12.01	11.81	3.54
CO-65	M1	MH-4	MH-9	Circular Pipe	Concrete	0.013	24	0	0	2.33	12.33	175	11.2	10.68	0.003	3.33	3.33	16.53	16.01	11.79	11.55	3.01
CO-66	M1	MH-3	MH-10	Circular Pipe	Concrete	0.013	24	0	0	4.56	13.01	142	10.58	10.11	0.003	3.2	3.25	15.78	15.36	11.4	11.09	3.78
CO-72	M2	MH-19	MH-20	Circular Pipe	Concrete	0.013	24	0	0	8.74	15.17	220	8.42	7.43	0.005	3.23	3.23	13.65	12.66	9.51	8.48	5
CO-73	S2	MH-20	MH-21	Circular Pipe	Concrete	0.013	24	0	0	8.74	16.58	216	7.43	6.27	0.005	3.23	3.83	12.66	12.1	8.48	7.3	5.35
CO-74	Composite S1 S2	MH-21	MH-22	Circular Pipe	Concrete	0.013	36	0	0	8.74	41.72	207	6.27	5.46	0.004	2.83	3.33	12.1	11.79	7.2	6.56	4.67
CO-75	M2	MH-22	MH-23	Circular Pipe	Concrete	0.013	36	0	0	8.74	30.46	139	5.46	5.17	0.002	3.33	3.45	11.79	11.62	6.56	6.1	3.72
CO-89	S2	MH-23	OF-4	Circular Pipe	Concrete	0.013	36	0	0	8.74	44.14	153	5.17	4.5	0.004	3.45	4.02	11.62	11.52	6.1	5.41	4.86
CO-92	S1	CB-45	MH-26	Circular Pipe	Concrete	0.013	24	0	0	0.92	19.36	56	11.9	11.49	0.007	2.33	3.23	16.23	16.72	12.32	12.34	3.16
CO-97	M2	CB-47	MH-28	Circular Pipe	Concrete	0.013	24	0	0	1.17	13.52	56	12.18	11.98	0.004	2.33	3.03	16.51	17.01	12.58	12.36	2.64
CO-99	M1	MH-28	MH-29	Circular Pipe	Concrete	0.013	24	0	0	1.17	15.37	78	11.98	11.62	0.005	3.03	3.2	17.01	16.82	12.36	12.36	2.88
CO-101	S1	CB-48	MH-29	Circular Pipe	Concrete	0.013	24	0	0	0.68	18.39	56	11.99	11.62	0.007	2.33	3.2	16.32	16.82	12.34	12.36	2.78
CO-102	M1	MH-26	MH-30	Circular Pipe	Concrete	0.013	24	0	0	3.96	11.44	90	11.49	11.26	0.003	3.23	3.23	16.72	16.49	12.34	12.22	3.31
CO-104	S1	CB-50	MH-30	Circular Pipe	Concrete	0.013	24	0	0	1.2	19.36	56	11.67	11.26	0.007	2.33	3.23	16	16.49	12.2	12.22	3.42
CO-108	M1	MH-29	CB-35	Circular Pipe	Concrete	0.013	24	0	0	1.84	14.96	16	11.62	11.55	0.004	3.2	2.53	16.82	16.08	12.36	12.36	3.24
CO-109	M1	CB-35	MH-26	Circular Pipe	Concrete	0.013	24	0	0	3.04	12.09	21	11.55	11.49	0.003	2.53	3.23	16.08	16.72	12.36	12.34	3.2
CO-110	M1	MH-30	CB-36	Circular Pipe	Concrete	0.013	24	0	0	5.16	11.37	103	11.26	11	0.003	3.23	2.53	16.49	15.53	12.22	12.02	3.53
CO-111	M2	CB-36	CB-37	Circular Pipe	Concrete	0.013	24	0	0	6.35	12.36	221	11	10.34	0.003	2.53	2.53	15.53	14.87	12.02	11.34	3.96
CO-112	M1	CB-37	CB-38	Circular Pipe	Concrete	0.013	24	0	0	7.56	15.12	215	10.34	9.38	0.004	2.53	2.53	14.87	13.91	11.34	10.47	4.81
CO-113	M2	CB-38	MH-19	Circular Pipe	Concrete	0.013	24	0	0	8.74	15.15	214	9.38	8.42	0.004	2.53	3.23	13.91	13.65	10.47	9.51	4.99
CO-131	Pressure	CB-57	CB-64	Box Pipe	Concrete	0.013	12	24	24	3.43	8.09	190	6.09	5.94	0.001	2.13	3.02	10.22	10.96	8.22	8.2	0.86
CO-133	Pressure	CB-58	MH-32	Box Pipe	Concrete	0.013	12	24	48	14.87	20.54	150	5.16	5.03	0.001	6.37	6.87	13.53	13.9	8.09	8.07	1.86
CO-135	Pressure	MH-32	MH-33	Box Pipe	Concrete	0.013	12	24	48	14.87	26.38	7	5.03	5.02	0.001	6.87	6.93	13.9	13.95	8.07	8.07	1.86
CO-136	Pressure	MH-33	OF-6	Box Pipe	Concrete	0.013	12	24	48	14.87	23.94	17	5.02	5	0.001	6.93	5	13.95	12	8.07	8.07	1.86
CO-137	Composite Pressure M1	CB-54	MH-34	Box Pipe	Concrete	0.013	18	24	24	1.19	8.36	76	6.24	6.18	0.001	1.51	1.76	9.75	9.94	8.22	8.22	1.45
CO-138	Pressure	MH-34	CB-57	Box Pipe	Concrete	0.013	18	24	24	2.24	8.09	109	6.18	6.09	0.001	1.76	2.13	9.94	10.22	8.22	8.22	0.56
CO-139	Composite Pressure S1	CB-71	MH-34	Circular Pipe	Concrete	0.013	24	0	0	1.05	21.67	56	6.69	6.18	0.009	1.83	1.76	10.52	9.94	8.22	8.22	3.56
CO-141	Pressure	CB-64	MH-35	Box Pipe	Concrete	0.013	12	24	24	4.65	7.99	26	5.94	5.92	0.001	3.02	3.11	10.96	11.03	8.2	8.2	1.16
CO-142	Pressure	MH-35	CB-63	Box Pipe	Concrete	0.013	12	24	24	5.58	8.17	174	5.92	5.78	0.001	3.11	3.75	11.03	11.53	8.2	8.17	1.4
CO-143	Composite Pressure S1	CB-69	MH-35	Circular Pipe	Concrete	0.013	24	0	0	0.93	31.7	56	7.02	5.92	0.02	2.36	3.11	11.38	11.03	8.2	8.2	4.48
CO-150	Pressure	CB-61	MH-38	Box Pipe	Concrete	0.013	12	24	36	10.23	14.07	101	5.48	5.4	0.001	5.22	5.5	12.7	12.9	8.13	8.12	1.71
CO-151	Pressure	MH-38	CB-59	Box Pipe	Concrete	0.013	12	24	42	11.33	16.28	74	5.4	5.34	0.001	5.5	5.75	12.9	13.09	8.12	8.11	1.62
CO-152	Composite Pressure S1	CB-66	MH-38	Circular Pipe	Concrete	0.013	24	0	0	1.1	31.76	56	6.5	5.4	0.02	4.67	5.5	13.17	12.9	8.12	8.12	4.72
CO-153	Pressure	CB-59	MH-39	Box Pipe	Concrete	0.013	12	24	42	12.55	17.67	101	5.34	5.25	0.001	5.75	5.97	13.09	13.22	8.11	8.1	1.79
CO-154	Pressure	MH-39	CB-58	Box Pipe	Concrete	0.013	12	24	42	13.67	17.85	99	5.25	5.16	0.001	5.97	6.37	13.22	13.53	8.1	8.09	1.95
CO-155	Composite Pressure S1	CB-65	MH-39	Circular Pipe	Concrete	0.013	24	0	0	1.13	31.7	56	6.35	5.25	0.02	5.49	5.97	13.84	13.22	8.1	8.1	4.75
CO-157	Pressure	CB-62	CB-61	Box Pipe	Concrete	0.013	12	24	36	9.11	13.8	200	5.64	5.48	0.001	4.34	5.22	11.98	12.7	8.15	8.13	1.52
CO-159	Pressure	MH-40	CB-62	Box Pipe	Concrete	0.013	12	24	30	7.89	11	74	5.7	5.64	0.001	4.08	4.34	11.78	11.98	8.16	8.15	1.58
CO-160	Composite Pressure S1	CB-67	MH-40	Circular Pipe	Concrete	0.013	24	0	0	1.2	31.7	56	6.8	5.7	0.02	3.32	4.08	12.12	11.78	8.16	8.16	4.85
CO-161	Pressure	CB-63	MH-40	Box Pipe	Concrete	0.013	12	24	30	6.69	10.87	101	5.78	5.7	0.001	3.75	4.08	11.53	11.78	8.17	8.16	1.34

Final Estimated Discharge to OF-6: **14.87** <--- Drainline "A"
Final Estimated Discharge to OF-1: **7.44** <--- Drainline "B"
Final Estimated Discharge to OF-4: **8.74** <--- Drainline "C"

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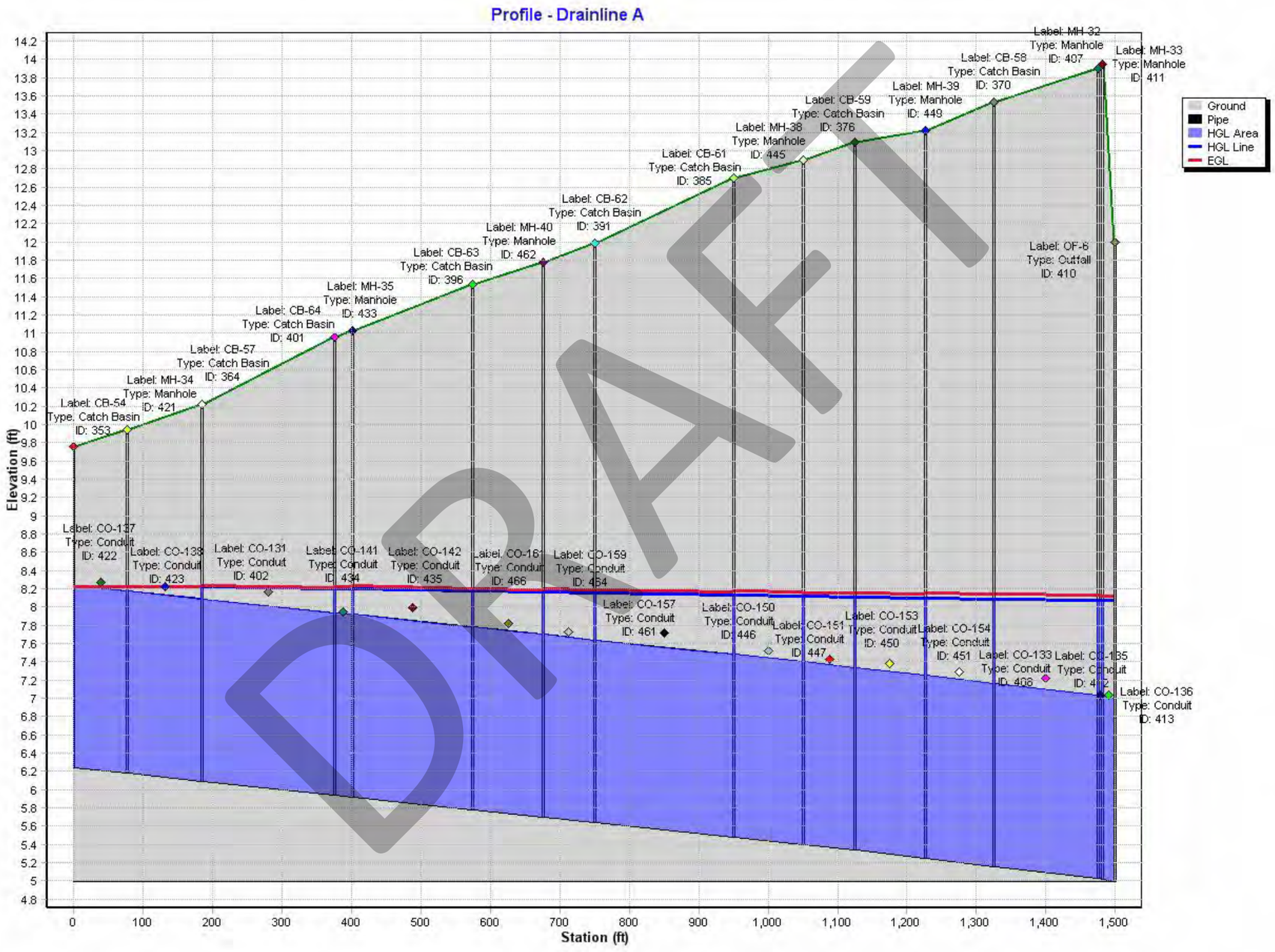
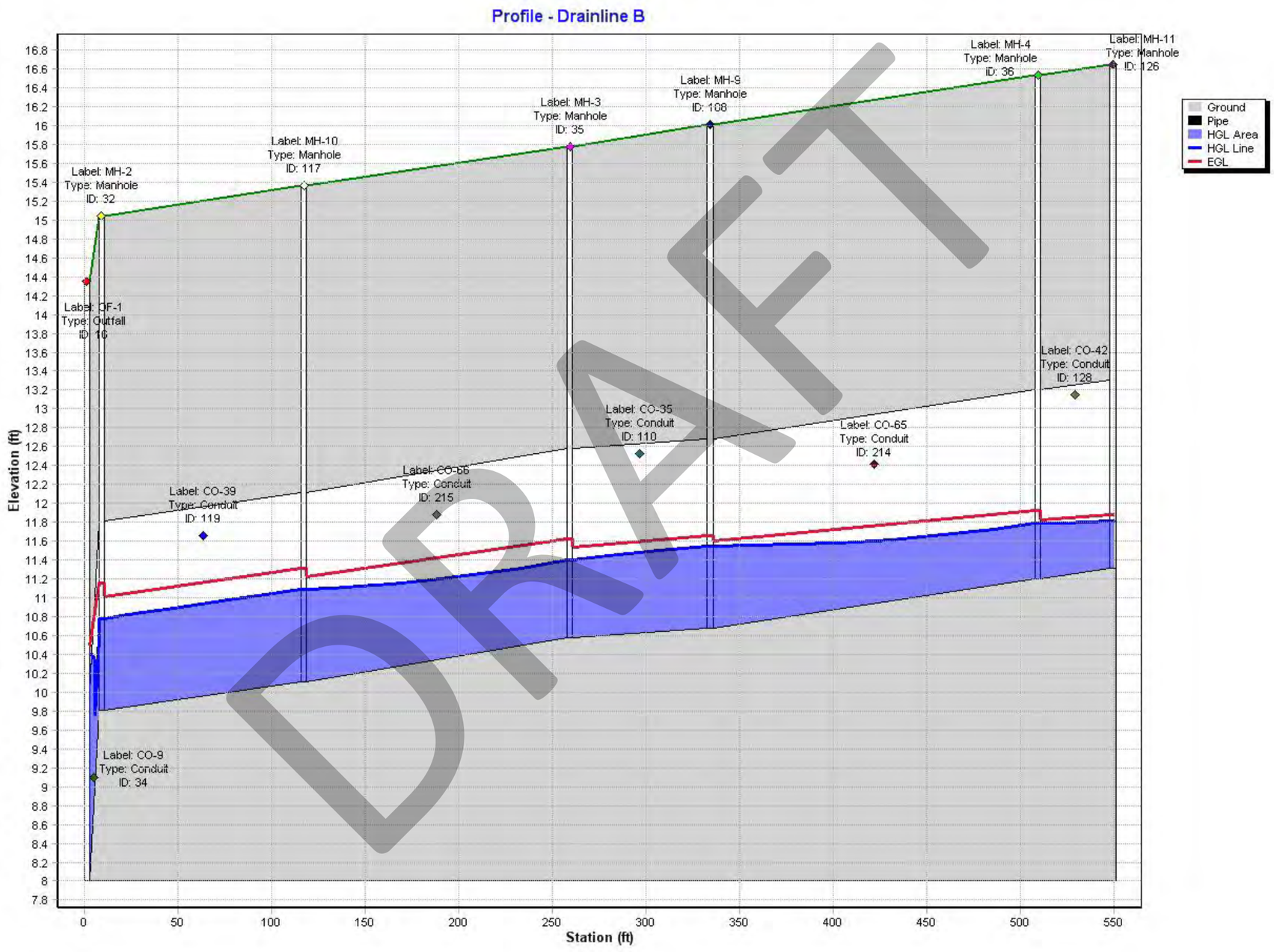

Profile - Drainline A
Elevation (ft)
Station (ft)
Ground
Pipe
HGL Area
HGL Line
EGL
Label: CB-54 Type: Catch Basin ID: 353
Label: MH-34 Type: Manhole ID: 421
Label: CB-57 Type: Catch Basin ID: 364
Label: CB-64 Type: Catch Basin ID: 401
Label: MH-35 Type: Manhole ID: 433
Label: CB-63 Type: Catch Basin ID: 396
Label: MH-40 Type: Manhole ID: 462
Label: CB-62 Type: Catch Basin ID: 391
Label: CB-61 Type: Catch Basin ID: 385
Label: MH-38 Type: Manhole ID: 445
Label: CB-59 Type: Catch Basin ID: 376
Label: MH-39 Type: Manhole ID: 449
Label: CB-58 Type: Catch Basin ID: 370
Label: MH-32 Type: Manhole ID: 407
Label: MH-33 Type: Manhole ID: 411
Label: OF-6 Type: Outfall ID: 410
Label: CO-137 Type: Conduit ID: 422
Label: CO-138 Type: Conduit ID: 423
Label: CO-131 Type: Conduit ID: 402
Label: CO-141 Type: Conduit ID: 434
Label: CO-142 Type: Conduit ID: 435
Label: CO-161 Type: Conduit ID: 466
Label: CO-159 Type: Conduit ID: 464
Label: CO-157 Type: Conduit ID: 461
Label: CO-150 Type: Conduit ID: 446
Label: CO-151 Type: Conduit ID: 447
Label: CO-153 Type: Conduit ID: 450
Label: CO-154 Type: Conduit ID: 451
Label: CO-133 Type: Conduit ID: 408
Label: CO-135 Type: Conduit ID: 412
Label: CO-136 Type: Conduit ID: 413

DRAFT


Profile - Drainline B
Ground
Pipe
HGL Area
HGL Line
EGL
Label: MH-2
Type: Manhole
ID: 32
Label: MH-10
Type: Manhole
ID: 117
Label: MH-3
Type: Manhole
ID: 35
Label: MH-9
Type: Manhole
ID: 108
Label: MH-4
Type: Manhole
ID: 36
Label: MH-11
Type: Manhole
ID: 126
Label: OF-1
Type: Outfall
ID: 16
Label: CO-39
Type: Conduit
ID: 119
Label: CO-55
Type: Conduit
ID: 215
Label: CO-35
Type: Conduit
ID: 110
Label: CO-65
Type: Conduit
ID: 214
Label: CO-42
Type: Conduit
ID: 128
Label: CO-9
Type: Conduit
ID: 34
Elevation (ft)
Station (ft)

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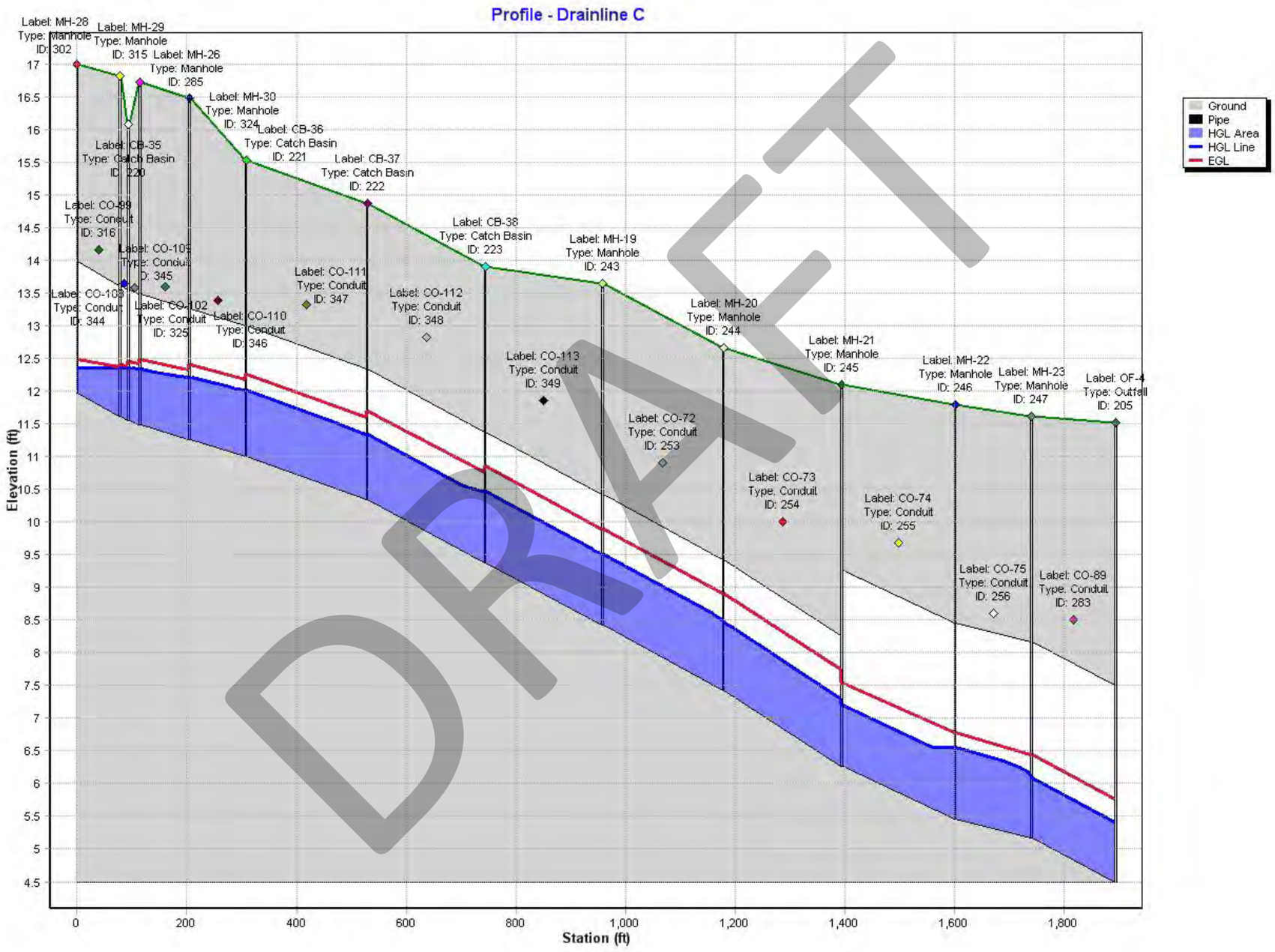
Profile - Drainline C
Ground
Pipe
HGL Area
HGL Line
EGL
Elevation (ft)
Station (ft)
Label: MH-28
Type: Manhole
ID: 302
Label: MH-29
Type: Manhole
ID: 315
Label: MH-26
Type: Manhole
ID: 285
Label: MH-30
Type: Manhole
ID: 324
Label: CB-36
Type: Catch Basin
ID: 221
Label: CB-37
Type: Catch Basin
ID: 222
Label: CB-35
Type: Catch Basin
ID: 220
Label: CO-99
Type: Conduit
ID: 316
Label: CO-103
Type: Conduit
ID: 345
Label: CO-100
Type: Conduit
ID: 344
Label: CO-102
Type: Conduit
ID: 325
Label: CO-110
Type: Conduit
ID: 346
Label: CO-111
Type: Conduit
ID: 347
Label: CO-112
Type: Conduit
ID: 348
Label: CB-38
Type: Catch Basin
ID: 223
Label: MH-19
Type: Manhole
ID: 243
Label: CO-113
Type: Conduit
ID: 349
Label: MH-20
Type: Manhole
ID: 244
Label: CO-72
Type: Conduit
ID: 253
Label: MH-21
Type: Manhole
ID: 245
Label: CO-73
Type: Conduit
ID: 254
Label: MH-22
Type: Manhole
ID: 246
Label: MH-23
Type: Manhole
ID: 247
Label: OF-4
Type: Outfall
ID: 205
Label: CO-74
Type: Conduit
ID: 255
Label: CO-75
Type: Conduit
ID: 256
Label: CO-89
Type: Conduit
ID: 283

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APPENDIX E – IMPACT OF OUTFALLS

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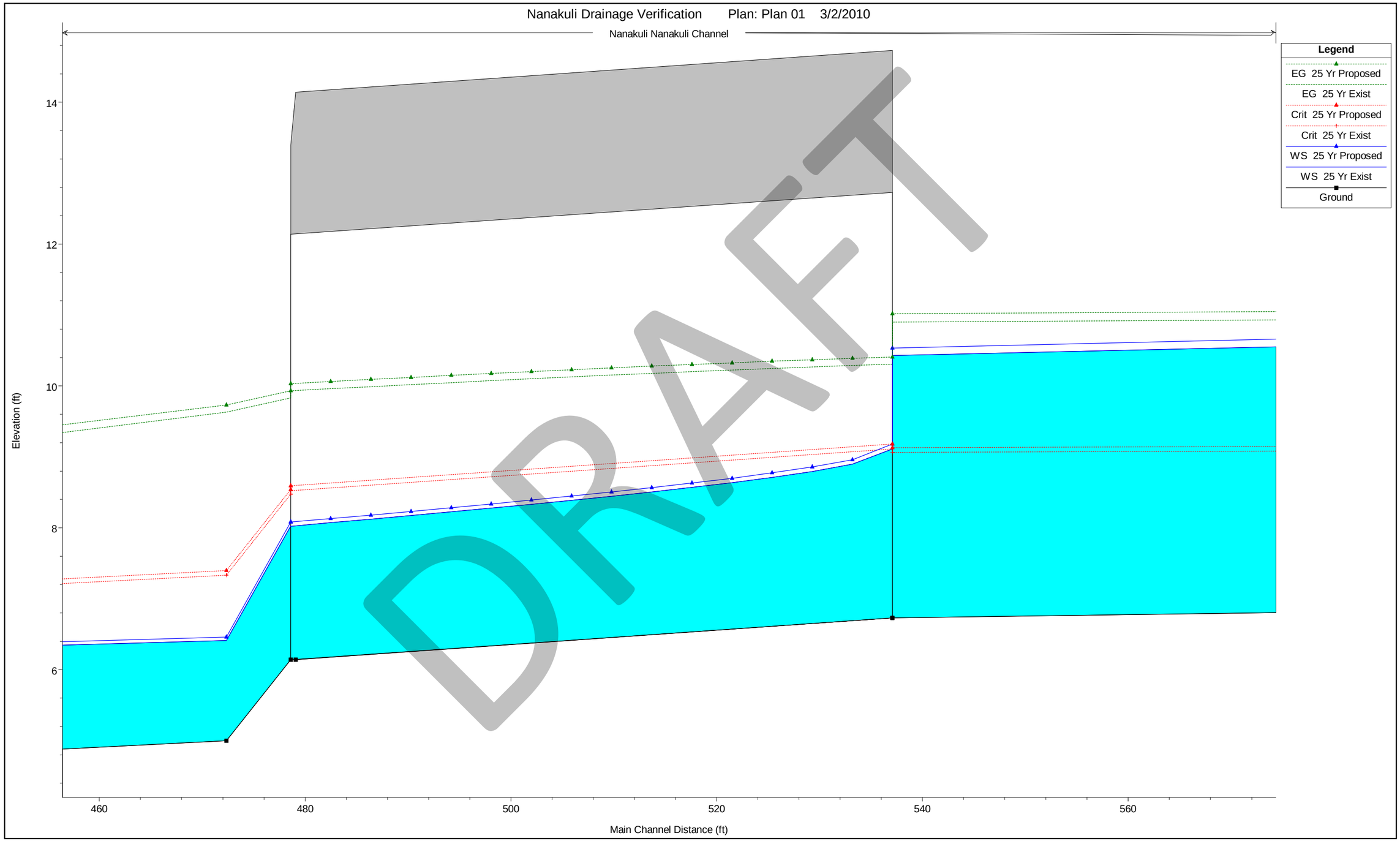

Impact of Outfall Discharges into DHHL Drainage Canal

Summary of Outfall Impacts on DHHL Drainage Canal

Channel Station	Channel Station (Station 0+00 @ Farrington Hwy CL)	Invert Elevation (ft)	Existing Water Elevation (ft)	New Water Elevation (ft)	ΔWater Elevation (inches)
0+00.00	(-)5+06.34	1.45	4.75	4.8	0.6
4+50.84	(-)0+55.50	4.84	7.89	7.94	0.6
4+72.34	(-)0+34.00	5	8.01	8.07	0.72
4+77.34	(-)0+27.75	6.14	9.88	9.94	0.72
5+37.09	0+30.75	6.73	13.7	13.81	1.32
6+06.34	1+00.00	6.87	14.28	14.4	1.44
16+56.34	11+50.00	8.97	14.44	14.55	1.32

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Draft

Noise Technical Report

Farrington Highway Intersection Improvements at Nanakuli Avenue and Haleakala Avenue

Waianae, Oahu, Hawaii

March 2010

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Appendices

Introduction to Acoustics
Traffic Data

Chapter 1 Summary

The Hawaii State Department of Transportation (HDOT) initiated this study to improve traffic flow and safety along Farrington Highway. The study is to support the environmental assessment that is being conducted along Farrington Highway at Haleakala Avenue and Nanakuli Avenue. Exhibit 1 indicates the location of the project area within Oahu.

The purpose of this technical report is to describe the existing noise environment and evaluate current and future predicted traffic noise levels at noise sensitive sites located in the study area. Mitigation measures will be described (if applicable) and the effects of temporary construction noise.

Traffic noise levels along the current roadways were measured, and existing and future traffic noise levels were modeled using the FHWA Traffic Noise Model (TNM®) 2.5 model. Predicted traffic noise levels range from 48 dBA L_{eq} to 71 dBA L_{eq} for the existing conditions. Traffic noise is the dominant source of noise in the study area.

For the future No-Build conditions traffic noise levels ranged from 49 dBA L_{eq} to 71 dBA L_{eq}. Traffic noise levels for the No-Build conditions at noise sensitive receptors are predicted to increase by approximately 1 dBA L_{eq} over existing conditions.

For the Build Future scenarios traffic noise levels along the proposed roadways will be dependent upon distance and shielding conditions present. Traffic noise levels for the Build Alternative are predicted to increase by approximately 1 dBA L_{eq} to 2 dBA L_{eq} over existing conditions. Future increased traffic volumes in the study area and the additional center lane on Farrington Highway contribute to higher future traffic noise levels in the study area.

Thirty-six residences and one church are predicted to be affected by traffic noise. All 36 residences and one church are currently affected by traffic noise from Farrington Highway. Noise mitigation measures including noise barriers were evaluated for feasibility and reasonableness. Noise mitigation measures were found to be not feasible for residential sites because limited right-of-way and access limitations to residences adjacent to Farrington Highway.

Insulation of the church building affected by noise could be feasible. This remedy, in accordance with FHWA and HDOT policy only applies to public or non-profit institutional buildings such as schools, churches, or libraries. One church, the Samoan Wesleyan Methodist Church is the only institutional building affected by the project. Discussion between HDOT and church owners can determine the potential for noise insulation at this facility.

Chapter 2 Land Use and Area Description

2.1 Project Description

The Hawaii State Department of Transportation (HDOT) initiated this study to improve traffic flow and safety along Farrington Highway. The study is to support the environmental assessment that is being conducted along Farrington Highway from Helelua Street to Nanakuli Stream. Exhibit 1 indicates the location of the project area within Oahu.

This noise study will describe the existing noise environment, predict future traffic noise impacts, evaluate potential mitigation strategies (if applicable) and estimate potential temporary construction effects to the noise environment.

2.2 Zoning and Existing Land Use

Mauka of the proposed project site is largely residential, primarily consisting of single-family homes and Hawaiian homestead lands. Four public schools, a high school, middle school, and two elementary schools service the Nānākuli area as well as one public charter school. The public charter school and one of the elementary schools are located along Farrington Highway. The other schools lie within the valley. Commercial land use includes a shopping center, convenience stores, gas stations, and public utility facilities, all lying north of the project site. Serving the Nānākuli residents is a community learning center, Boys and Girls Club, and churches located along the project lines. Makai of Farrington Highway is the coast and Ulehawa and Nānākuli Beach Parks.

The Nānākuli coast is lined with beach parks and within the valley are various recreational services for the community. The project area, in particular lines a portion of the coast with many recreational and community sites. Within the project vicinity, from West to East, Ulehawa Beach Park is the western most beach park followed by Nānākuli Beach Park, which is comprised of Kalanianaole Beach Park, Zablan's Beach and ending with Piliokahe, east of Nanakuli Stream. Both Ulehawa Beach Park and Nānākuli Beach Parks are within the project area. Nānākuli Beach Park includes a playground and basketball courts. Further up the valley is the recently completed in 2008 NFL YET center for the youth of Nānākuli and adjacent to the Nānākuli High School is the Boys and Girls Club Teen Center.

Exhibit 3 shows the land uses in the noise study area. The zoning in the noise study area are as follows:

- AG-2 – Agriculture
- B-2 – Business
- C – Commercial
- P-2 – Preservation
- R-5 –

2.3 Methods

Ambient noise levels were measured for 15-minute periods at four locations near the project area (Exhibit 2) to describe the existing noise environment, identify major noise sources in the project area, validate the noise prediction model, and characterize the background environmental noise levels (Table 2). Measurements were taken October 14th and 15th, 2009 with a calibrated Larson Davis Model 820 noise meter which complies with ANSI S1.4 Standard for a Type I accuracy instrument. Measurement locations represent larger clusters of noise-sensitive receptors near the proposed project. Existing noise levels were subsequently modeled at 29 locations that represent noise sensitive uses in the study area and shown in Exhibit 2. Noise measurement locations were only used to calibrate the noise model and not used for predicting noise levels at noise sensitive locations because noise measurements were not representative of noise sensitive locations.

FHWA's Traffic Noise Model (TNM®) Version 2.5 computer model (FHWA, 2004) was used to predict $L_{eq(h)}$[1] traffic noise levels as shown in Table 4. TNM® was used to predict noise levels at discrete, but representative points by considering interactions between different noise sources on the propagation of noise. The model predicts the traffic noise level at a receiver location resulting from a series of straight-line roadway segments. Noise emissions from free-flowing traffic depend on the number of automobiles, medium trucks, heavy trucks, motorcycles and buses per hour; vehicular speed, and reference noise emission levels of specified vehicles. TNM® considers the effects of intervening barriers, topography, trees, and atmospheric absorption of sound.

By intent and design, noise from sources other than traffic is not included. Therefore, when non-traffic noise such as aircraft noise is considerable in an area, the TNM® modeled results can be slightly less than the measured noise levels. For this reason the results from the noise measurements were used to calibrate the TNM® model by comparing the predicted and measured noise levels at the four measurement locations using the traffic count data obtained during the measurement periods. These traffic counts reflect the conditions present during the period of the measurement and therefore help to insure the model is producing accurate sound level predictions. The calibration process proved to be successful because the differences between measured and modeled noise levels at the receptors were within +/- 1 dBA as shown in Table 2. A match between measurement and modeled sound levels this close indicates that no calibration adjustment of the model is necessary in accordance with FHWA policy.

Base maps were exported as DXF files and imported into the TNM® package. In addition, ArcGIS and was used to develop the TNM® model. Major roadways, topographical features, building rows, and sensitive receptors were digitized into the model. The proposed roadway alignments were added to the model from design drawings.

Predicted traffic levels for at least 20 years in the future are to be used in noise studies. For this study the existing year used is 2009 and the future year used is 2030. Also per HDOT

[1] Leq – Equivalent Sound Level. The steady A-weighted sound level over any specified period of time that has the same acoustic energy as the fluctuating noise during that period. It is a measure of cumulative acoustical energy.

policy, a worst case traffic noise condition was used. The worst case traffic condition is defined as the noisiest hour of the day when traffic volumes are heaviest but speeds are not substantially impeded. The traffic noise analysis used peak-noise-hour traffic data and speeds for the existing conditions (year 2009), and projected peak-noise-hour traffic data for future year (2030) No Build and Build alternatives. This information is discussed in Chapter 4. Traffic data and speeds were generated by HDOT. The traffic data (volumes and speeds) were applied to the existing and proposed roadways. The traffic volumes and vehicle mix for the project are documented in Appendix B.

Predicted noise levels were compared with the FHWA noise abatement criteria (NAC), as shown in Table 1, and the number of affected receptors were counted. Mitigation measures were evaluated for engineering feasibility and reasonableness using FHWA criteria for receptors where noise levels were predicted to approach or exceed the NAC.

Construction noise was qualitatively assessed using FHWA reference levels. Suggested construction noise abatement measures are provided for inclusion in contractor documents.

2.4 Noise Regulations and Impact Criteria

Applicable noise regulations and guidelines provide a basis for evaluating potential noise impacts. For federally funded highway projects, traffic noise impacts occur when modeled $L_{eq(h)}$ noise levels approach or exceed the noise abatement criteria (NAC) established by the FHWA, or substantially exceed existing noise levels (U.S. Department of Transportation, 1982, Noise Abatement Council). HDOT policy considers a future increase of 15 dBA or more above existing noise levels to be a substantial increase. HDOT policy also considers a noise impact to occur if modeled $L_{eq(h)}$ noise levels are 1 dBA less than the noise abatement criterion.

As shown in Table 1, the FHWA noise abatement criteria specify maximum $L_{eq(h)}$ noise levels for various land activity categories. For Category A receptors where serenity and quiet are of extraordinary significance, the exterior noise criterion is 57 dBA. For Category B receptors such as residences, parks, schools, churches, and similar areas, the exterior noise criterion is 67 dBA. For Category C “developed lands” which includes most commercial spaces, the exterior noise criterion is 72 dBA. No noise criterion is provided for Category D “undeveloped lands”. And finally, for inhabited buildings with no outdoor land use, the interior Category E noise criterion is 52 dBA. A reduction of 10 dBA can be assumed for noise transmitting to the interior of Category E receptors through open windows, which is the assumed condition unless positive knowledge of a windows closed condition exists. A minimum 20 dBA noise reduction is allowed for a closed window condition.

Table 1. FHWA Noise Abatement Criteria

Activity Category	L_{eq} (h) (dBA)	Description of Activity Category
A	57 (exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.
C	72 (exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	n/a	Undeveloped lands.
E	52 (interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

Source: U.S. Department of Transportation, 1982.

Chapter 3 Existing Noise Levels

Existing noise levels were measured at four locations and are presented in Table 2. The 15-minute noise measurements were conducted during various periods throughout the day. The measured noise levels, traffic counts, and average vehicle speeds obtained during the noise measurements were also used to determine if calibration the TNM® traffic noise model was necessary (as described in the Methodology section of this report).Table 2 shows the comparison between measured noise levels and modeled noise levels for the noise measurement locations. Traffic noise was for the most part the dominant noise source in the project area, so the TNM® model results matched very well (+/- 2dBA) when compared to the measured noise levels.

Much of the noise study area land use is residential. The majority of the residences in the noise study area are located east of Farrington Highway with parkland and school uses located to the west of Farrington Highway, along the shoreline. Roadway traffic along Farrington Highway was the dominant source of noise in the area. Sound levels in the study area tend to reduce as the distance from Farrington Highway to the sensitive receptor increases.

Noise levels at the four measurement locations varied from 67 to 69 dBA L_{eq} (Table 2), depending on the proximity to local roadways. The noise measurements were performed during the daytime on October 14th and 15th, 2009. The metrological conditions were ideal for taking noise measurements. On October 14th there was a temperature of approximately 76 degrees Fahrenheit with no precipitation and partial cloud cover. October 15th saw a temperature of approximately 78 degrees Fahrenheit with no precipitation and partial cloud cover. In brief, the noise measurement locations consisted of the following (see Table 2 and Exhibit 1):

- Measurement 1 was located at a church parking lot at the eastern boundary of a residential neighborhood in the eastern portion of the study area south of the intersection of Farrington Highway and Nanakuli Avenue. The measurement point was approximately 50 feet from Farrington Highway. The measured noise level at 12:30 hours was 69 dBA L_{eq}.

- Measurement 2 was located at the Nanaikapono Elementary School Driveway. The measurement point was approximately 60 feet from Farrington Highway. The measured noise level at 13:00 hours was 68 dBA L_{eq}.

- Measurement 3 was located along the frontage to Farrington Highway at a beach park on the western portion of the study area near the intersection of Farrington Highway and Haleakala Avenue. The measurement point was approximately 50 feet from Farrington Highway. The measured noise level at 10:00 hours was 69 dBA L_{eq}.

- Measurement 4 was located along the frontage to Farrington Highway in front of the Ka Waihona o Ka Na'auao Public Charter School. The measurement point was approximately 100 feet from Farrington Highway. The measured noise level at 11:00 hours was 67 dBA L_{eq}.

Table 2. Noise Measurement Data and TNM® Model Calibration Check

Location No.	Description	Measured Noise Level (dBA L_{eq})	Modeled Noise Level For Calibration (dBA L_{eq})	Difference between Modeled and Measured Noise Level (dBA L_{eq})
A	Saint Rita's Church Parking Lot	69	69	0
B	Nanaikapono Elementary School Driveway	68	68	0
C	Ulehawa Beach Park Frontage to Farrington Hwy	69	69	0
D	Ka Waihona o Ka Na'auao Public Charter School Frontage to Farrington Hwy	67	67	0

For noise model validation, measured noise levels, traffic counts, and average traffic speeds taken during the measurements were used to validate the TNM® traffic noise model. Each of the four measured sites were found to model within +/-1 dBA of the measured levels. Because a 3 dBA change in noise levels is barely perceptible to the average human ear, an agreement of +/-1 dBA is considered acceptable for noise model validation purposes.

The close verification of the modeled and measured noise levels indicates that the model is accurately representing the traffic noise levels in this area. Thus, the model can be relied upon to accurately predict the traffic noise levels for future peak vehicle hour traffic conditions. The measured sites were taken at locations near Farrington Highway that did not represent sensitive use areas. Because of their location, the measured sites were only used to calibrate the noise model and are not carried forward in the analysis to follow.

3.1 Existing Noise Conditions

Table 3 shows the TNM® predicted noise results for the modeled sites that represent sensitive use locations within the noise study area for the existing worst case noise condition. The locations of the receptors can be seen on Exhibit 2.

The modeled traffic noise levels for the existing conditions along the current roadways range from 48 to 71 dBA L_{eq} as shown on Table 3. The modeled traffic noise levels at these receptors are dependent upon the proximity of the receptor to the existing roadways, the amount of physical shielding provided by buildings, and topography. Nine modeled sites representing 36 residences and one church are currently affected by roadway traffic noise.

Table 3. Predicted Noise Levels for the Existing Condition (Worst Traffic Noise Condition)

Modeled Site Number	No. of Units Represented by the Receptor	NAC Criteria	Existing Traffic Noise Level L_{eq}(h) dBA	L_{eq} dBA at or Above NAC (Yes/No)
1	6	B	62	No
2	6	B	**71**	Yes
3	4 + Church	B	62	No
4	4	B	**71**	Yes
5	4	B	61	No
6	4	B	**71**	Yes
7	4	B	61	No
8	4	B	57	No
9	4	B	**71**	Yes
10	4	B	57	No
11	Park	B	65	No
12	3	B	61	No
13	3	B	56	No
14	4	B	53	No
15	2	B	**69**	Yes
16	School	B	48	No
17	School	B	59	No
18	Playfield	B	48	No
19	School	B	58	No
20	4	B	**69**	Yes
21	4	B	58	No
22	Athletic Court	B	64	No
23	4	B	**69**	Yes
24	4	B	59	No
25	4	B	**69**	Yes
26	4	B	58	No
27	Park	B	64	No
28	4	B	58	No
29	4 + Church	B	**69**	Yes

Bold indicates an impacted receptor according to the NAC

Chapter 4 Project Impacts

4.1 Traffic Noise Analysis

The following section describes operational noise impacts for the roadway widening. The modeled locations noise level for the future scenarios, as was the case for the measurement locations, are representative of an area and apply to all residences in the vicinity of the location.

4.1.1 No Build Future

As with the Existing traffic noise levels, the No-Build (Year 2030) future traffic noise levels along the current roadways will be dependent upon distance from and shielding conditions present between the roadway and the receiver. Traffic noise levels with the No-Build future condition will increase over time due to increased traffic volumes on the study area roadway network. Traffic noise levels for the No-Build future condition at the 29 receptor locations are predicted to range from 49 to 71 dBA L_{eq}. Traffic noise levels are expected to rise by one to two decibel over the existing traffic noise levels with no new additional receptors experiencing noise levels above the NAC (Table 4).

4.1.2 Build Future

The Build Future scenario traffic noise levels along the proposed roadways will be dependent upon distance and shielding conditions present. Predicted traffic noise levels for the Build scenario will rise over time due to increased traffic volumes in the study area on the new roadway network in the future and due to increased proximity of some sensitive receptors to the widened facility. In areas near Farrington Highway existing traffic noise levels at sensitive receptors are predicted to increase by approximately 1 dBA L_{eq} to 2 dBA L_{eq}. Noise levels at many areas along the northern third of the project area are expected to remain unchanged. Table 4 lists the noise levels for each receptor analyzed under the Build Alternative.

4.2 Traffic Noise Impacts

The following section describes the traffic noise impacts in the study area.

4.2.1 Existing

Table 4 shows the traffic noise levels under the existing conditions. Under the existing conditions there are nine receptors that represent 36 residences and one church affected by traffic noise.

4.2.2 No-Build Future

Table 4 shows that under the Year 2030 No-Build Future conditions, the same 36 residences and one church are affected by traffic noise that currently experience traffic noise levels above the NAC.

4.2.3 Build Future

Under Year 2030 Build Future conditions the same 36 residences and one church are affected by traffic noise that currently experience traffic noise levels above the NAC (Table 4). These impacts are largely due to the proximity of noise sensitive sites in relation to traffic volumes on Farrington Highway. While the increase in future traffic contributes to the noise levels at sensitive sites, no new noise sensitive sites are expected to experience noise levels above the NAC under the Build scenario.

Table 4. Predicted Traffic Noise Levels and Impact Conditions

Site Number	No. of Dwelling Units Represented by the Receiver	NAC Criteria	Existing Traffic Noise Level Leq dBA	No Build Traffic Noise Level Leq/dBA 2030	Difference from Existing	Build Traffic Noise Level Leq/dBA 2030	Difference from Existing
1	6	B/66	62	62	0	62	0
2	6	B/66	**71**	**71**	0	**71**	0
3	4 + Church	B/66	62	62	0	62	0
4	4	B/66	**71**	**71**	0	**71**	0
5	4	B/66	61	62	1	61	0
6	4	B/66	**71**	**71**	0	**71**	0
7	4	B/66	61	61	0	61	0
8	4	B/66	57	57	0	57	0
9	4	B/66	**71**	**71**	0	**71**	0
10	4	B/66	57	57	0	57	0
11	Park	B/66	65	65	0	65	0
12	3	B/66	61	62	1	62	1
13	3	B/66	56	56	0	57	1
14	4	B/66	53	53	0	53	0
15	2	B/66	**69**	**70**	1	**70**	1
16	School	B/66	48	49	1	49	1
17	School	B/66	59	60	1	61	2
18	Playfield	B/66	48	49	1	49	1
19	School	B/66	58	59	1	59	1
20	4	B/66	**69**	**70**	1	**70**	1
21	4	B/66	58	59	1	59	1
22	Athletic Court	B/66	64	65	1	66	2
23	4	B/66	**69**	**70**	1	**70**	1
24	4	B/66	59	60	1	60	1
25	4	B/66	**69**	**70**	1	**70**	1
26	4	B/66	58	59	1	59	1
27	Park	B/66	64	65	1	65	1
28	4	B/66	58	59	1	59	1
29	4 + Church	B/66	**69**	**70**	1	**70**	1

Bold indicates an impacted receptor according to the NAC

Chapter 5 Noise Mitigation Methodology

Because predicted traffic noise levels are expected to exceed FHWA/HDOT noise criteria limits for some receivers, mitigation measures are warranted for consideration. Noise abatement is to be considered only where frequent human use occurs and where a lower noise level would provide benefits (U.S. DOT, 1982).

Several different traffic noise abatement measures are evaluated whenever traffic noise impacts are expected. For example, noise generated from long-term operation of the project can be reduced by implementing traffic management measures, acquiring land as buffer zones, realigning the roadway, soundproofing public use or nonprofit institutional structures, and constructing noise barriers or berms. These measures were evaluated for their potential to reduce noise impacts from the proposed project.

Any specific mitigation measure recommended as part of the project must be feasible and reasonable. In this context feasible means the physical ability to implement the noise mitigation measure in such a manner as to provide an acceptable noise reduction benefit, while reasonable means being able to implement the mitigation measure at an acceptable cost.

Thirty-six residential units and one church, represented by Modeled Locations 2, 4, 6, 9, 15, 20, 23, 25, and 29 (see Table 4) are predicted to be impacted by traffic noise under the build alternative in the Year 2030. All 36 residences and one church are currently impacted by traffic noise under the existing conditions. All 36 locations have been evaluated for potential mitigation measures because they exceed FHWA/HDOT noise criteria limits.

Traffic noise mitigation measures will not be effective on these 36 residences and one church because mitigation options are not feasible to effectively reduce traffic noise at these locations.

5.1 Traffic Management Measures

Traffic management measures include modification of speed limits, traffic control devices, and restricting or prohibiting truck traffic. Restricting truck use on the new roadways could reduce noise levels at nearby receivers because trucks are louder than cars. The speed limit of the new facility is expected to be 35 miles per hour. Reducing the speed could reduce noise in the project area but would conflict with mobility through the study area and would be counter to the purpose of the new facility. Imposing restrictions on the use of un-muffled compression brakes in the project area would provide some noise reduction although not substantial enough to be considered a feasible method for noise mitigation (5 dBA reduction goal). Therefore providing a substantial noise reduction through traffic management measures would not be feasible.

5.1.1 Land Acquisition for Noise Buffers or Barriers

Acquiring land for noise buffer purposes at the impacted sites would require relocating residences and would require HDOT to purchase additional right-of-way. Typically, residences within 500 feet of roadways are exposed to varying amounts of roadway noise.

Relocating the affected receptors and purchasing right-of-way would be unreasonably expensive for the purpose of noise mitigation.

Creation of noise buffers could reduce the potential for future development along the roadways that are incompatible with traffic noise. Areas within the project area that are currently undeveloped or abandoned could remain as such to avoid noise from the new facility.

5.1.2 Realigning the Roadway

The project's horizontal alignment is already designed to avoid displacing any residences in the noise study area. Changes in the horizontal alignment could cause residential displacements and could shift the traffic noise to other sensitive receptors. The vertical alignment is constrained by the need to match surrounding roadway grades. Locating the Build Alternative alignment on a completely new alignment is likely not possible and could be prohibitively expensive. Even if found to be possible doing so would provide only marginal improvement (i.e. less than 5 dBA L_{eq} improvement). Therefore realigning the roadway is not reasonable for noise mitigation.

5.1.3 Noise Insulation of Buildings

Insulation of buildings could be feasible, but this remedy in accordance with FHWA and HDOT policy only applies to public or non-profit institutional buildings such as schools, churches, or libraries. One church, the Samoan Wesleyan Methodist Church is the only institutional building affected by the project. Discussion between HDOT and church owners can determine the potential for noise insulation at this facility.

5.1.4 Noise Barriers

Noise barriers include soundwalls (noise barrier walls), berms, and buildings that are not sensitive to noise. Berms are not reasonable for this project because in order to construct berms HDOT would need to purchase additional right-of-way, which would be prohibitively expensive for noise mitigation. A noise barrier's effectiveness is determined by its height and length and by project site topography. To be effective, the barrier must block the "line of sight" between the highest point of a noise source (i.e., a truck's exhaust stack) and the receiver. Typically soundwalls vary in height anywhere from eight to 24 feet or more on occasion. A noise barrier must be long enough (at least eight times as long as the distance from the home or receiver to the barrier) to prevent sounds from passing around (flanking) the ends, have no openings (e.g., gaps for driveways), and be dense enough so that noise would not be transmitted through the barrier. Intervening rows of buildings that are not noise-sensitive could also be used as barriers (U.S. DOT, 1973).

HDOT evaluates many factors to determine whether barriers would be feasible and/or reasonable. Determination of engineering feasibility includes whether barriers could be built in a location to achieve a noise reduction of at least 5 dBA at one or more receptors.

Determination of reasonability includes consideration of the number of sensitive receptors that benefit by at least 5 dBA reductions, the cost-effectiveness of the barriers, and concerns such as aesthetics, safety, and the desires of nearby residents. HDOT calculates

reasonableness based on the number of residences that benefit by reduction of at least 5 dBA with a noise barrier, at a cost typically not to exceed $35,000 per dwelling unit ($35k/DU).

In this study all 36 residences predicted to be impacted under the future Build noise conditions (see Table 4) are located adjacent to Farrington Highway. This area was reviewed for noise barrier placement; however locating a noise barrier along the affected residences along this area of Farrington Highway is not possible without removing access to individual properties as nearly all affected residences have separate driveways connections to Farrington Highway. For this reason, noise barrier placement is not feasible to reduce traffic noise levels at affected residences.

Chapter 6 Construction Noise Analysis

If the Build Alternative were to be constructed, areas adjacent to the project will be exposed to construction noise. Although of a temporary nature, the additional noise can be annoying to the public.

Estimates of maximum noise levels at a distance of 50 feet for various pieces of construction equipment are provided in Table 5. While actual noise levels will vary due to particular equipment, phase of construction, and the influence of the person using the equipment, every effort should be made to minimize the adverse affects of construction noise whenever possible. A list of potential construction noise abatement methods is included at the end of this chapter.

Construction noise is typically regulated on a project-specific basis in the form of Standard Specifications or Special Provisions in the contractor's documents (see below). The local noise ordinance states that construction noise be limited to the hours of 7:00 AM to 10:00 PM. Thus within the property boundaries of sensitive land uses (Table 1) there cannot be exceedances of 50 dBA at night from construction activities between the hours of 10:00 PM to 7:00 AM.

Table 5. Construction Equipment Noise Levels

Equipment Description	Ground Impact Device ?	Acoustic Usage Factor (%)	Specified Limit L_{max} @ 50 feet (dBA, Slow)	Actual Measured L_{max} @ 50 feet (dBA, Slow)
All Other Equipment > 5 HP	No	50	85	N/A
Auger Drill Rig	No	20	85	**84**
Backhoe	No	40	80	78
Bar Bender	No	20	80	N/A
Blasting	Yes	N/A	94	N/A
Boring Jack Power Unit	No	50	80	83
Chain Saw	No	50	85	84
Clam Shovel (dropping)	Yes	20	93	87
Compactor (ground)	No	20	80	83
Compressor (air)	No	40	80	78
Concrete Batch Plant	No	15	83	N/A
Concrete Mixer Truck	No	40	85	79
Concrete Pump Truck	No	20	82	81
Concrete Saw	No	20	90	90
Crane	No	16	85	81
Dozer	No	40	85	82
Drill Rig Truck	No	20	84	79
Drum Mixer	No	50	80	80
Dump Truck	No	40	84	76
Excavator	No	40	85	81
Flat Bed Truck	No	40	84	74

Equipment Description	Ground Impact Device ?	Acoustic Usage Factor (%)	Specified Limit L_{max} @ 50 feet (dBA, Slow)	Actual Measured L_{max} @ 50 feet (dBA, Slow)
Front End Loader	No	40	80	79
Generator	No	50	82	81
Generator (<25 KVA, VMS signs)	No	50	70	73
Gradall	No	40	85	83
Grader	No	40	85	83
Grapple (on backhoe)	No	40	85	87
Horizontal Boring Hydr. Jack	No	25	80	82
Hydra Break Ram	Yes	10	90	N/A
Impact Pile Driver	Yes	20	95	101
Jackhammer	Yes	20	85	89
Man Lift	No	20	85	75
Mounted Impact Hammer (hoe ram)	Yes	20	90	90
Pavement Scarafier	No	20	85	90
Paver	No	50	85	77
Pickup Truck	No	40	55	75
Pneumatic Tools	No	50	85	85
Pumps	No	50	77	81
Refrigerator Unit	No	100	82	73
Rivet Buster/Chipping Gun	Yes	20	85	79
Rock Drill	No	20	85	81
Roller	No	20	85	80
Sand Blasting (Single Nozzle)	No	20	85	96
Scraper	No	40	85	84
Shears (on Backhoe)	No	40	85	96
Slurry Plant	No	100	78	78
Soil Mix Drill Rig	No	50	80	N/A
Tractor	No	40	84	N/A
Vacuum Excavator (Vac-truck)	No	40	85	85
Vacuum Street Sweeper	No	10	80	82
Ventilation Fan	No	100	85	79
Vibrating Hopper	No	50	85	79
Vibratory Concrete Mixer	No	20	80	80
Vibratory Pile Driver	No	20	95	101
Warning Horn	No	5	85	83
Welder/Torch	No	40	73	74

Source: USDOT, FHWA 2006

Several construction noise abatement methods can be implemented to limit the effect on the noise environment. Shown below is a list of standard noise control specifications that may be incorporated into construction contracts to mitigate the effects of construction noise:

- All equipment used shall have sound control devices no less effective than those provided on the original equipment. No equipment shall have unmuffled exhaust.

- All equipment shall comply with the pertinent equipment noise standards found in the FHWA Roadway Construction Noise Model (RCNM) as shown in Table 5.

- No pile driving, hoe ramming, or blasting operations shall be performed within 2,000 feet of any occupied dwelling unit on Sundays, legal holidays and between the hours of 8:00 PM and 8:00 AM on other days, without the approval of the Engineer.

- The noise from rock crushing or screening operations within 2,000 feet of any occupied dwelling shall be mitigated by strategic placement of material stockpiles between the operation and the affected dwelling or by other means approved by the Engineer.

Should specific noise complaints occur during the construction of the project, one or more of the following noise abatement measures may be required at the Contractor's expense, as directed by the Engineer:

- Locate stationary construction equipment as far from the nearby noise sensitive properties as possible.

- Shut off idling equipment.

- Use alternative methods or equipment which produce less noise.

- Reschedule construction operations to avoid periods of noise annoyance identified in the complaint.

- Notify nearby residences whenever extremely noisy work will be occurring.

- Install temporary or portable acoustic barriers around stationary construction noise sources.

- Operate electric-powered equipment using line voltage power instead of on-site generators.

- Use manually-adjustable and/or the new broadband backup alarms set to the low noise setting on all construction vehicles used during nighttime hours.

Chapter 7 References

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U.S. Department of Transportation, Federal Highway Administration, 2006. *FHWA Highway Construction Noise Handbook and Roadway Construction Noise Model (RCNM, ver. 1.0)*. Washington D.C.

Chapter 8 Exhibits

Exhibit 1. Project Location

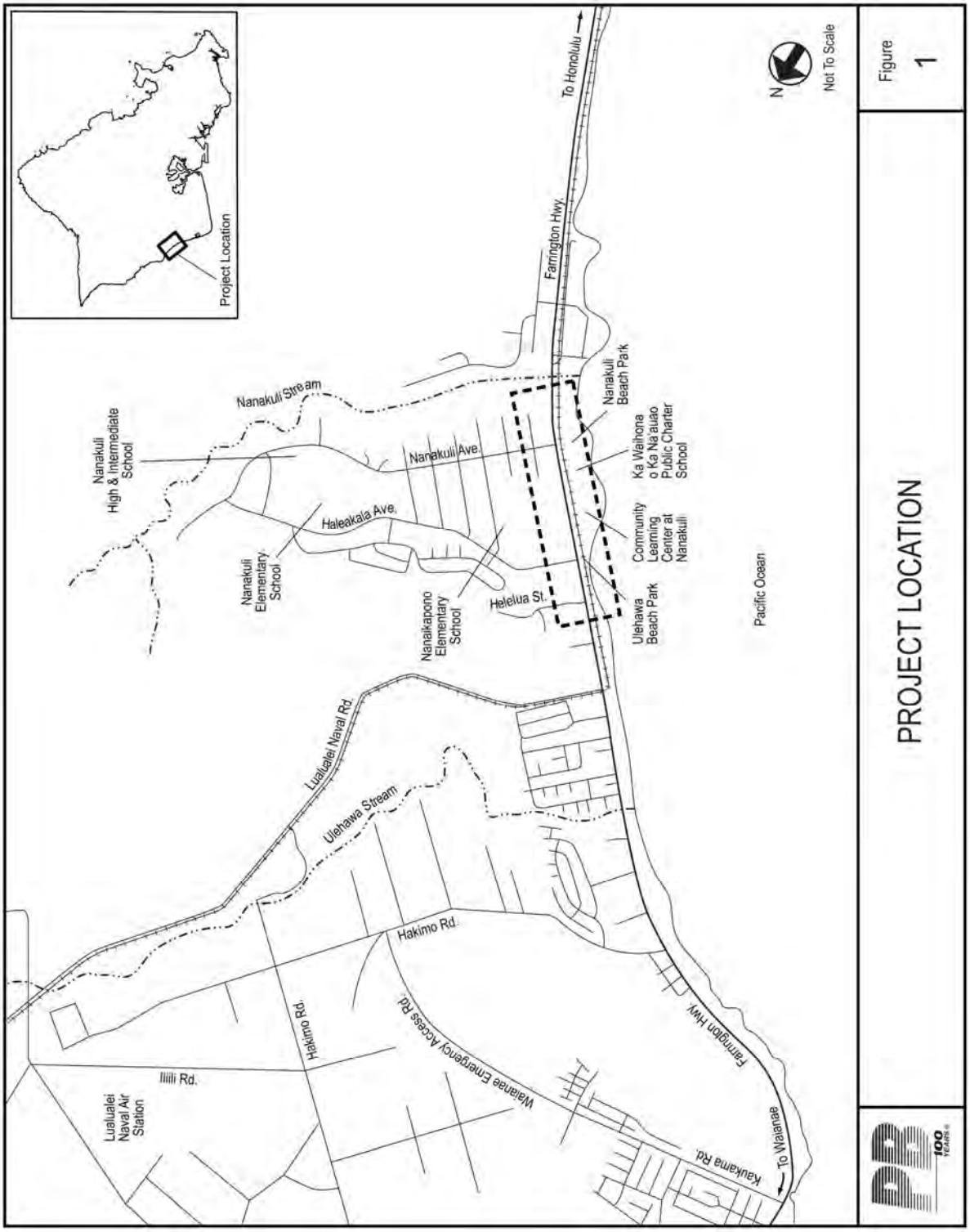
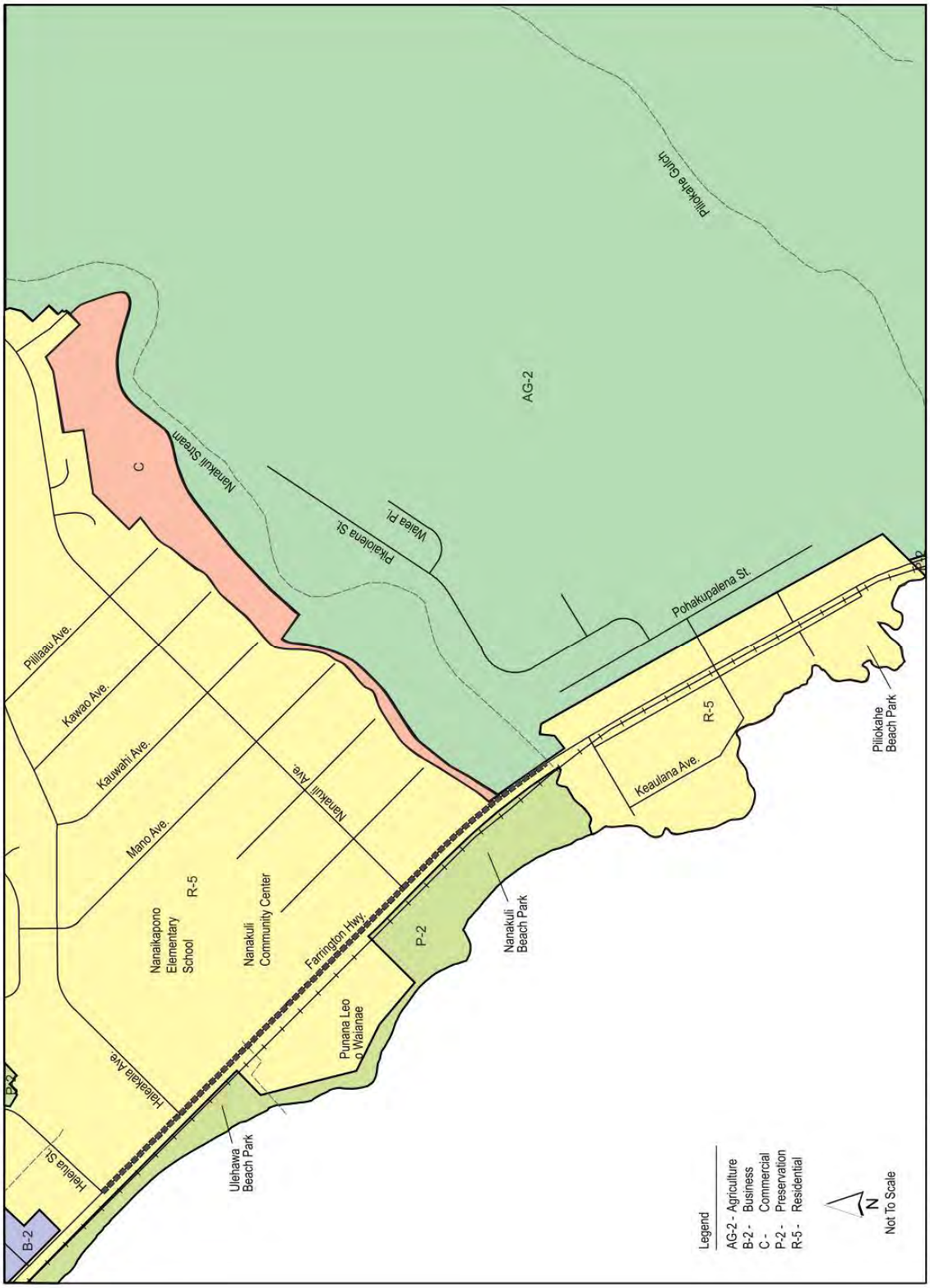


Exhibit 2. Locations of Measured and Modeled Receptors

Exhibit 3. Existing Zoning



Introduction to Acoustics

Sound is created when objects vibrate, resulting in a minute variation in surrounding atmospheric pressure called sound pressure. The human response to sound depends on the magnitude of a sound as a function of its frequency and time pattern (EPA, 1974). Magnitude measures the physical sound energy in the air. The range of magnitude, from the faintest to the loudest sound the ear can hear, is very large so, for convenience, sound pressure is expressed on a logarithmic scale in units called decibels (dB). Loudness, compared with physical sound measurement, refers to how people subjectively judge a sound. This varies from person to person. Table A-1 shows the magnitudes of typical noise sources.

Table A-1. Typical Noise Levels

Transportation Sources	Sound Level (dBA)	Other Sources	Description
	130		Painfully loud
Jet takeoff (200 feet)	120		
Car horn (3 feet)	110		Maximum vocal effort
	100	Shout (0.5 feet)	
	95		Very annoying
Heavy truck (50 feet)	90	Jack hammer (50 feet)	Loss of hearing with prolonged exposure
		Home shop tools (3 feet)	
Train on a structure (50 feet)	85	Backhoe (50 feet)	
City bus (50 feet)	80	Bulldozer (50 feet)	Annoying
Train (50 feet)	75	Blender (3 feet)	
City bus at stop (50 feet)			
Freeway traffic (50 feet)	70	Lawn mower (50 feet)	
Train in station (50 feet)	65	Washing machine (3 feet), Large office	Intrusive
	60	Speech (3 feet) TV (10 feet)	
Light traffic (50 feet)	55	Talking (10 feet)	
Light traffic (100 feet)	50		Quiet
	45	Refrigerator (3 feet)	
	40	Library	
	30	Bedroom at night, Soft whisper (15 feet)	Very quiet

Sources: USDOT (1995); EPA (1971, 1974).

Humans respond to a sound's frequency or pitch. While humans can perceive a large range of frequencies (approximately 20 to 20,000 Hz), hearing efficiency decreases at the low and high end of this range. Thus, the human ear can very effectively perceive sounds with frequencies

between approximately 500 and 5,000 Hz. Environmental noise is composed of many frequencies, each occurring simultaneously at its own sound pressure level. Frequency weighting, which is applied electronically by a sound level meter, combines the overall sound spectrum into one sound level that simulates how a typical person hears sounds. The commonly used frequency weighting for environmental noise is A-weighting (dBA), which is most similar to how humans perceive sounds of low to moderate magnitude.

Because of the logarithmic decibel scale, a doubling of the number of sound sources (such as the number of cars operating on a roadway) increases noise levels by 3 dBA. A ten-fold increase in the number of sound sources would add 10 dBA. As a result, a sound source emitting a sound level of 60 dBA combined with another sound source of 60 dBA yields a combined sound level of 63 dBA, not 120 dBA. The human ear can barely perceive a 1-dBA change, can perceive a 3-dBA increase, but a 5- or 6-dBA increase is readily noticeable and appears as if the sound is about one and one-half times as loud. A 10-dBA increase appears to most listeners to be a doubling in sound level.

Noise levels from traffic sources depend on traffic volume, vehicle speed, the type of vehicle and the pavement surface conditions. Generally, an increase in traffic volume, speed, or vehicle size increases traffic noise levels. Vehicular noise is a combination of noises from the engine/transmission, exhaust, and tires. Other conditions affecting the generation and propagation of traffic noise include defective mufflers, steep grades, terrain, vegetation, distance from the roadway, and shielding by barriers and buildings.

Sound levels decrease with distance from the source. For a line source such as a busy roadway, sound levels decrease 3 dBA over hard ground (concrete, pavement) or 4.5 dBA over soft ground (grass) for every doubling of distance between the source and the receptor. For a point source such as construction sources or a single isolated vehicle, sound levels would decrease between 6 and 7.5 dBA, respectively for every doubling of distance from the source.

The propagation of sound can be greatly affected by terrain and the elevation of the receiver relative to the sound source. Level ground is the simplest scenario: sound travels in a straight line-of-sight path between the source and receiver. If the sound source is depressed or the receiver is elevated, sound generally travels directly to the receiver. Sound levels may be reduced because the terrain crests between the source and receiver, resulting in a partial sound barrier near the receiver. If the sound source is elevated or the receiver is depressed, sound often is reduced at the receiver. The edge of the roadway can act as a partial sound barrier, blocking some sound transmission between the source and receiver.

Even a short barrier, such as a solid concrete jersey-type safety barrier, can be effective at further reducing traffic noise levels. However, to be truly effective a noise barrier must break the line-of-sight between a noise source and the listener. Breaking the line-of-sight between the receiver and the highest sound source typically results in a noise reduction of approximately 5 dBA. Noise levels can be reduced by as much as 15 dBA with a well designed and properly constructed noise barrier, however this much of a reduction is uncommon and difficult to achieve.

Sound Level Descriptors

A widely used descriptor for environmental noise is the equivalent sound level (L_{eq}). The L_{eq} can be considered a measure of the average sound energy during a specified time period. L_{eq} is defined as the constant sound level that, over a given period, transmits to the receiver the same amount of acoustical energy as the actual time-varying sound. For example, two individual sounds, one of which contains twice as much energy but lasts only half as long, have the same L_{eq} sound levels. L_{eq} measured over a one-hour period is the hourly L_{eq} [$L_{eq\,(h)}$)], which is used for highway noise impact and abatement analyses.

Short-term sound levels, such as those from a single truck passing by, can be described by either the total sound energy or the highest sound level that occurs during the event. The Sound Exposure Level (SEL) is a measure of total sound energy from an event condensed into a one-second-duration period, and is useful in determining what the L_{eq} would be over an extended period when several sound events occur, even if the sound sources are different. The maximum sound level (L_{max}) is the greatest short-duration sound level that occurs during a single event. L_{max} is related to interference with speech and with sleep disruption. In comparison, L_{min} is the minimum sound level occurring during a period.

People generally find a moderately high, constant sound level more tolerable than a relatively quiet background level interrupted by frequent high-level noise intrusions. An individual's response to sound depends greatly on the range of sound magnitude variation in a given environment. For example, steady traffic noise from a highway is normally less bothersome than occasional aircraft flyovers in a relatively quiet area. In light of this subjective response, it is often useful to look at a statistical distribution of sound levels over a specified period in addition to the average sound level. One such metric is the Statistical Sound Level, whose distributions identify the sound level exceeded and the percentage of time that the level was exceeded. While it is difficult to conceptualize what a Statistical Sound Level actually sounds like, their use allows for a more thorough description of the range of sound levels during the given measurement period. These distributions are identified with an L_n where n is the percentage of time that the levels ("L") are exceeded. For example, the L_{10} level is the noise level that is exceeded 10 percent of the time. The L_{50} is the level exceeded one half the time, for example for 30 minutes during an hour-long period.

Traffic Data

The following is the traffic data described in the methodology section that is used in this noise study.

Table B-1. Traffic Data

Roadway	Existing Conditions	No Build 2030	Build 2030
Farrington Highway NB – south of Nanakuli	1867	2426	2426
Farrington Highway NB – south of Haleakala	1620	2106	2106
Farrington Highway NB – north of Haleakala	1749	1325	1325
Farrington Highway SB – north of Haleakala	1110	1444	1444
Farrington Highway SB – south of Haleakala	1080	1404	1404
Farrington Highway SB – south of Nanakuli	1167	1518	1518
Nanakuli Ave EB	323	384	384
Nanakuli Ave WB	286	268	268
Haleakala Ave EB	308	225	225
Haleakala Ave WB	254	216	216

Farrington Highway Vehicle Mix: 90% Auto, 4% Medium Trucks, 6% Heavy Trucks
Nanakuli and Haleakala Avenues Vehicle Mix: 95% Auto, 5% Medium Trucks, 0% Heavy Trucks

DRAFT

Archaeological Field Inspection and Literature Review for the Farrington Highway Intersection Improvements at Nānākuli Avenue and Haleakalā Avenue, Nānākuli and Lualualei Ahupuaʻa, Waiʻanae District, Oʻahu Island, Multiple TMKs

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Management Summary

Reference	Archaeological Field Inspection and Literature Review for the Farrington Highway Intersection Improvements at Nānākuli Avenue and Heleakalā Avenue, Nānākuli and Lualualei Ahupua‘a, Wai‘anae District, O‘ahu Island, Multiple TMKs (Altizer et al. 2010).
Date	March 2010
Project Number (s)	PB America Job Code: 93A-01-05; Cultural Surveys Hawai‘i Inc. (CSH) Job Code: NANAKULI 5
Project Location	The project is located along 4,347 linear feet of Farrington Highway on the leeward side of O‘ahu Island in Nānākuli Town between Helelua Street and Nānākuli Stream, Nānākuli and Lualualei Ahupua‘a, Wai‘anae District, O‘ahu Island. This area is depicted on the (1998) U.S. Geological Survey Wai‘anae and Schofield Barracks Topographic Quadrangles.
Agencies	State Historic Preservation Division (SHPD), State of Hawai‘i, Department of Transportation Highways Division (HDOT), and Federal Highways Administration (FHWA)
Investigation Permit Number	The archaeological field inspection associated with this project was completed under CSH’s annual archaeological permit No. 09-20 issued by SHPD per Hawai‘i Administrative Rules (HAR) Chapter 13-282.
Project Funding	FHWA, HDOT
Land Jurisdiction	HDOT
Project Area Acreage	Approximately 9 acres
Project Description	The project involves widening the portion of Farrington Highway from Helelua Street to the northwestern bank of Nānākuli Stream in order to accommodate an auxiliary lane. The auxiliary lane would facilitate left turns at Nānākuli Avenue and Haleakalā Avenue, as well as improve overall intersection performance and safety. Other proposed improvements include utility relocations, a shared use path along the *makai* side of the highway, highway lighting, and drainage. Widening would occur on the *makai* portion of the highway, however, some sidewalk and drainage improvements would also occur on the *mauka* portion of the project area.
Project Related Ground Disturbance	Ground disturbance is estimated for approximately 25% of the project area. Ground disturbance would include excavation, scraping, grading, and leveling to allow for re-paving and construction of the widened facilities. A shared use bike path is proposed for construction on the *makai* side of the roadway. Bus stops would be relocated. Some

	leveling and build-up for the curbs and sidewalk would occur on the *mauka* side. A portion of State Inventory of Historic Properties (SIHP) # 50-80-12-9714, the O’ahu Rail and Land Company (OR&L) railroad tracks, would be relocated.
Historic Preservation Regulatory Context	Because of FHWA funding, this project is a federal undertaking requiring compliance with Section 106 of the National Historic Preservation Act (NHPA), the National Environmental Policy Act (NEPA), and the federal Department of Transportation Act (DTA). As an HDOT project within state right-of-way, the project is also subject to Hawai‘i State environmental and historic preservation review legislation, Hawai‘i Revised Statutes [HRS] Chapter 343 and HRS 6E-8/Hawai‘i Administrative Rules [HAR] Chapter 13-13-275, respectively.
Document Purpose	This investigation is not an archaeological inventory survey, per the requirements of HAR Chapter 13-276; however, through detailed historical, cultural, and archaeological background research, and a field inspection of the project area, this investigation identifies cultural resources[1] that may be affected by the project. The document is intended to facilitate the project’s planning and support the project’s historic preservation compliance. Based on results, cultural resource management recommendations are presented. A companion cultural impact assessment (CIA) study (Lincoln and Hammatt 2009), prepared to support the project’s Hawai‘i state environmental review, per the guidelines of the Hawai‘i State Department of Health’s Office of Environmental Quality Control “*Guidelines for Assessing Cultural Impacts*”, further evaluates the project’s potential impacts to cultural resources. Both documents will support the project’s historic preservation consultation effort.
Fieldwork Effort	Fieldwork was conducted on May 20, 2009 by CSH archaeologist Kendy Altizer, B.A. Fieldwork required one person-day to complete and was conducted under the general supervision of Hallett H. Hammatt, Ph.D. (principle investigator).
Identified Cultural Resources and Significance Assessments[2]	This investigation identified three cultural resources/historic properties[3] that will or may be affected by the proposed project: • The section of the OR&L Railroad (SIHP # 50-80-12-9714) adjacent to the current Farrington Highway project area is listed on the National Register of Historic Places, under significance Criteria A, B and C. • Farrington Highway was constructed in the 1930s as part of the Territorial Highway System. A Portion of Farrington Highway further north along the Wai‘anae Coastline has been previously documented as SIHP# 50-80-7-6824 and determined National

	and Hawai‘i Register eligible under Criterion D (McDermott and Tulchin 2006). • A previously recorded portion of what may be a subsurface cultural layer containing evidence of pre-contact Native Hawaiian habitation was documented at the northern end of the project area between Haleakalā Avenue and Helelua Street (BWS-4 –Ostroff and Desilets 2005). It does not appear that this deposit was assigned a SIHP number, or evaluated for National or Hawai‘i Register eligibility; however, this cultural layer, if it is indeed the result of human habitation, is likely significant under Criterion D. In addition, based on background research and prior archaeological investigations in the project area's vicinity, there is the potential for encountering additional pre-contact and post-contact subsurface cultural deposits related to traditional Native Hawaiian land use and habitation, historic military use of the area, and/or human remains.
Discussion of Project Effect and Recommendations	The following discussion and recommendations are based on results of this investigation and CSH's communication with agents for the project proponents regarding the project's potential impacts to the cultural resources described above: Originally constructed in the early 20th Century, portions of Farrington Highway within the project area have been greatly modified in the last 30 or 40 years with the addition of traffic lanes and roadway appurtenances. Additionally, the setting of this portion of Farrington Highway has been altered since the highway was constructed. Accordingly, this portion of Farrington Highway does not contain integrity of design, setting, materials, workmanship, feeling, or association. It would most likely not be considered eligible to either the National or Hawai‘i Register of Historic Places because it lacks the integrity to convey its significance under any of the significance criteria. Current construction plans indicate the portion of the OR&L (SIHP # 50-80-12-9714) located in the current project area would be relocated by construction activities. This proposed relocation will likely represent a "use" of a significant historic site (the OR&L) under Section 4(f) of the DTA[4]. Accordingly, a Section 4(f) Evaluation[5] will most likely need to be prepared as part of the project's NEPA documentation. Under federal historic preservation legislation, a project specific effect determination of "adverse effect" may be warranted for the proposed road widening project; however in consultation with SHPD, it was determined that the track relocation would remain within the historic OR&L right-of-way and would not affect its historic value. Therefore, the proposed project would have NO Adverse Effect on the portion of the OR&L (SIHP # 50-80-12-

	9714) located in the current project area. Because there are multiple different projects being conducted in the area that have a possibility of impacting the OR&L, a multi-project Programmatic Agreement (PA) for the OR&L railroad treatment is under development among SHPD, FHWA, HDOT, (understood as the land owner of the right-of-way), and the Hawaiian Railway Society. Before construction begins for the Farrington Highway intersection improvements at Nānākuli Avenue and Haleakalā Avenue, the agreement should be in place and should detail the exact nature of impact to the OR&L, and the appropriate treatment. The agreement would stipulate the obligations of each party and time frames for any work to be undertaken. In addition, the proposed project may impact a portion of a previously recorded subsurface cultural layer containing evidence of pre-contact Native Hawaiian habitation present at the northern end of the project area between Haleakalā Avenue and Helelua Street. There is also a possibility of encountering previously unidentified subsurface cultural deposits related to traditional Native Hawaiian land use and habitation, historic military use of the area, and/or human remains. Based on the findings of this study and the cultural sensitivity of the area, CSH anticipates that SHPD would require an archaeological inventory survey with a subsurface testing component prior to ground disturbing activities, and/or an archaeological monitoring program during proposed ground disturbing activities associated with this project. However, an inventory survey in this portion of Farrington Highway would disrupt traffic flow in an already heavily congested area. In addition, safety of local residents, pedestrians, motorists, and the field crew is a concern. For these safety reasons there is a precedent for roadwork, including utility installation, along this stretch of Farrington Highway to be conducted under archaeological monitoring programs without prior archaeological inventory survey investigations (Ostroff and Desilets 2005, Jones and Hammatt 2005, Souza and Hammatt 2006, Yucha and Hammatt 2008, Jones and Hammatt in prep.). Therefore, a comprehensive archaeological monitoring program may be a safer, more viable mitigation alternative. Consultation with SHPD will resolve the appropriateness of the archaeological monitoring program as a mitigation measure.

[1] In historic preservation parlance, cultural resources are the physical remains and/or geographic locations that reflect the activity, heritage, and/or beliefs of ethnic groups, local communities, states and/or nations. Generally, they are at least 50 years old, although there are exceptions, and include: buildings and structures; groupings of buildings or structures (historic districts); certain objects; archaeological artifacts,

features, sites, and/or deposits; groupings of archaeological sites (archaeological districts); and, in some instances, natural landscape features and/or geographic locations of cultural significance.

[2] Cultural resource significance is evaluated and expressed as eligibility for listing on the National and/or Hawai‘i Register of Historic Places (National and Hawai‘i Registers). To be considered eligible for listing on the National and/or Hawai‘i Register a cultural resource must possess integrity of location, design, setting, materials, workmanship, feeling, and association, and meet one or more of the following broad cultural/historic significance criteria: “A” reflects major trends or events in the history of the state or nation; “B” is associated with the lives of persons significant in our past; “C” is an excellent example of a site type/work of a master; “D” has yielded or may be likely to yield information important in prehistory or history; and, “E” (Hawaii Register only) has traditional cultural significance to an ethnic group, includes religious structures and/or burials.

[3] Historic properties, as defined under federal historic preservation legislation, are cultural resources that are at least 50 years old (with exceptions) and have been determined eligible for inclusion in the National Register of Historic Places based on their integrity and historic/cultural significance in terms of established significance criteria. Determinations of eligibility are generally made by a federal agency official in consultation with SHPD. Under federal legislation, a project’s (undertaking’s) potential effect on historic properties must be evaluated and potentially mitigated. Under Hawai‘i State historic preservation legislation, historic properties are defined as any cultural resources that are 50 years old, regardless of their historic/cultural significance under state law, and a project’s effect and potential mitigation measures are evaluated based on the project’s potential impact to “significant” historic properties (those historic properties determined eligible, based on their integrity and historic/cultural significance in terms of established significance criteria, for inclusion in the Hawai‘i Register of Historic Places). Determinations of eligibility to the Hawai‘i Register result when a state agency official’s historic property “significance assessment” is approved by SHPD, or when SHPD itself makes an eligibility determination for a historic property.

[4] Section 4(f) of the DTA stipulates that FHWA may approve a program or project that uses or otherwise affects land from any significant historic site only if two conditions are met. First, there must be no prudent and feasible alternative to the use of the historic site. Second, the action must include all possible planning to minimize harm to the historic site. Section 4(f) language describes a significant historic site as a site that is eligible to the National Register under criteria A, B, or C, and hence worthy of preservation in place. According to Section 4(f), sites eligible under criterion D are not considered significant historic sites because their information content that gives them significance can be recovered through mitigation measures. These sites therefore do not require preservation in place.

[5] A Section 4(f) Evaluation is the federal Department of Transportation’s internal administrative record that documents the conclusion that there is no prudent and feasible alternative to the use of the historic site, and that all possible project planning was undertaken to minimize harm.

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Section 1 Introduction

1.1 Project Background

At the request of the HDOT, CSH conducted a field inspection and literature review for the widening of Farrington Highway from Helelua Street to Nānākuli Stream. The project area is in Nānākuli Town on Farrington Highway, in Nānākuli and Lualualei Ahupua‘a, District of Wai‘anae, Island of O‘ahu. This area is depicted on the 1998 U.S. Geological Survey Wai‘anae and Schofield Barracks topographic quadrangles (Figure 1), TMK map (1) 8-9-001, 02, and 05 and an inset section of TMK 8-7-08: por. 36 and 37 (Figure 2), a map of multiple parcels that overlap the APE (Figure 3 and Figure 4), and an aerial photograph (Figure 5).

The project is funded by HDOT and FHWA. Because of FHWA funding, this project is a federal undertaking requiring compliance with Section 106 of the NHPA, NEPA, and the federal DTA. As an HDOT project within state right-of-way, the project is also subject to Hawai‘i State environmental and historic preservation review legislation, HRS Chapter 343 and HRS 6E-8/ HAR Chapter 13-13-275, respectively.

The purpose of the project is to install left-turn lanes at Haleakalā Avenue and Nānākuli Avenue that would improve traffic operations and safety (Figure 6 and Figure 7). In addition the project would construct a shared use path, sidewalks on the *mauka* side of the roadway, drainage improvements, as well as relocate utilities. Widening would occur on the *makai* portion of the highway, however, some sidewalk and drainage improvements would also occur on the *mauka* portion of the project area. These highway and infrastructure improvements will impact an existing bike and pedestrian path, as well as a portion of SIHP # 50-80-12-9714, OR&L Railroad tracks. The project area is approximately 0.8 miles (4,347 linear feet) long and covers approximately 9 acres. Ground disturbance would occur within the 101 ft. HDOT right-of-way (Figure 2, Figure 3, and Figure 4).

Ground disturbance is estimated for approximately 25% of the project area. Ground disturbance would include excavation, scraping, grading, and leveling to allow for re-paving and construction of the widened facilities. A shared use bike path is proposed for construction on the *makai* side of the roadway. Bus stops would be relocated. Some leveling and build-up for the curbs and sidewalk would occur on the *mauka* side. A portion of the OR&L railroad tracks would be relocated.

This investigation is not an archaeological inventory survey, per the requirements of HAR Chapter 13-276; however, through detailed historical, cultural, and archaeological background research, and a field inspection of the project area, this investigation identifies cultural resources that may be affected by the project. The document is intended to facilitate the project’s planning and support the project’s historic preservation compliance. Based on results, cultural resource management recommendations are presented. A companion cultural impact assessment (CIA) study (Lincoln and Hammatt 2009),

Figure 1. Portions of 1998 U.S. Geological Survey Wai‘anae, and Schofield Barracks 7.5-minute topographic quadrangles, showing the Farrington Highway project area

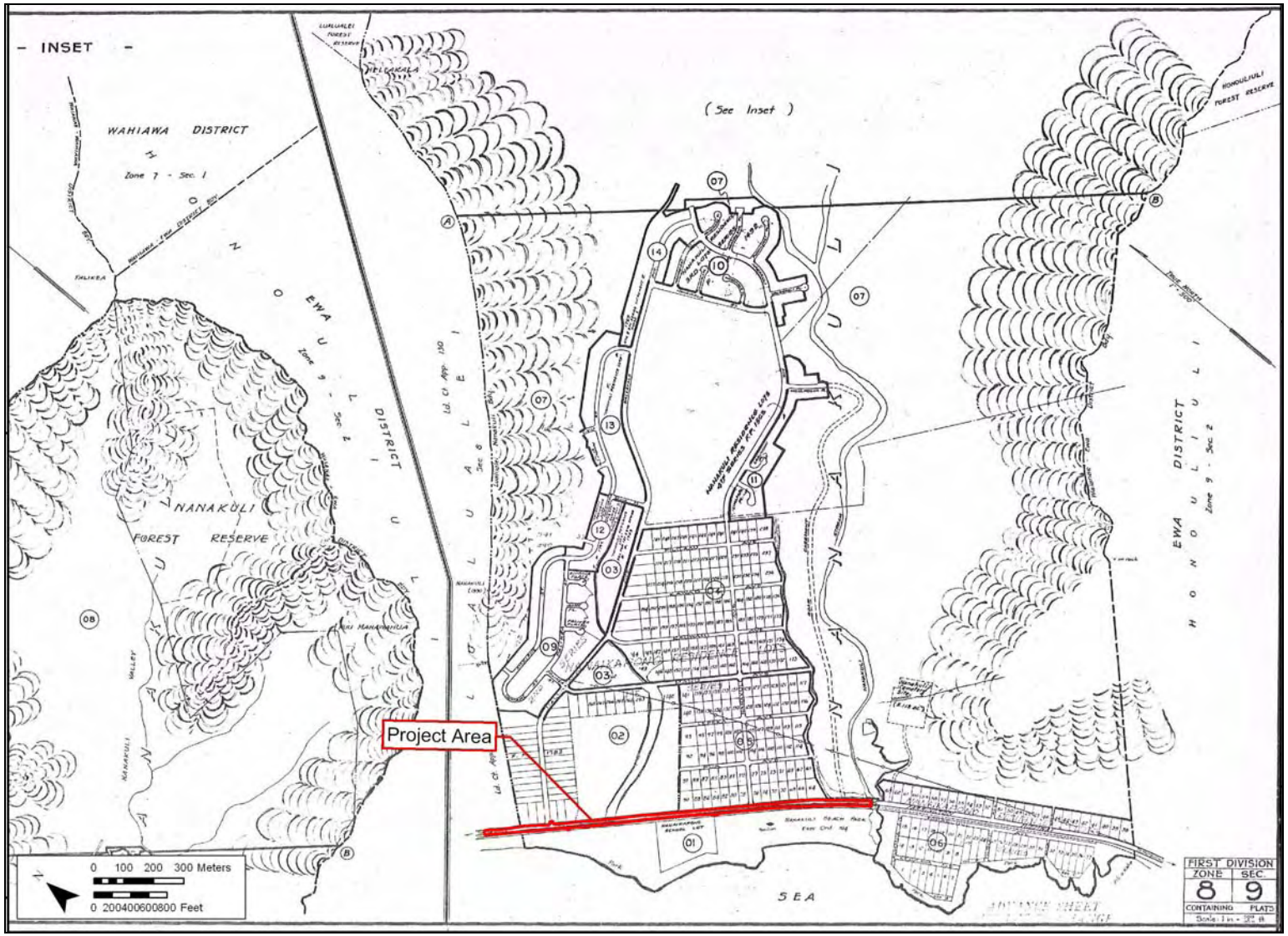

Figure 2. TMK (1) 8-9-001, 02, and 05 and a section of TMK 8-7-08: por. 36 and 37 (inset), showing the project area

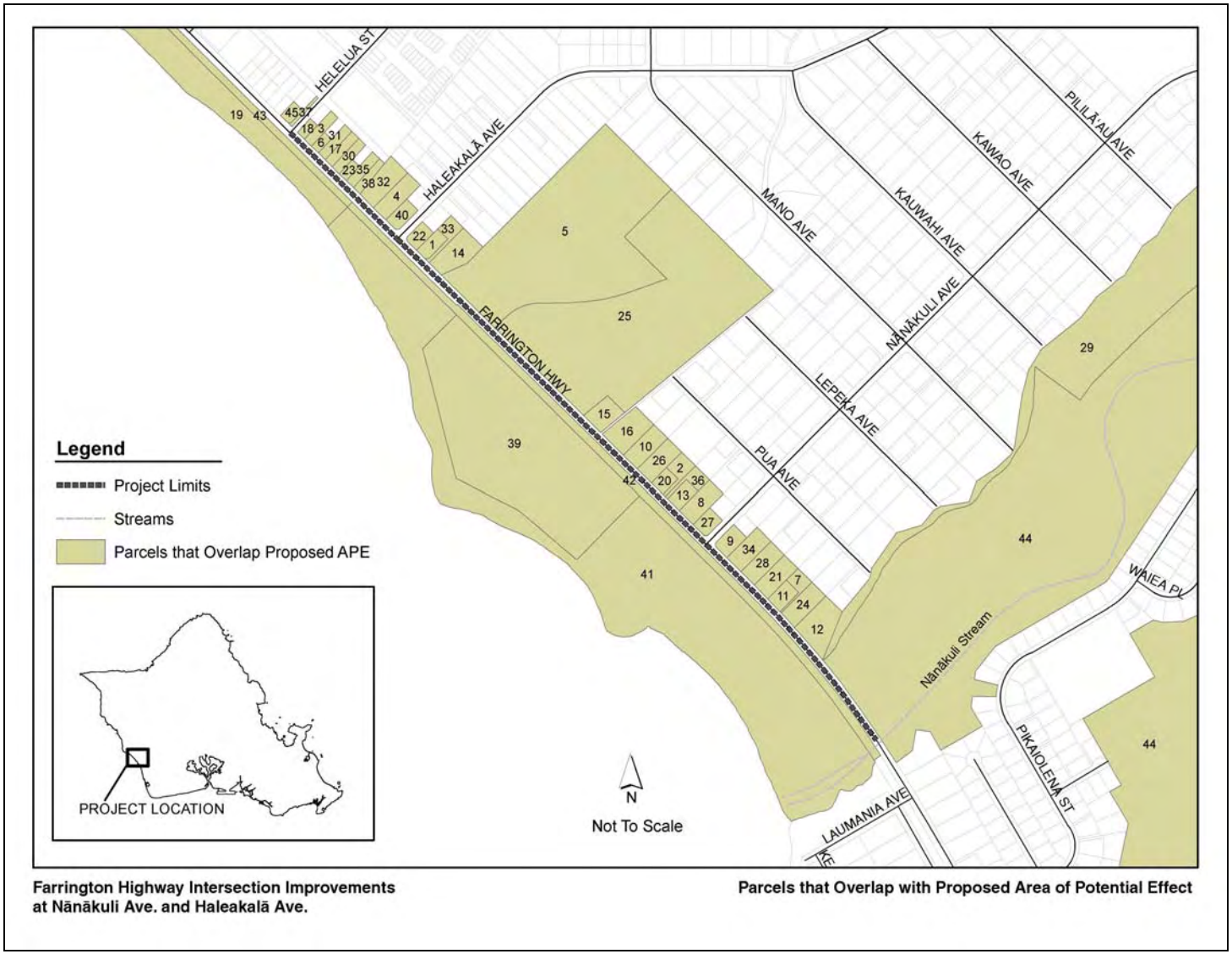

Figure 3. Map of the project area indicating parcels potentially affected by the current undertaking (PB America’s 2009)

Farrington Highway Intersection Improvements at Nanakuli Ave. and Haleakala Ave: TMK List of Parcels that Overlap with APE

Map Identifier	Tax Map Key	Site Address	Owner	Owner Type	Tax Year
1	89002003	89-48 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
2	89005011	89-216 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
3	87008007	87-109A Helelua St	R C J Corporation	Fee Owner	2009
4	89002030	89-14 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
5	89002065		State Of Hawaii	Fee Owner	2009
6	87008006	87-2196 Farrington Hwy	Benicta,Teofilo C	Fee Owner	2009
7	89005003	89-298A Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
8	89005009	89-232 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
9	89005007	89-115 Nanakuli Ave	Hawaiian Home Lands	Fee Owner	2009
10	89005013	89-196 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
11	89005087	89-298 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
12	89005001	89-318 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
13	89005010	89-226 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
14	89002002	89-56 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
16	89005014	89-188 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
17	87008028	87-2210 Farrington Hwy	Crowning Touchstone Llc	Fee Owner	2009
18	87008008	87-2186 Farrington Hwy	Ho,Sonny	Fee Owner	2009
19	87008026	87-2021 Farrington Hwy	State Of Hawaii	Fee Owner	2009
20	89005084	89-210 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
21	89005004	89-286 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
22	89002049	89-38 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
23	87008069	87-2220 Farrington Hwy	Barrett,Henry K	Fee Owner	2009
24	89005002	89-308 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
25	89002001	89-102 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
26	89005012	89-206 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
27	89005008	89-106 Nanakuli Ave	Hawaiian Home Lands	Fee Owner	2009
28	89005005	89-280 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
29	89007004		Hawaiian Home Lands	Fee Owner	2009
30	87008004	87-2214 Farrington Hwy	Barrett,Wesley N	Fee Owner	2009
31	87008005	87-2204 Farrington Hwy	Chung,Lee J	Fee Owner	2009
32	89002031	89-8 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
33	89002056	89-50 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
34	89005006	89-270 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
35	87008002	87-2224 Farrington Hwy	Yuen Grocery & Liquor Co Lt	Fee Owner	2009
36	89005090		Hawaiian Home Lands	Fee Owner	2009
37	87008080		City And County Of Honolulu	Fee Owner	2009
38	87008001	87-2230 Farrington Hwy	Yuen Grocery & Liquor Co Lt	Fee Owner	2009
39	89001004	89-199 Farrington Hwy	Hawaiian Home Lands	Fee Owner	2009
40	89002029	89-40 Haleakala Ave	Hawaiian Home Lands	Fee Owner	2009
41	89001002	89-269 Farrington Hwy	State Of Hawaii	Fee Owner	2009
42	89001003		State Of Hawaii	Fee Owner	2009
43	87008027		State Of Hawaii	Fee Owner	2009
44	89007002	89-216 Huikala Pl	Hawaiian Home Lands	Fee Owner	2009
45	87008055	87-2180 Farrington Hwy	Stockholm Deutsche Capital Inv Corp	Fee Owner	2009

Source(s): City and County of Honolulu, Dept. of Planning and Permitting, HOLIS, "Tax_Parcel.shp"(2008), "siteaddress.dbf"(2008), and "vownalltype.dbf"(2008).

Figure 4. List of parcels that overlap the APE

Figure 5. Aerial photograph showing the current project area (U.S. Geological Survey Orthoimagery 2005)

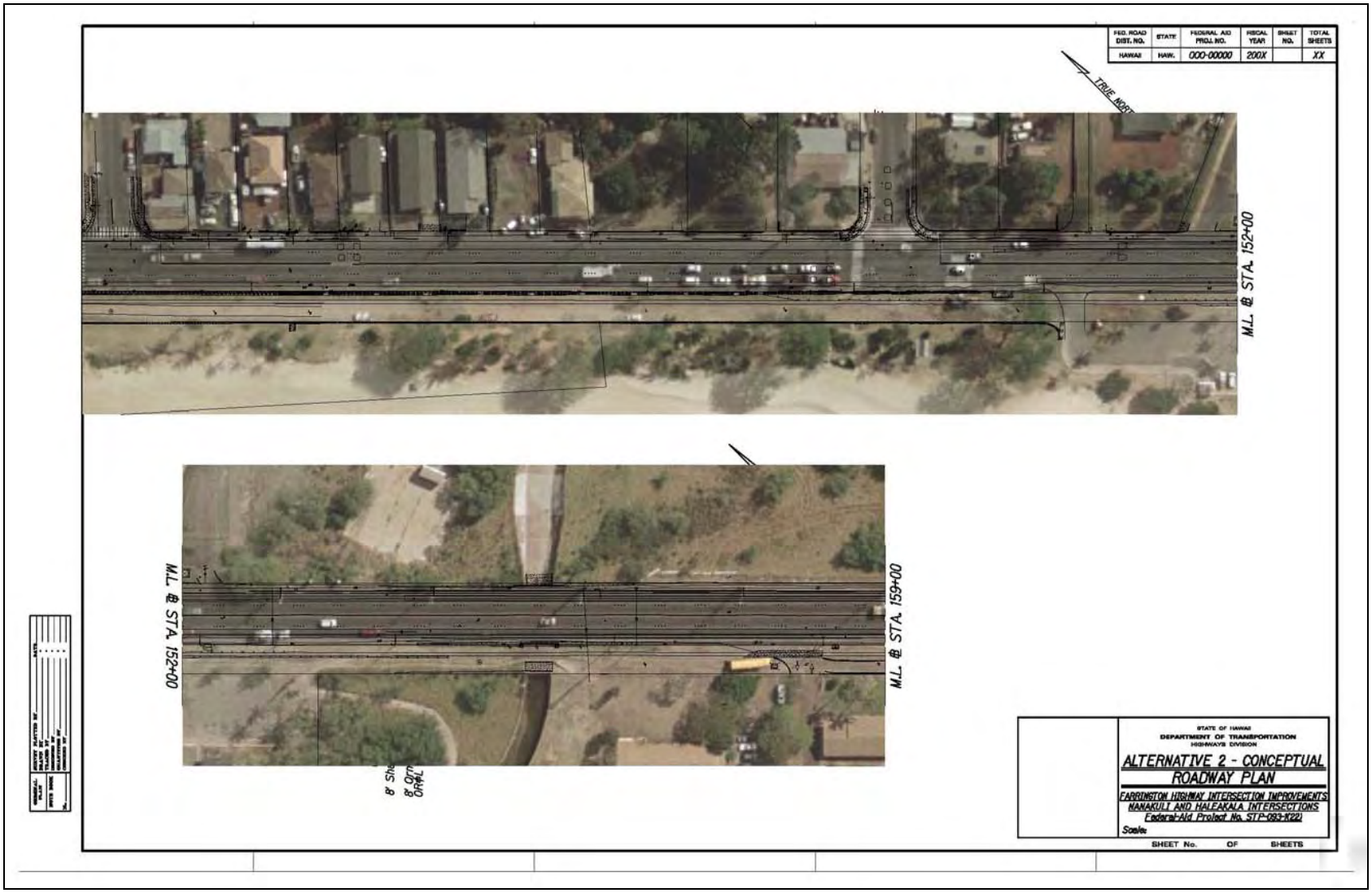

Figure 6. Conceptual Roadway Plan overlain on an aerial photograph, north portion, showing vicinity of Farrington Highway and Helelua Street (Hawai‘i Department of Transportation 2008)

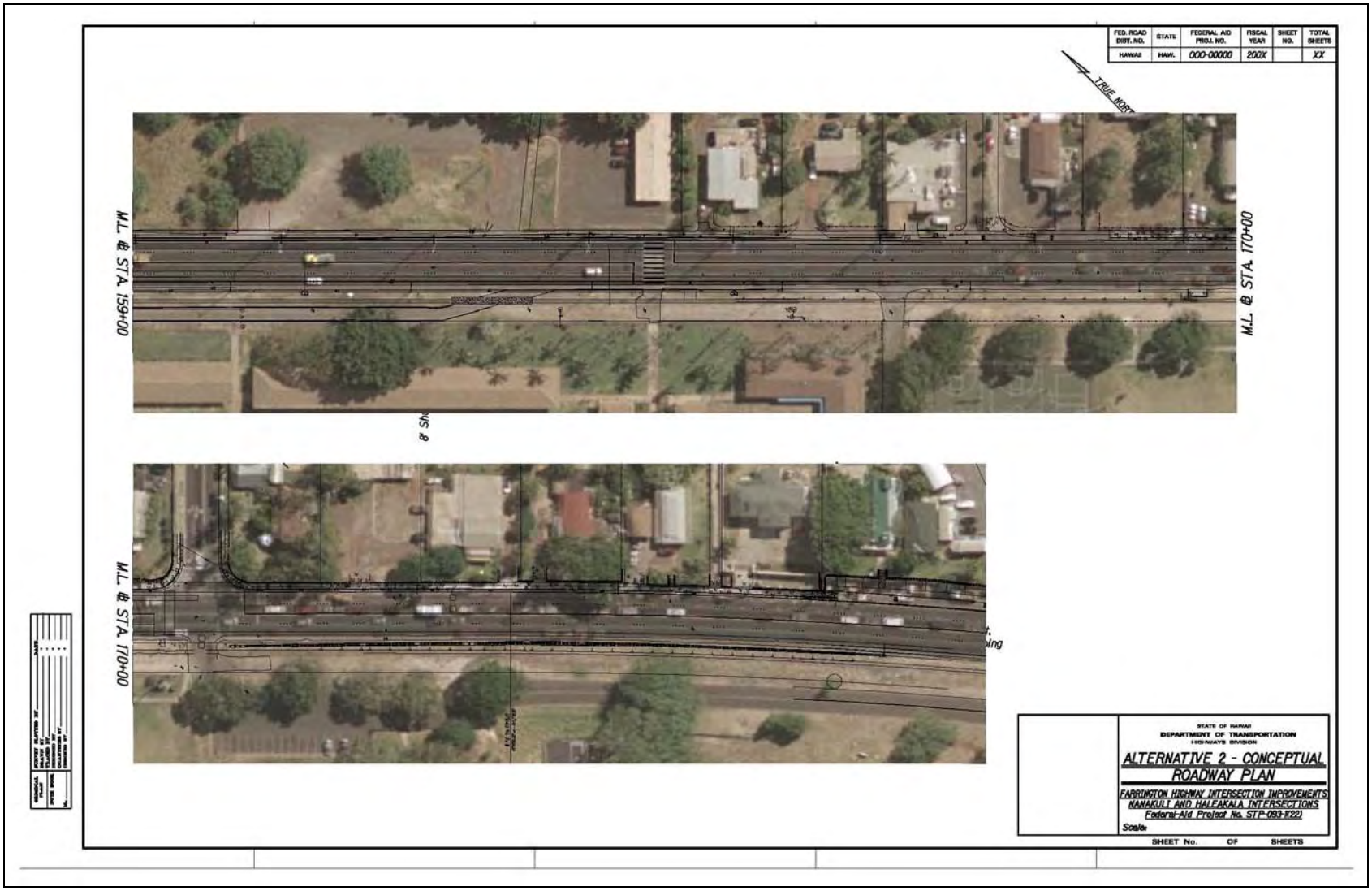

Figure 7. Conceptual Roadway Plan overlain on an aerial photograph, south portion, showing vicinity of Farrington Highway and Nānākuli Avenue (Hawai‘i Department of Transportation 2008)

prepared to support the project’s Hawai‘i state environmental review, per the guidelines of the Hawai‘i State Department of Health’s Office of Environmental Quality Control “*Guidelines for Assessing Cultural Impacts*”, further evaluates the project’s potential impacts to cultural resources. Both documents will support the project’s historic preservation consultation effort.

1.2 Environmental Setting

1.2.1 Natural Environment

The project area is located on the leeward side of O‘ahu, which receives less than 20 inches of rain annually (Juvik and Juvik 1998: 56). The project area is approximately 15 to 20 ft. above average mean sea level (AMSL), and varies between 200 and 700 ft. inland from the coast line. Foote et al. (1972) classify the soil in the project area as coral outcrop in the northern two-thirds, while and Mamala stony, silty, clay loam 0 to 12 percent slopes and Pulehu clay loam 0 to 3 percent slopes are present in the southern third of the project area (Figure 8).

Coral outcrop consists of, “coral or cemented calcareous sand with a thin over layer of friable red soil material present in cracks, crevices and depressions within the outcrop; this thin layer is similar to the Mamala Series” (Foot et al. 1972: 29). Mamala stony, silty, clay loam is characterized by 0 to 12 percent slopes, and stones are common in the profile. Calcareous sand and coral limestone underlies the Mamala soil at depths of 8 to 20 inches. Runoff is slow to medium and erosion hazard is slight to moderate (Foote et al. 1972: 93). Pulehu clay loam, 0 to 3 percent slopes is present on alluvial fans as well as stream terraces and basins. It is present in the southeastern end of the project area adjacent to Nānākuli Stream. Soils of this series are characterized by a top stratum of dark brown clay loam with subsequent thinner strata of, “dark brown to dark grayish-brown single grain stratified loam, loamy sand, fine sandy loam, and silty loam” (Foote et al. 1972:116).

Topography in the project area is generally flat because of the built, urban landscape and the nature of the project area, a portion of highway. The project area is on the Nānākuli coastal flat, with Nānākuli Valley and the Wai‘anae Mountain range further inland. Nānākuli Stream is present on the southeastern border of the project area.

Local vegetation observed in the vicinity of the project area includes large *kiawe* (*Prosopis pallida*), coconut (*Cocos nucifera*), and *hau* (*Hibiscus tiliaceus*) trees along with hibiscus (*Kokia drynarioides*) plants and a variety of grasses.

1.2.2 Built Environment

The project area is a built highway. The tracks of the OR&L Railroad, SIHP # 50-80-12-9714, parallel Farrington Highway on the *makai* side. These railroad tracks, along with Farrington Highway itself, were the only surface historic properties observed within the project area (Figure 9 and Figure 10). Other modern infrastructure present in the vicinity includes Ka Waihona Charter School, Nānākuli Beach Park, private residences, and local businesses.

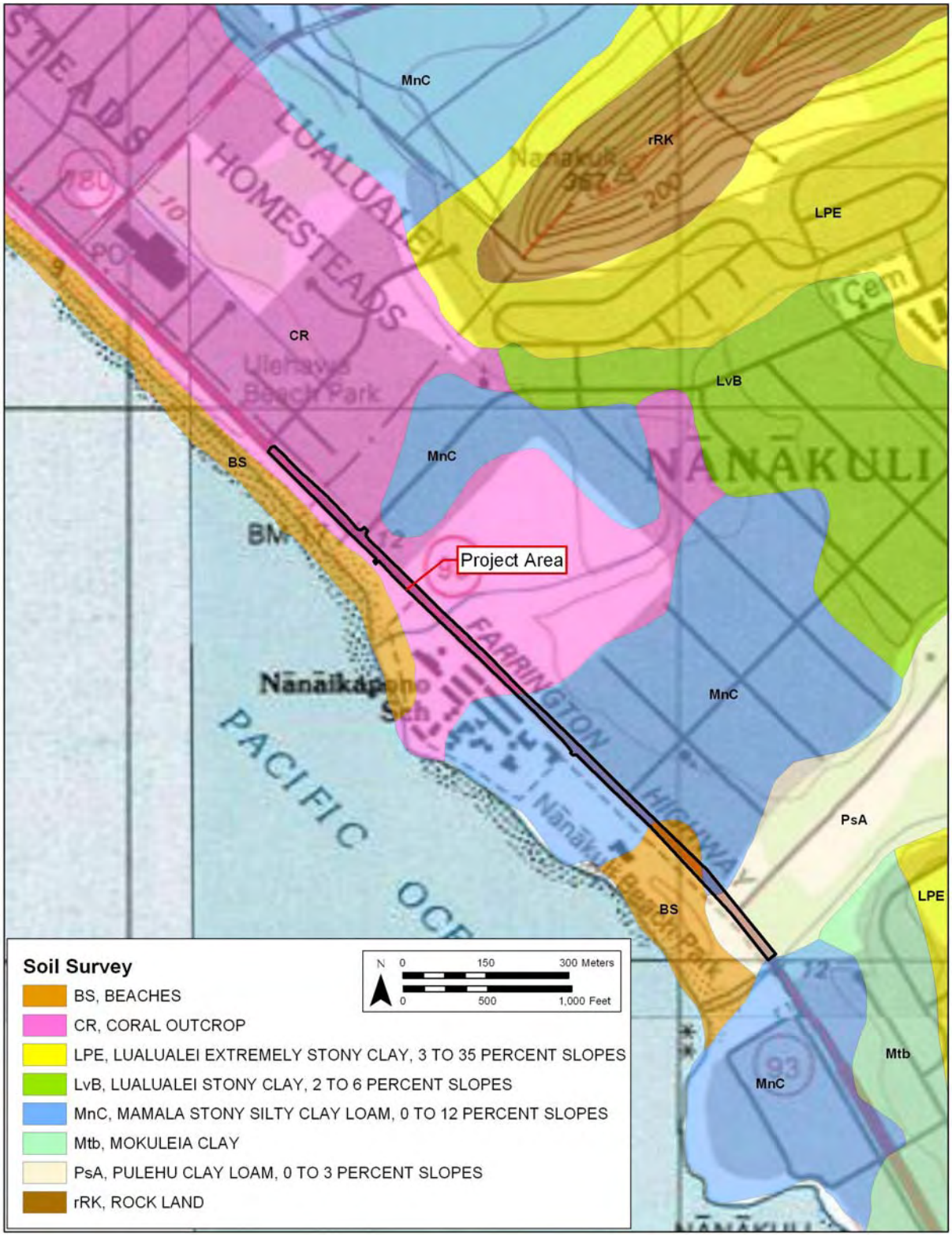

Figure 8. Soils map showing Coral Outcrop and Mamala Stony Silty Clay Loam in the project area (Foote et al. 1972; U.S. Department of Agriculture 2001)

Figure 9. Photo of project area, facing north, at the intersection of Farrington Highway and Nānākuli Avenue

Figure 10. Photo of the project area, facing south, at the intersection of Farrington Highway and Haleakalā Avenue

Section 2 Background Research

Background research for this document included a review of previous archaeological studies on file at SHPD/DNLR. Archaeological reports, historic maps and photographs contained within the CSH library were also consulted. In addition, *Māhele* records were examined from the Waihona'Aina database (www.waihona.com). This research provided the environmental, cultural, and archaeological background for the project area. The sources studied were used to formulate a predictive model regarding the expected types and locations of historic properties in the project area.

Though the project area does encompass a small portion of Lualualei Ahupua‘a, community residents feel that this small portion is included within Nānākuli Ahupua‘a; therefore only Nānākuli Ahupua‘a is addressed in this document (Lincoln and Hammatt 2009). This section begins with a truncated review of documentary evidence for the general character of Nānākuli Ahupua‘a as it evolved before western contact in the later 18th century. This section is meant to give the reader a general background overview of the project area; for more in depth analysis of traditional background please see the cultural impact assessment for this project (Lincoln and Hammatt 2009). The development of Nānākuli Town and its environs during the 19th century and into the 20th century was recorded in increasingly abundant documentation -including government records, private accounts, newspapers, maps and photographs. These documents, which allow a more precise focus on the project area, are discussed in the remainder of this section.

2.1 Traditional and Historical Background

The District of Wai‘anae extends from Nānākuli on the west coast of O‘ahu north to Ka‘ena Point, and once incorporated eight *ahupua‘a*, including Wai‘anae. In ancient times the District of Wai‘anae was known for its multitude of fish; especially for deep sea fishing off Ka‘ena, where the ocean currents meet. The meaning of Wai‘anae (mullet water) also implies an abundance of fish — *‘anae* means the full grown mullet (*Mugil cephalus*) (Pukui et al. 1974). In 1840, Wilkes made the following comment: “The natives are much occupied in catching and drying fish, which is made a profitable business, by taking them to O‘ahu, where they command a ready sale” (Wilkes 1845: 81-82). Handy and Handy (1972) attribute the naming of Wai‘anae to a large fresh water pond for mullet called Pueha [sic] (Puehu). Today, the Wai‘anae coast is still considered one of the best fishing grounds on O‘ahu.

Wai‘anae was also known for the independent lifestyle and attitudes of its inhabitants, another trend that continues today. This independence was a factor in many of the political struggles of the pre-contact and early historic period when the district was the scene of battles and rebellions and often the refuge of dissidents and/or contentious factions. This independent spirit is often attributed to many generations coping with marginal environments, as many areas of Wai‘anae, and especially Lualualei, were notorious for their inhospitable climate.

2.2 The *Ahupua‘a* of Nānākuli

The *ahupua‘a* of Nānākuli encompasses 1,062 acres and is bounded on the east by Honouliuli in the ‘Ewa District and on the west by Lualualei in the Wai‘anae District. The leeward area

between Mākua and Nānākuli is especially noted for its susceptibility to drought and famine. In valleys such as Nānākuli, where perennial streams are lacking, agricultural resources would have been sparse due to poor water and land resources. It is probable that there were small, scattered settlements here and there whose main subsistence was the *‘uala* (*Ipomoea batatas)* or sweet potato.

> The eastern slopes of the southern end of the Wai‘anae Mountains below Pu‘u Puna were famous for sweet potato growing. Although there was a little taro grown in the valleys of Wai‘anae-uka, sweet potatoes grown on the *kula* lands were the main food of the people here. On the other side of the Wai‘anae Mountains sweet potatoes were planted on the dry slopes of Nānākuli, Lualualei, Wai‘anae-kai, and the other small valleys as far as Mākua. With the exception of Wai‘anae-kai, the sweet potato was the staple for the inhabitants of this dry section…(Handy 1940:156).

To make up for this agricultural deficit, the coastal areas were rich in marine resources and there was always an abundant supply of fish (Handy and Handy 1972:275, 277).

2.2.1 Mythological and Traditional Accounts of Nānākuli

Previous research of the traditional history and mythology of Nānākuli Valley has revealed a dearth of information. A common perception is that Nānākuli was a poor land with little agriculture, leading the few residents to instead rely on marine resources. One translation of the naming of the *ahupua‘a*, which seems to support this perception, is that Nānākuli means, “to look deaf” (Sterling and Summers 1978: 61-2). This is said to refer to the behavior of Nānākuli residents, who, embarrassed about not being able to offer food to passing strangers, pretended to be deaf. Cultural Specialist, Mary Pukui Kawena, relates a story told to her in 1945:

> Simeona Nawa‘a came in to the [Bishop] Museum and sat down to talk to me. In the course of the conversation he told me these things:
>
> Nanakuli - it was Kanui, a native woman of Wai‘anae who told him why this place was so named. In the olden days, this place was sparsely inhabited because of the scarcity of water. The fishing was good but planting very poor. When it rained, some sweet potatoes would be put into the ground, but the crops were always poor and miserable.
>
> There were a few brackish pools from which they obtained their drinking water and it is only when they went to the upland of Wai‘anae that they were able to get fresh water. They carried the water home in large calabashes hung on *mamaka* or carrying sticks and used their water very carefully after they got it home. They spent most of their time fishing and most of the fish they caught were dried as gifts for friends and relatives in the upland. Sometimes they carried dried and fresh fish to these people in the upland and in exchange received poi and other vegetable foods. As often as not, it was the people of the upland who came with their products and went home with fish.

> Because of the great scarcity of water and vegetable food, they were ashamed to greet passing strangers. They remained out of sight as much as possible. Sometimes they met people before they were able to hide, so they just looked at strangers with expressionless faces and acted as though they were stone deaf and did not hear the greeting. This was so that the strangers would not ask for water which they did not have in that locality.
>
> The strangers would go to other places and mention the peculiar, deaf people who just stared and they would be told that the people were not deaf but ashamed of their inability to be hospitable. So the place they lived was called *Nana*, or “look”, and *kuli*, “deaf” - that is, Deaf mutes who just look. [Sterling and Summers 1978: 61-62, referring to Hawaiian Ethnological Notes at the B.P. Bishop Museum, March 6, 1945].

An old time resident of the area, Wm. Z. H. Olepau, reported other explanations for the meaning of Nānākuli on March 20, 1933:

> There were two women who went up the hill of Pu‘u Hakila or Pu‘u Hela to dry their *Kapas* [tapa cloth]. While the *kapas* were being dried they left and went down the hill to the pool for some water. They heard dogs barking, so they stood, looking around for the barking was deafening.
>
> (1) Women used to go to the top of the hill to dry their *kapa*, and when they got there they looked at their knees - *nana kuli*.
>
> (2) Royalists of the valley used to sit with their knees up and watch their knees - *nana kuli* (In Sterling & Summers 1978: 62).

A further explanation of the name Nānākuli is reprinted from Thrum’s *Hawaiian Annual*, ([1922: 87] in Sterling and Summers [1978:62]):

> The name of “Nānākuli”, a section of Wai‘anae, meaning “knee examination”, is said to relate to an incident in the travels of the famous Kuali‘i, when his attendants wished to see and press his knees, to relieve the king’s fatigue after the journey.

Samuel Kamakau gives yet another explanation for the origin of the name Nānākuli:

> After his return from Moloka‘i, when he had ruled six years over O‘ahu and Moloka‘i, Kahahana abandoned the advice of Ka‘ōpulupulu and began to lay burdens upon the country people and to dig up the bones from their burial places to make arrows for rat-shooting and hooks for fishing. The bones of chiefs were bartered for skirts for chiefesses and handles for *kahili*. Ka‘ōpulupulu came in vain to remonstrate with him, and the *kahuna* and all his followers, relatives, and members of his household tattooed their knees [*kuli*] as a sign of the chief’s deafness [*kuli*] to his admonitions (Kamakau 1992: 133).

An interview with an informant, Fred Cachola, who worked and lived in the Wai‘anae District for many years, brought forth another story and possible meaning for Nānākuli (McGuire and

Hammatt 1999: 53-54). According to local stories, the name of Nānākuli once had a Hawaiian hidden meaning, which was “Nānā-i-ka-‘ule”. It got this name from ancient times, and might have something to do with the shape of the mountain range. The shape of one mountain ridge is similar to an *‘ule* [penis] in one area and the testicles in another place. Nānāika‘ule literally means, “looking at a man’s testicles”, or “looking at his penis”. According to Mr. Cachola, Reverend Awai, the first principal of the elementary school to the north of the project area, was also aware of this story about the name origin of Nānākuli, and decided to name the school Nānāikapono instead, which translates as, “look to the way of righteousness.”

Another informant in Nānākuli, Mrs. Lehua Kapaku, revealed an entirely different story about the *ahupua‘a*, based on the legends of the hero/god, Māui (McGuire and Hammatt 1999: 82-83). Māui had several brothers and two sisters. One sister was Lualualei, which means “*sacred wreath*” and is the name of the *ahupua‘a* north of Nānākuli. The second sister was a beloved baby, named Nānāiku‘ulei, which means, “look to my pretty lei”. Mrs. Lehua Kapaku suggests that this may be the original name for the Nānākuli *ahupua‘a*.

2.2.2 Early Historic Period

Accounts of early foreign observers give only a generalized picture of the late pre-contact/early historic patterns of population and activity within the Wai‘anae District and Nānākuli Ahupua‘a. Captain George Vancouver, sailing along the Wai‘anae Coast in 1793, noted: "The face of the country did not...promise an abundant supply [of water]; the situation was exposed." He described the coast as "one barren rocky waste nearly destitute of verdure, cultivation or inhabitants" (in Krauss 1993: 17).

The only village Vancouver observed was "at Waianae, located in a grove of coconut and other trees on the southern side of a small sandy bay" (Krauss 1993: 17). It is probably this village that was visited in 1815 by John B. Whitman, who described the western coast of O‘ahu between Wai‘anae and Honolulu:

> After proceeding for some time over an uncultivated plain, we arrived at small village situated on the sea shore. It consisted of about twenty huts occupied by fishermen (Holt 1979:82).

The "uncultivated plain" Whitman observed before reaching Wai‘anae likely encompassed Nānākuli.

Specific information regarding Nānākuli in the early historic period is sparse. The first mention of coastal settlement in Nānākuli comes from a description by John Papa ‘Ī‘ī about a visit to his aunt’s in the early 1800’s. No specific description of the settlement was given, other than an indication that breadfruit trees were growing near the shore (Ī‘ī 1959:28). The major coastal trail that circled O‘ahu ran across the mouth of the valley, and presumably, settlements would have been located along this trail.

The coast of Nānākuli appears, up to late pre-contact/early post-contact times, to have sustained a sparse population, which was limited to isolated, perhaps temporary, habitations supported by marine resources. Environmental components including the dry climate (Armstrong 1973: 56) and geologic limitations of shallow soil (Haun 1991: 310) were likely determinative constraints upon population density along the coast. Although these and various other historic

accounts describe the coastal regions of Nānākuli as relatively uninhabited because of their limited subsistence resources, archaeological evidence suggests that late pre-contact and early historic land usage occurred inland of the coastline.

By 1811, sandalwood merchants began actively exploiting the Hawai‘i market and huge amounts of sandalwood were exported to China. Traditionally, Hawaiians used sandalwood for medicinal purposes and as a scent to perfume their *kapa*. Kamehameha I and a few other chiefs controlled the bulk of the sandalwood trade. Kamakau (1992: 204) writes, “The chiefs also were ordered to send out their men to cut sandalwood. The chief immediately declared all sandalwood to be the property of the government.”

The sandalwood trade greatly impacted Hawaiian culture, and the traditional lifestyle Hawaiians had always pursued was altered drastically. In an effort to acquire western goods, ships, guns and ammunition, the chiefs had acquired massive debts to American merchants (‘Ī‘ī 1959:155). These debts were paid off in shiploads of sandalwood. When Kamehameha found out how valuable the sandalwood trees were, he ordered the people not to let the felled trees fall on the young saplings, to ensure their protection for future trade (Kamakau 1992: 209-210). According to Samuel Kamakau:

> The debts were met by the sale of sandalwood. The chiefs, old and young, went into the mountains with their retainers, accompanied by the king and his officials, to take charge of the cutting, and some of the commoners cut while others carried the wood to the ships at the various landings; none was allowed to remain behind. Many of them suffered for food . . . and many died and were buried there. The land was denuded of sandalwood by this means (Kamakau 1992: 252).

Kamakau comments about the plight of the common people and the general state of the land during this time:

> This rush of labor to the mountains brought about a scarcity of cultivated food throughout the whole group. The people were forced to eat herbs and tree ferns, hence the famine called Hīlaulele, Hāhāpilau, Laulele, Pualele, ‘Ama‘u, or Hāpu‘u, from the wild plants resorted to. (Kamakau 1992: 204)

In 1816, Boki Kama‘ule‘ule was made governor of O‘ahu (and chief of the Wai‘anae district) and served in that capacity until 1829, when he sailed to New Hebrides in search of sandalwood. ‘Ī‘ī writes:

> It was Boki’s privilege to assign work, for he had been governor of the island of O‘ahu from the time Kamehameha I ordered all the chiefs to O‘ahu in 1816 to expel the Russians (‘Ī‘ī 1959: 145).

The sandalwood era was short lived and by 1829, the majority of the sandalwood trees had been harvested and the bottom fell out of the trade business. It is unclear how extensive Nānākuli sandalwood resources were, however, the effects of sandalwood gathering, population shifts, and disruption of traditional lifestyles and subsistence patterns would undoubtedly have affected the population of the *ahupua‘a*.

The Reverend William Ellis visited the Hawaiian Islands in 1823. At that time, he estimated the population on the island of O‘ahu to be about 20,000 (Ellis 1969:19). The missionaries were the first to gather systematic figures regarding population statistics throughout the various districts on each island. The first census figures were gathered from 1831-1832 and 1835-1836. Population figures for Nānākuli were not given, however population numbers given for Wai‘anae were 1,868 and 1,654 respectively (Schmitt 1973: 9).

Following western encroachment on the Wai‘anae Coast, a swift decline in population occurred due to disease and a "tendency to move to the city where there was more excitement" (McGrath et al. 1973: 25). In 1835, a missionary census listed 1,654 residents on the Wai‘anae Coast. The population of the Wai‘anae Coast was decimated by a smallpox epidemic in late 1853. In 1855, the Wai‘anae tax collector recorded 183 taxpayers on the leeward coast, which is thought to represent a total population of about 800 people. This catastrophic depopulation facilitated the passing of large pieces of land into the hands of a few landholders and led to the decline of the traditional economy that once supported the region (Hammatt et al. 1993: 10-11).

2.2.3 Mid-to-late 1800s

The Organic Acts of 1845 and 1846 initiated the process of the *Māhele* - the division of Hawaiian lands - that introduced private property into Hawaiian society. In 1848, the crown and the *ali‘i* (royalty) received their land titles. *Kuleana* awards to commoners for individual parcels within the *ahupua‘a* were subsequently granted in 1850. At the time of the *Māhele*, the *ahupua‘a* of Wai‘anae were listed as Crown lands and claimed by King Kamehameha III as his personal property (Board of Commissioners 1929: 28). As such, the land was under direct control of the King. Many of the chiefs had run up huge debts to American merchants throughout the early historic period and continuing up into the mid-1800s. A common practice at the time was to lease (or mortgage) large portions of unused land to other high chiefs and foreigners to generate income and pay off these earlier debts. In many cases, commoners were denied access to the land, upland agriculture ended, and traditional life was greatly altered. Members of the Manini, Jarrett, J. Robinson, Judd, and Dowsett families held such leases. Nānākuli was generally used as an annex ranch and ranch headquarters were not located in the *ahupua‘a* (Cordy 1997:6).

In 1850, the Privy Council passed resolutions that would affirm the rights of the commoners or native tenants. To apply for fee-simple title to their lands, native tenants were required to file their claim with the Land Commission within the specified time period of February 1846 and February 14, 1848. The *Kuleana* Act of 1850 confirmed and protected the rights of native tenants. Under this act, the claimant was required to have two witnesses who could testify they knew the claimant and the boundaries of the land, knew that the claimant had lived on the land for a minimum of two years, and knew that no one had challenged the claim. The land also had to be surveyed.

Not everyone who was eligible to apply for *kuleana* lands did so and, likewise, not all claims were awarded. Some claimants failed to follow through and come before the Land Commission, some did not produce two witnesses, and some did not get their land surveyed. For whatever reason, out of the potential 2,500,000 acres of Crown and Government lands “less than 30,000 acres of land were awarded to the native tenants” (Chinen 1958:31).

There appears to have been only one application, though unsuccessful, for quiet title to lands in Nānākuli during the time of the *Māhele*. Even though this award was not granted, it does give some insight into land use in Nānākuli Valley:

> To the Land Commissioners: *‘Ili* of Hapai, *Ahupua‘a* Nānākuli, Wai‘anae District, O‘ahu. I, the one whose name is below, have a *muliwai*, a pond, a cultivated *kula*, and for firewood also, a valley planted in *wauke mauka*, [and] a houselot. Kuluahi, X his mark (Ogden Environmental and Energy Services, Inc. 1995: 10; Cordy 1997: 6).

In the mid-1800s, the back of Nānākuli Valley appears to have been used solely for ranching purposes and probably did not support permanent habitation. Tax records from the mid-1800s for coastal Nānākuli indicate that possibly as many as 50 people resided along the shore. The population in the area dropped precipitously during the 1800s, and in 1888, the Hawaiian Island Directory referenced only four residents of Nānākuli (Cordy 1997:7).

2.2.4 1900s

Historic Maps

Land use in the region surrounding the project area in the early part of the 20th century is depicted on a series of historic maps. A portion of an 1899 Government Survey map (Figure 11) shows the project area in undeveloped land; note the presence of the OR&L on the *makai* side of the trail. A 1919 War Department map (Figure 12) shows some minor development of the project area vicinity and the presence of a military reservation on the *mauka* side. A 1927 US Geological Survey map (Figure 13) shows more development of the area with more infrastructure present as well as a few more houses. The Military Reservation was renamed Nānākuli Station by this time. A 1943 War Department map (Figure 14) shows infrastructure in

place for Nānākuli Town, and the 1954 U.S. Geological Survey map (Figure 15) shows the development of Nānākuli Town and further development of Lualualei to the north. Nānākuli Station is shown as a Naval Reservation. A prominent feature present in all of the historic maps is the OR&L railroad tracks. The tracks run parallel to Farrington Highway, on the *makai* side. Another feature in proximity to the project area is the U.S. Military Reservation present beginning on the 1919 War Department map (Figure 12).

Homesteading

There were two waves of homesteading on the Wai‘anae Coast. The first had more of an impact on Lualualei, while the second resulted in development of Nānākuli as a residential area.

After the overthrow of the Hawaiian monarchy in 1893, Crown Lands and Government Lands were combined to become Public Lands. The Crown Lands were no longer indistinguishable and inalienable. In 1895, the Republic of Hawai‘i decided to open up lands for homesteading in the hopes of attracting a “desirable class of immigrants”, in other words, Americans and those of Caucasian descent (Kuykendall and Day 1961: 204). The Dowsett-Galbraith ranch lease was set to expire in 1901, and the Hawaiian Government intended to auction off these lands to the highest bidder.

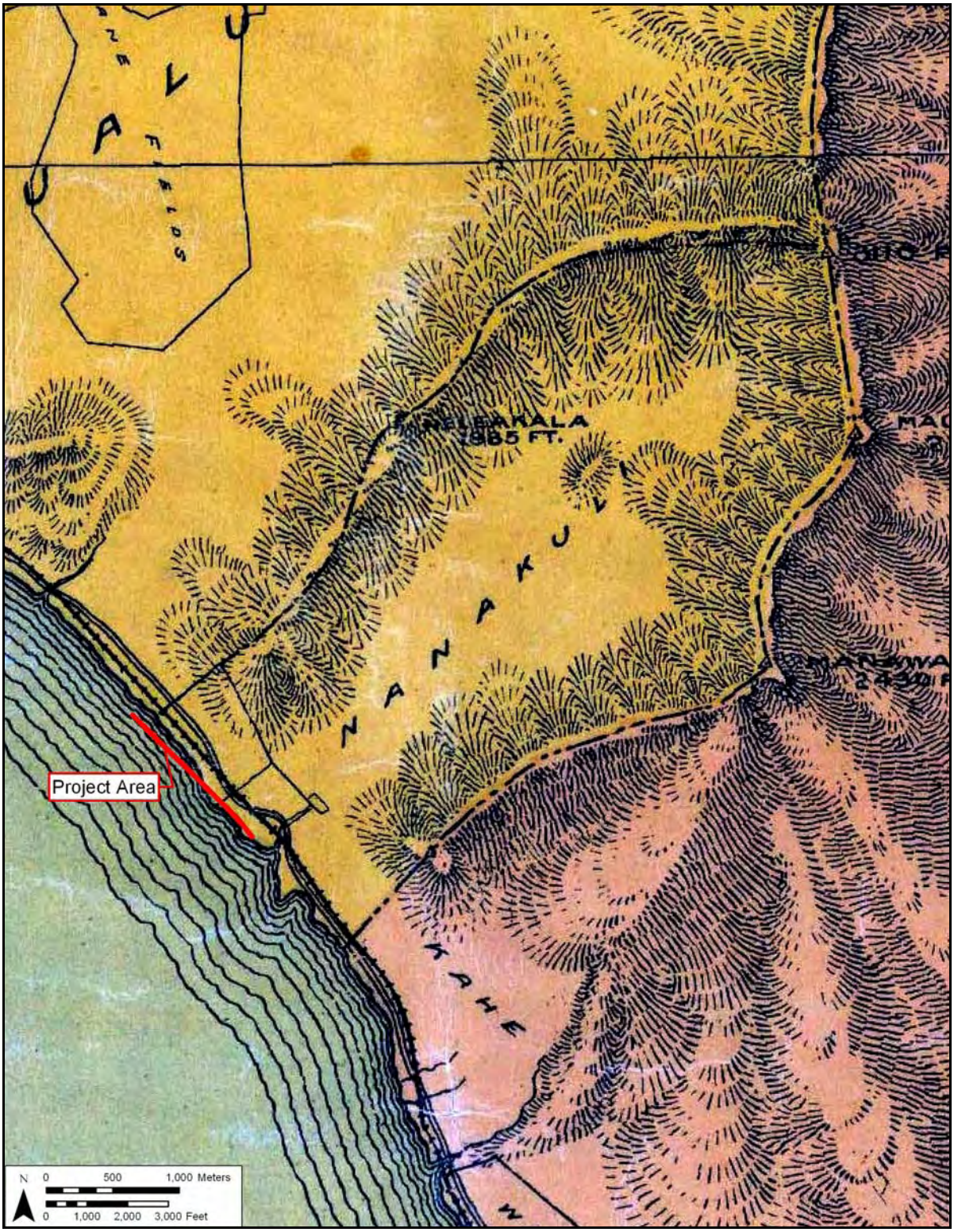

Figure 11. Portion of an 1899 Government Survey Map (Beasley and Taylor) showing portions of Nānākuli and Lualualei Ahupua‘a

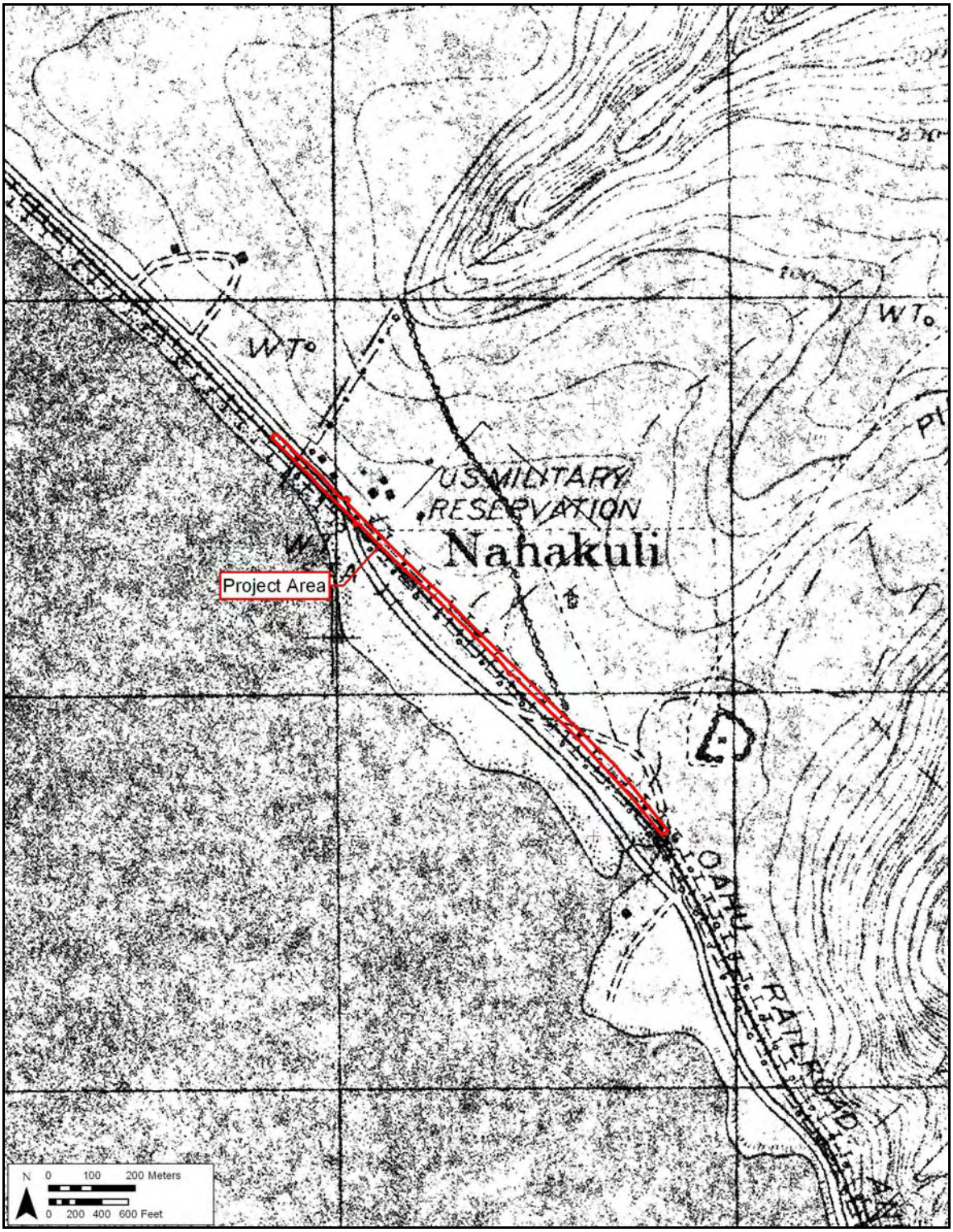

Figure 12. Portion of a 1919 War Department map showing the current project area; note the presence of the railroad

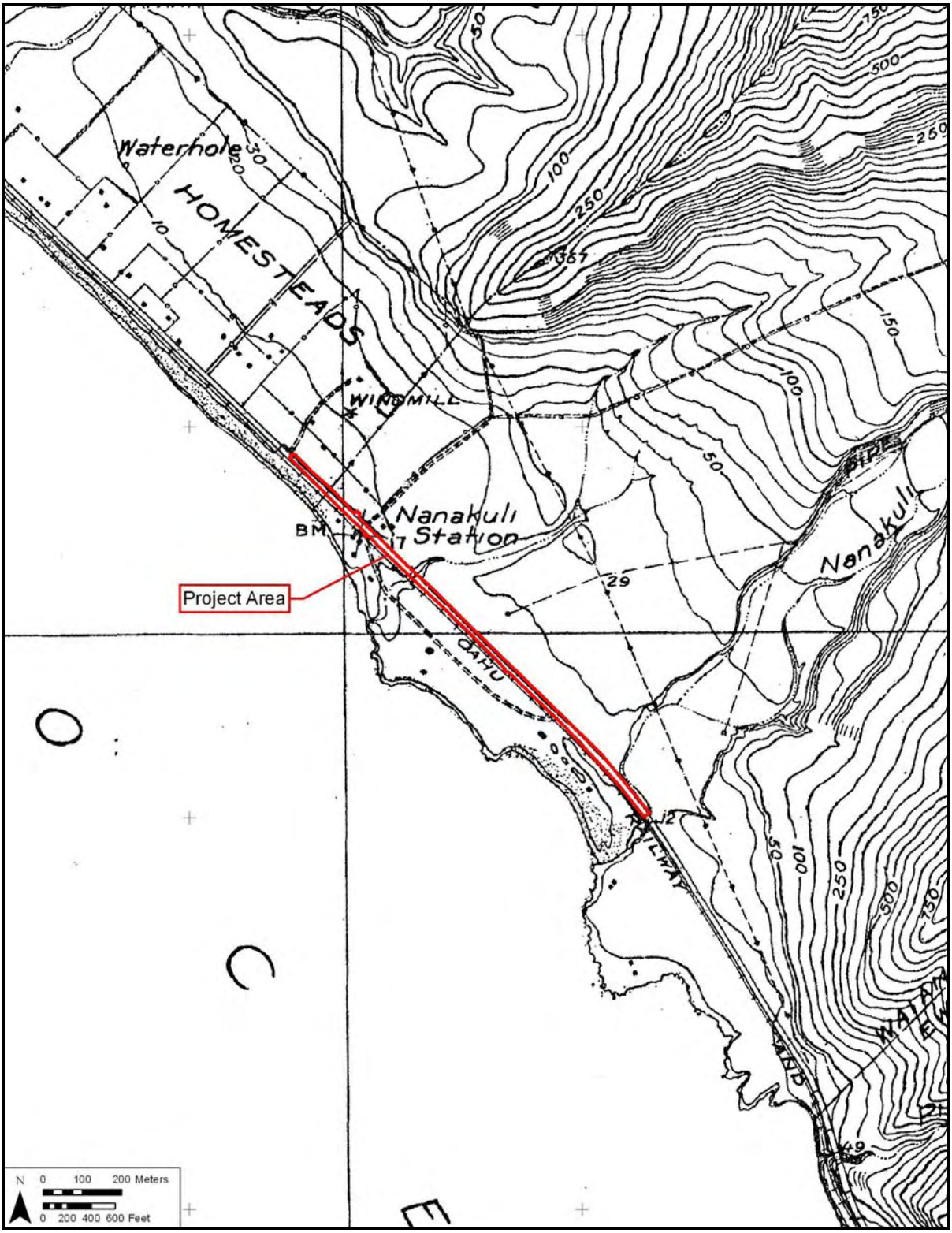

Figure 13. Portion of a 1927 U.S. Geological Survey map showing the project area; note development of the area

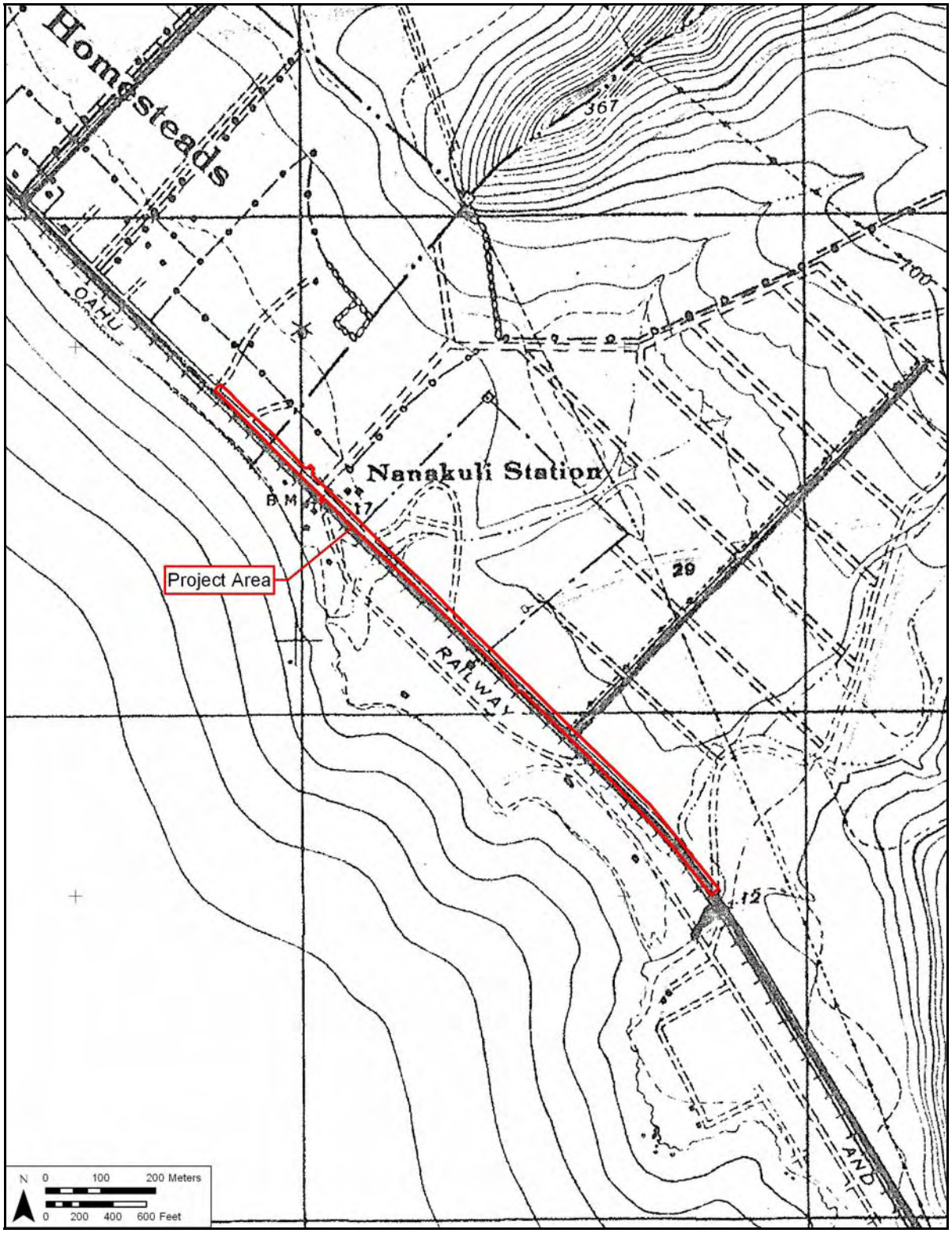

Figure 14. 1943 War Department map showing the current project area; note development of the area northeast of the project

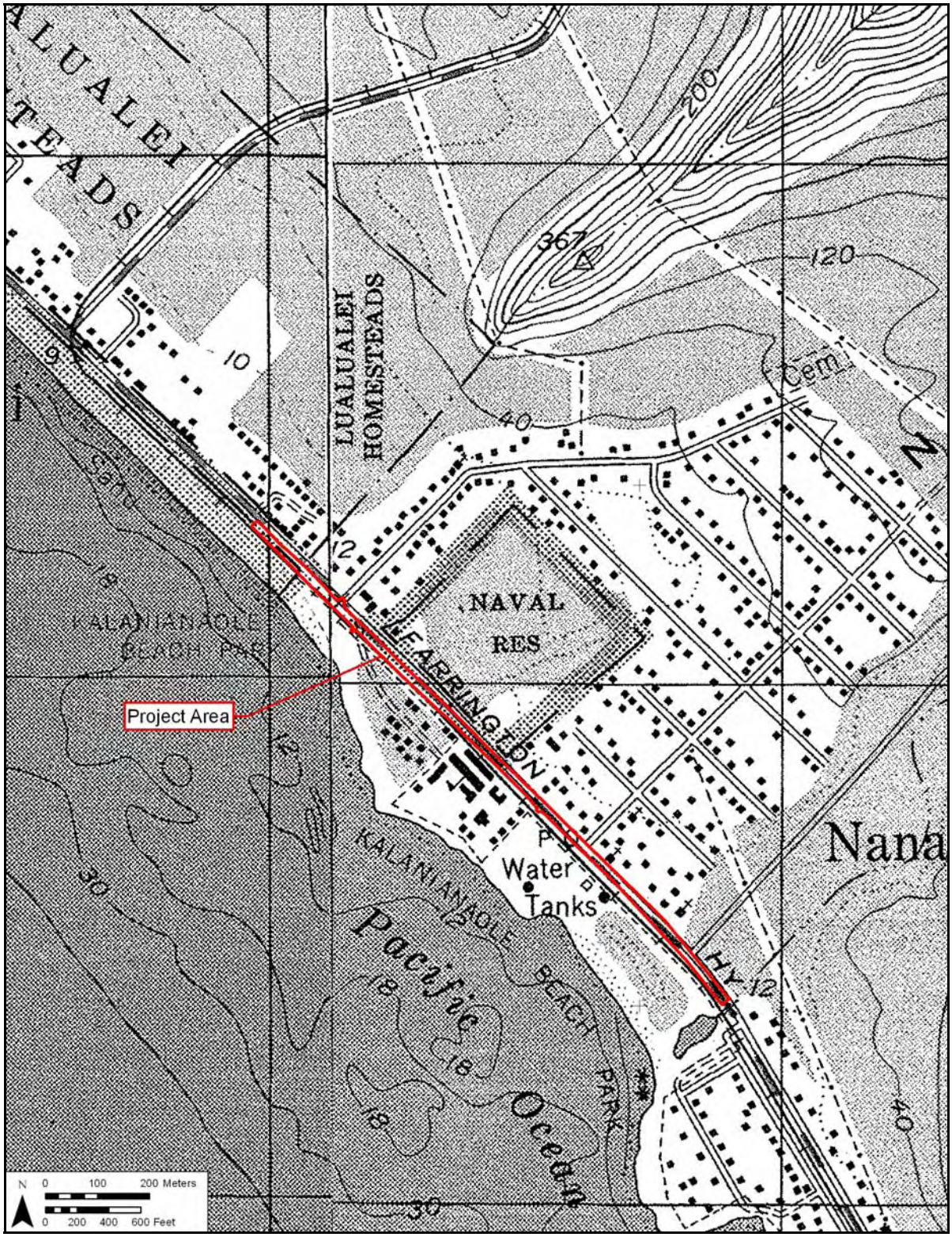

Figure 15. 1954 U. S. Geological Survey map showing the project area. Note the development of Nānākuli Town and Lualualei homesteads

In 1902, the Hawaiian Government ran advertisements in the local newspapers stating their intent to open up land in Lualualei for homesteads. The lots were classified as second class pastoral land, rather than agricultural land, because of the lack of water. A five year installment payment plan of one-fifth down during the first year and the balance of payments over a period of four years was the incentive to attract prospective homesteaders. There were other stipulations as well, in which the homesteader was required to make specific improvements to the property over the five year period (Hawaii Department. of the Interior, October 6, 1902, Hawai‘i State Archives).

Homesteads were sold in three series: the first series consisted of nine lots, which were sold between 1903 and 1909. These lots were much larger than the second and third series of lots sold. Seven of these lots averaged about 585 acres each. The two largest lots were 1,479.1 acres and 1,149.9 acres. The big-name families that obtained homestead lots at this time were Von Holt, McCandless and Dowsett. The majority of the Dowsett land was used to pasture cattle, with other portions being leased to the Sandwich Island Honey Company for apiaries (Commission on Boundaries 1862: 376, 237, 288, 324, 331).

The second series of eleven lots were much smaller and consisted of 50 to 60 acres each. These were situated *mauka* of the main road, near the coast and were sold following 1907. The third series consisted of 116 lots, some on land used by Wai‘anae Sugar Company to grow cane. The lots varied in size from 4.86 acres to 18.18 acres. These lots were opened up in 1912, and by the early 1920s, approximately 40 families had settled there (Haun 1991: 331-332).

The Hawaiian Government did not fulfill its promise to supply water and what little water existed was not enough to go around. Competition between the plantation and homesteaders for water caused friction within the community. The lack of water placed a hardship on the homesteaders. Water had to be carried in and many families lost their crops. The Wai‘anae Sugar Company had a lease with the government to take 2.5 million gallons of water daily from government lands; but even after their lease had expired, the plantation continued to take the water. In 1924, the government made an agreement with the plantation to release 112,000 gallons of water daily for the homesteaders.

The early wave of homesteading passed by dry, barren Nānākuli; however, despite an insufficient water supply, Nānākuli was an attraction to some people:

> Because of its water shortage, parched Nānākuli had never attracted many residents. It remained a kiawe wilderness. Yet, the very fact that nobody wanted it turned the area into a kind of informal public park. Its magnificent beaches attracted a growing colony of squatters from all over O‘ahu who were running out of places to camp… The entire island had been hung with Kapu signs. But not Nānākuli. There the tawny, crescent beaches were open to anyone. Some came for the summer. Others camped all year round. Most of them were Hawaiians. (McGrath et al. 1973: 103)... In the mid-1920's, not counting squatters, there were only ten residents in all of Nānākuli (McGrath 1973: 107).

Under the Hawaiian Homes Commission Act, a second wave of homesteading occurred in the late 1920s and 1930s. This law established almost 200,000 acres for homesteaders of Hawaiian blood. Previous leases of Nānākuli land had expired by this time, and the land was subdivided

for residential lots. By 1930, over 200 residential lots had been taken. Whether there would be sufficient water for the new homesteads, particularly because of continued consumption by the Wai‘anae Plantation, was in question. Water came in through a 2-inch pipe from the Lualualei water system, which was often dry (McGrath et al. 1973: 108-118). The struggle over water found homesteaders embroiled in a water rights issue with Wai‘anae Plantation that took several years of litigation to settle.

The Military

In 1917, the U.S. Government gave a 31.6-acre parcel for military use. The parcel was located where Nānāikapono Elementary School is presently located, and extended *mauka* into the valley. This site was named Camp Andrews and was used as a rest and recreation (R&R) area for military personnel, both prior to and during World War II (Figure 12-Figure 15). Since then, the Federal Government has given the Camp Andrews parcel back to the State of Hawai‘i, which is the current landowner (Nakamura and Pantaleo 1994: 19).

By 1929 over 8,184 acres of the McCandless Cattle Ranch lands, "the area which now constitutes the Lualualei branch" (Haun and Kelly 1984: 41) had been purchased by the U.S. military for the construction of a Naval Ammunition Depot for the ships of Pearl Harbor Naval Base. Although controversial, the depot did provide jobs during construction as well as after operations began in 1933 (McGrath et al. 1973: 113-118).

World War II greatly affected the Wai‘anae coast. Military troops were sent in to train and practice maneuvers. Concrete bunkers and gun emplacements were built on the beaches and ridges, and barbed wire was strung along the beaches.

2.2.5 Transportation on the Wai‘anae Coast (1880–1930)

Prior to the 1880s, the Wai‘anae coastline may not have undergone much alteration. The old coastal trail likely followed the natural topographic contours. With the introduction of horses, cattle, and wagons in the nineteenth century, many of the coastal trails were widened and graded to accommodate these new introductions. However, the changes were probably superficial alterations to existing trails and did not entail major realignments. Kuykendall (1953: 26) describes mid-nineteenth century road work: “Road making as practiced in Hawai‘i in the middle of the nineteenth century was a very superficial operation, in most places consisting of little more than clearing a right of way, doing a little rough grading, and supplying bridges of a sort where they could not be dispensed with.” The first real alteration to the Wai‘anae coastline likely came as a result of growth of the Wai‘anae Sugar Company. The company cultivated cane in three valleys – Mākaha, Wai‘anae, and Lualualei – and, to more easily transport their cane to the dock and to the mill at Wai‘anae Kai, a railroad was constructed in 1880. The construction of the railroad would have had an impact on the natural features in the area, such as sand dunes, as well as human made features, particularly the fishponds and saltponds maintained in the coastal zone. Additional alteration to the Wai‘anae coastline occurred in the late nineteenth century with the extension of Dillingham’s OR&L rail line along the Leeward Coast. One reporter writes a glowing story of the railroad trip to Wai‘anae at its opening on July 4, 1895:

> For nine miles the road runs within a stone’s throw of the ocean and under the shadow of the Wai‘anae Range. With the surf breaking now on the sand beach

> and now dashing high on the rocks on one side, and with the sharp craigs and the mountains interspersed with valleys on the other, patrons of the road are treated to some of the most magnificent scenery the country affords (McGrath et al. 1973: 56).

This report suggests the railroad hugged the ocean during a good portion of the trip. The railway's grade requirements demanded considerable alterations to natural landscapes in order to make them feasible for transport, including curve and slope reduction. A 1912 map of the Government Belt Road illustrates the alignment of the old Government Road, which was probably a modified version of the original coastal trail, and the alignment of the proposed Government Belt Road, which would parallel the OR&L alignment (Figure 16). After the Belt Road was completed, further roadwork was carried out in the 1930s on what was called the "Wai‘anae Road", later named Farrington Highway.

O‘ahu Railway and Land Company

Benjamin Dillingham, a prominent business man and developer, envisioned populating the western side of O‘ahu by introducing agriculture; however, the lack of water proved to be an obstacle until the discovery of artesian water solved the issue in the early 1880s. Dillingham saw that reliable transportation was needed to move crops from the west side of the island into Honolulu. With the help of several other businessmen and the Hawai‘i state legislature, Dillingham formed the O‘ahu Railway and Land Company (OR&L) in February 1889. The first few miles of track were laid and functional by the end of that year. The OR&L stretched as far as Kahuku by 1899 and agricultural interests were using the rail to ship produce to Honolulu, for the benefit of all. By 1914 track had been laid to Wahiawa to ship pineapple from the Dole Plantation.

The military also used the rail system during development of Pearl Harbor and Schofield Barracks, and during World War II the OR&L carried ammunition, supplies, troops and defense workers. Passenger fares also added to the profitability of the rail in the early part of the 20th century.

Following are two railroad chants in honor of Queen Lili‘uokalani, documented by Historian Nathan E. Napoka in 1979:

MAKALAPUA

Eia mai au ‘o Makalapua, Hō‘ alo i ka ihu o ka Lanakila.	Here am I, Makalapua Traveling companion of the Lanakila.
O ke ku‘e aa ka hao ka i Kuwili Ka ihona olu iho a o Halawa.	The piston works at Kuwili Down the pleasant descent to Halawa.
Ua lawa ka ‘ikena i ke awa lau Iā Ewa, ka i ‘a hāmau leo.	Satisifying is the view of the locks Of Ewa, land of the silent fish.
Ua pua ka uwahi a i Manana, ‘Awe ‘awe i ke kula a o Waipi‘o	The smoke rises at Manana And streams along at Waipio.

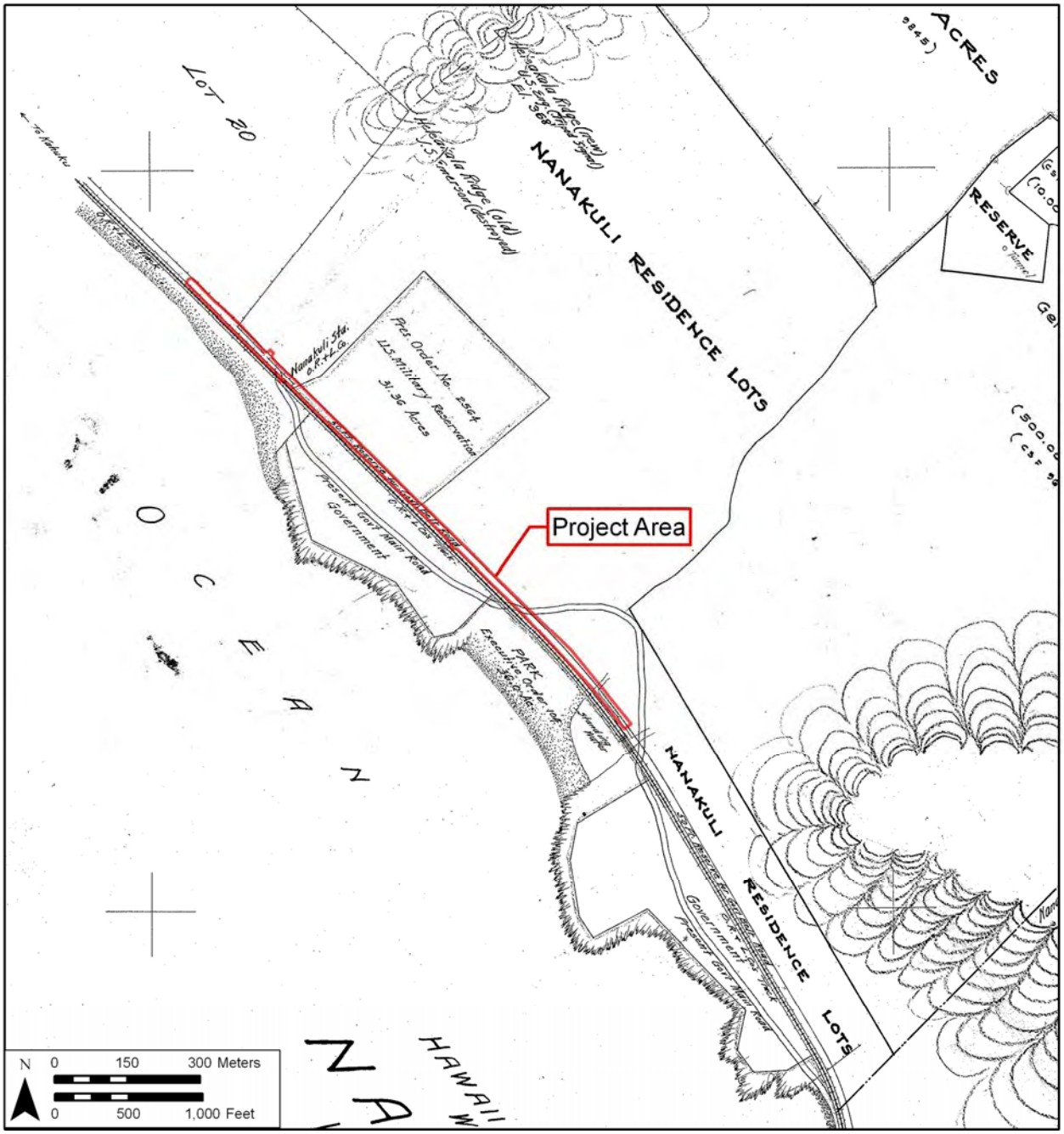

Figure 16. 1912 map of Nānakuli showing the Government Road (Newton 1912).

I kai ho‘i au o Honouliuli Ahulwale ke ko‘a a o Polea.	The lowland of Honouliuli is reached Where the coral of Polea lies exposed.
Ha‘ina ia mai ana ka puana Hō ‘alo i ka ihu o ka Lanakila. companion.	This is the conclusion of my song Telling of the Lanakila’s travelling
He inoa no Lili‘uokalani.	In honor of Lili‘uokalani

Lanakila ke Ka‘ahi Alii

‘O Lanakila ke Ka‘ahi ali‘i Nana i hali mai kohu aupuni.	Victory is the name of the Queen’s train That brought the ruler of the kingdom.
A hiki o ka lani i Moanalua I ka uwapo holuholu a o Halawa.	Here is your highness at Moanalua At the swaying bridge at Halawa.
Alawa iho ‘oe ma ka ‘ao ‘ao Hana no me ka huila i ke alahao.	Glance won’t you at the side And hear the clatter of the wheels.
A‘ohe ou loa a‘e Manana I ke ku‘upau a nā wiliki.	It is not far to Pearl City, With the speed of the engineer.
Ha‘awi ke aloha wehe papale Nā kini nā kupa ou e ka lani.	With a tip of the hat love is extended From all your loyal subjects.
Ho‘okahi no leo a o ke kuini Ho‘opa‘a ia mai no mikini	One command by the Queen And the train comes to an immediate halt.
A kau o ka lani i ke ka‘a pi‘o Huli aku huli mai h‘ola ‘ila‘.	The rode your Highness in her coach Turning calmly from side to side.
Heaku mākou o mai ‘oe O Lili‘uokalani la he inoa.	We call out to you Liluokalani is your name.
He inoa no Lili‘uokalani.	In honor of Liliuokalani.

After World War II the railroad was utilized less as the use of motorized vehicles became more economical. By 1947 all rail operations ceased outside of Honolulu, and the Department of the Navy took over the OR&L in 1950. The remnants of the OR&L, which consist of approximately 15 miles of track from Barbers Point to the Lualualei Naval Station, are the longest set of surviving tracks in Hawai‘i (Cummins 1974; Conde and Best 1973).

The Government Road

Farrington Highway was originally constructed in the 1930s. Its predecessor along the Wai‘anae Coast was variously termed the “Government Road” or “Old Wai‘anae Road” and provided less than ideal travel and transport conditions for the Wai‘anae District. Farrington Highway’s predecessor was described as a “mud hole in the winter and billowed dust in the summer” (McGrath et al. 1973:51). The Old Wai‘anae Road was not paved and there were no bridges to cross streams. Because of the transport limitations over the Old Wai‘anae Road, prior to the construction of Farrington Highway, most transport and travel between Wai‘anae and Honolulu was made using the OR&L Railroad or steamer ship (McGrath et al. 1973).

The construction of Farrington Highway was a component of the overall Territorial Highway System. It was only after 1925 that Territorial officials made use of available federal funding assistance for road and bridge construction. This led to abundant bridge and road construction after 1925 in Hawai‘i. Further federal assistance became available in the 1930s as part of the Works Progress Administration and National Reclamation Association programs; this funding lead to additional standardization and improvement of the Territorial Highway System (Thompson 1983: III-15). These improvements were significant events that greatly facilitated intra-island travel, transportation, and communication. Farrington Highway was eventually named after Wallace Rider Farrington (1871-1933), a former Honolulu Newspaper man, Mayor of Honolulu, and Territorial Governor of Hawai‘i (1921-1929), who was influential in expanding Hawai‘i’s roadways.

Once constructed, Farrington Highway became an important transportation and communication corridor that connected Oahu’s Wai‘anae District with Honolulu and the rest of the island. Figure 17 is a photograph of the “Old Wai‘anae Road” in Mākaha, north of the current project area, facing south towards Wai‘anae. Figure 18 shows the rural nature of Farrington Highway along the Waianae Coast in the 1940s. Figure 19 shows Farrington Highway during World War II—this photo is taken of the southern portion of the current project area.

2.2.6 Modern Land Use

After WWII ended, the lower portions of Nānākuli and Lualualei Valleys were further developed into residential lots after Chinn Ho bought the Wai‘anae Sugar Plantation. In Nānākuli, the land *mauka* of the current residential area continues to be leased and utilized for animal husbandry including cattle grazing, horse ranches, and pig and poultry operations.

The present Nānākuli Beach Park is a consolidation of several locally named beach sections. In 1916, Benjamin Zablan was appointed as Wai‘anae District Manager. He moved his family to Nānākuli and made his home on a beach stretch, now the stretch adjacent and south of Nānākuli Avenue. The southeastern end of this stretch was a safe swimming spot and was soon known to the local children as “Zablan’s Beach”. The beach was eventually named Nānākuli Beach, but local residents wished to give it a more specific name. In 1940, local residents petitioned the board of supervisors to name the park Kalaniana‘ole, in honor of Prince Jonah Kūhiō Kalaniana‘ole, the “father of the Hawaiian Homestead Act.” In recent years, Kalaniana‘ole was combined with nearby Piliokahe Park to the south to form the Nānākuli Beach Park (Clark 1977: 83).

Figure 17. Photograph of the old Wai‘anae Road (McGrath et al. 1973:51).

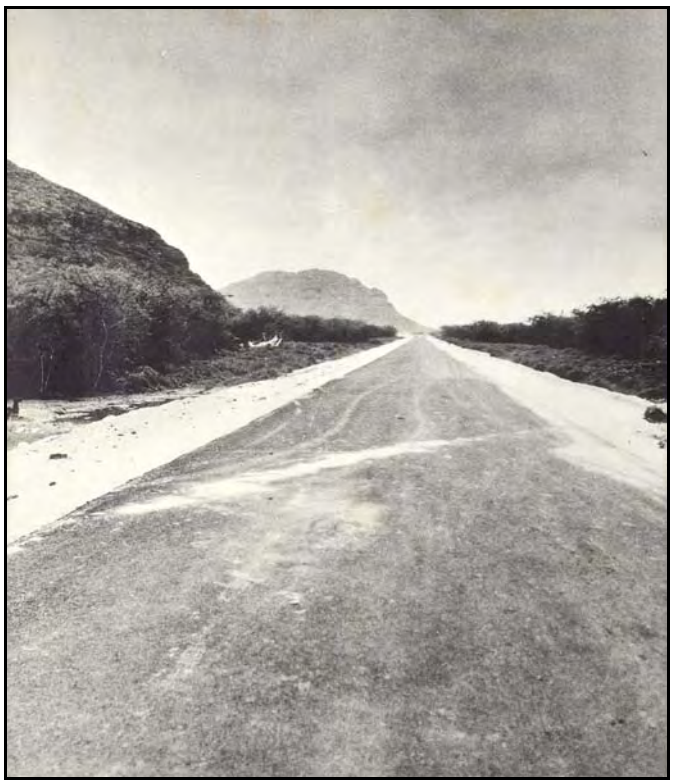

Figure 18. Photograph of Farrington Highway, late 1940s, along the Waianae Coast (McGrath et al. 1973:144)

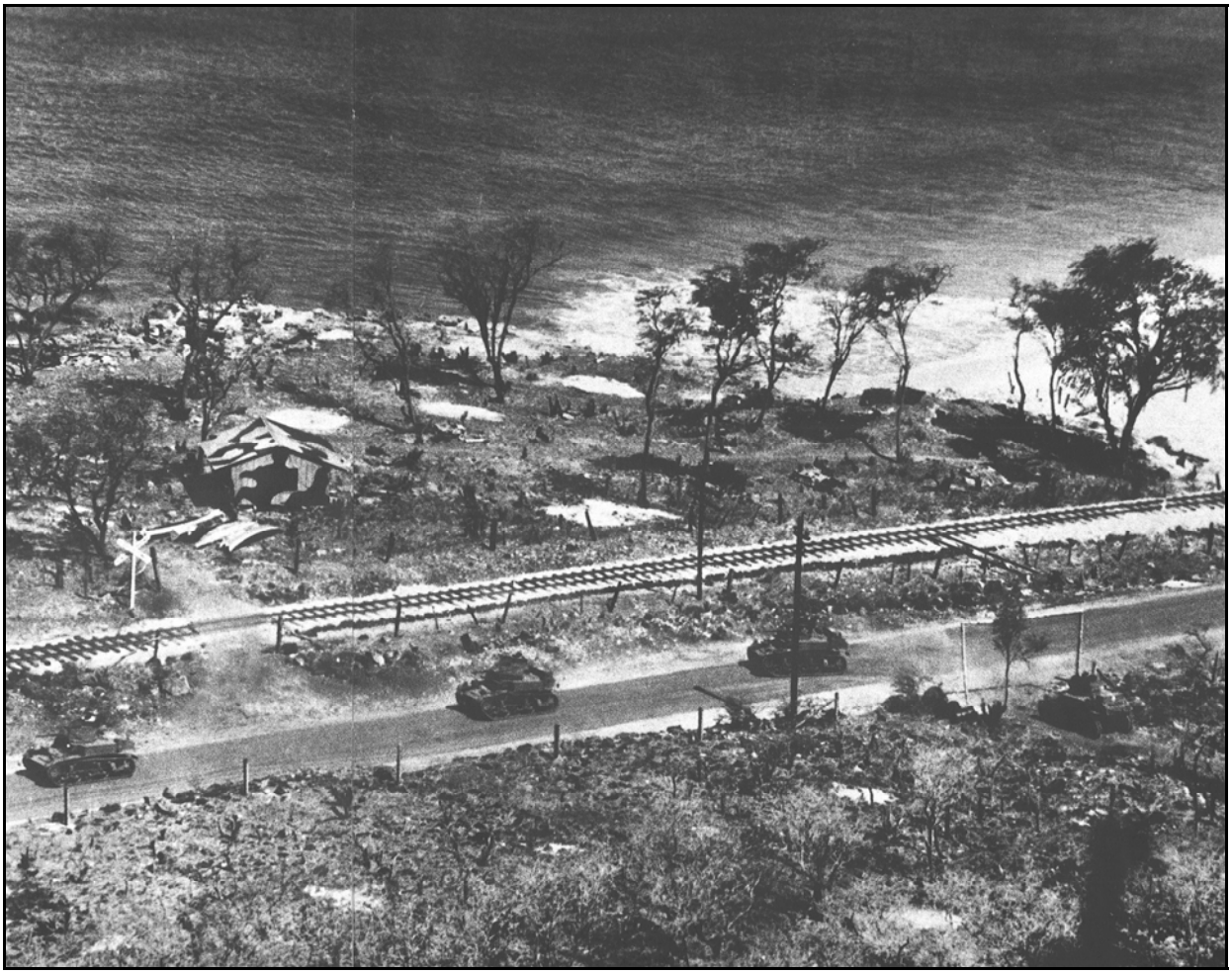

Figure 19. Photograph of Farrington Highway in the southern portion of the current project area, taken during World War II (McGrath et al. 1973:138-139).

2.3 Previous Archaeological Research

The following maps depict previous archaeological research and recorded sites in the vicinity of the project area, while the following table summarizes previous archaeological investigations in Nānākuli Ahupua‘a (Figure 20, Figure 21, and Table 1).

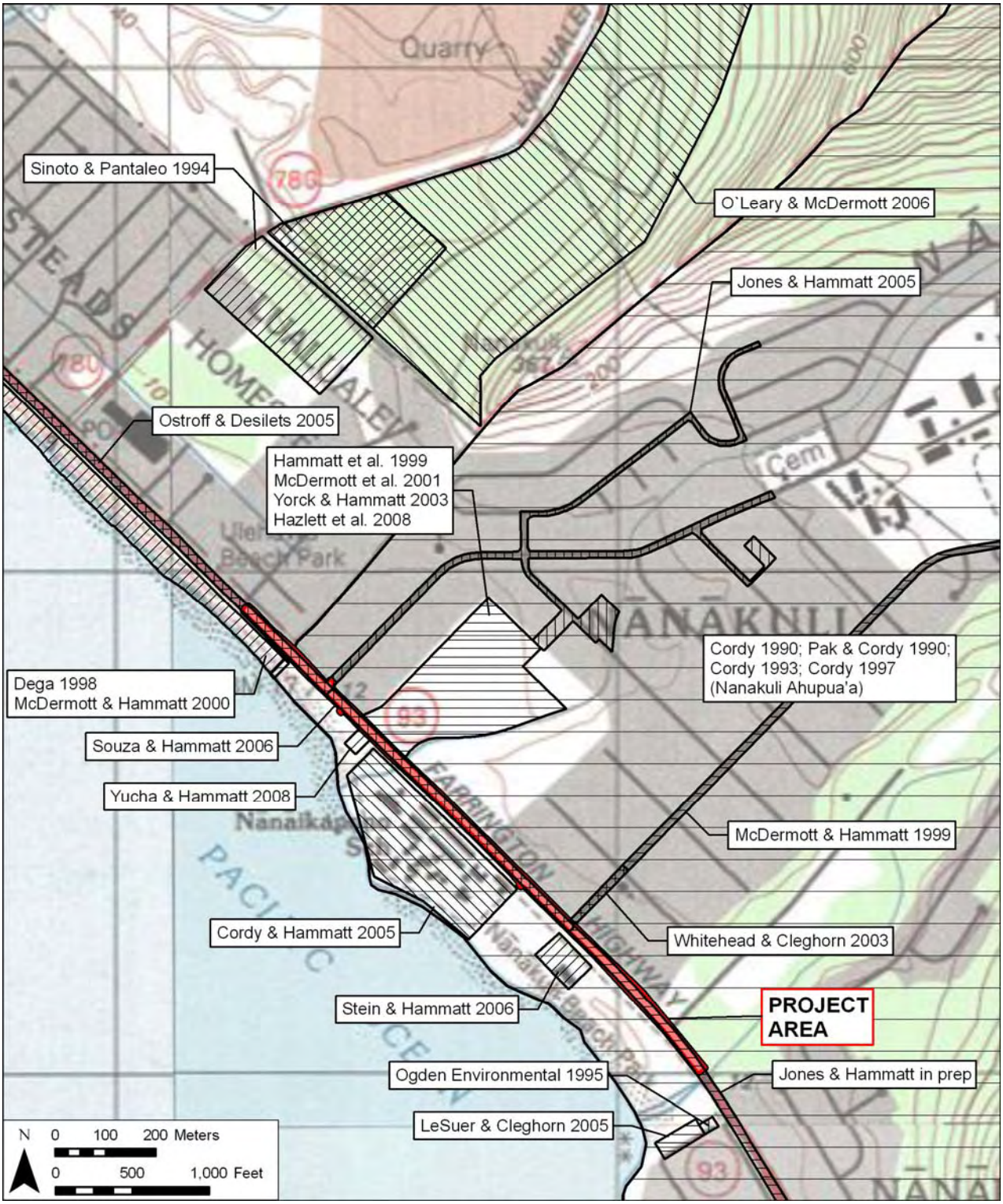

Figure 20. 1998 U.S. Geological Survey 7.5-minute Wai‘anae and Schofield Barracks Quadrangle Map displaying previous archaeological studies in the vicinity of the project area

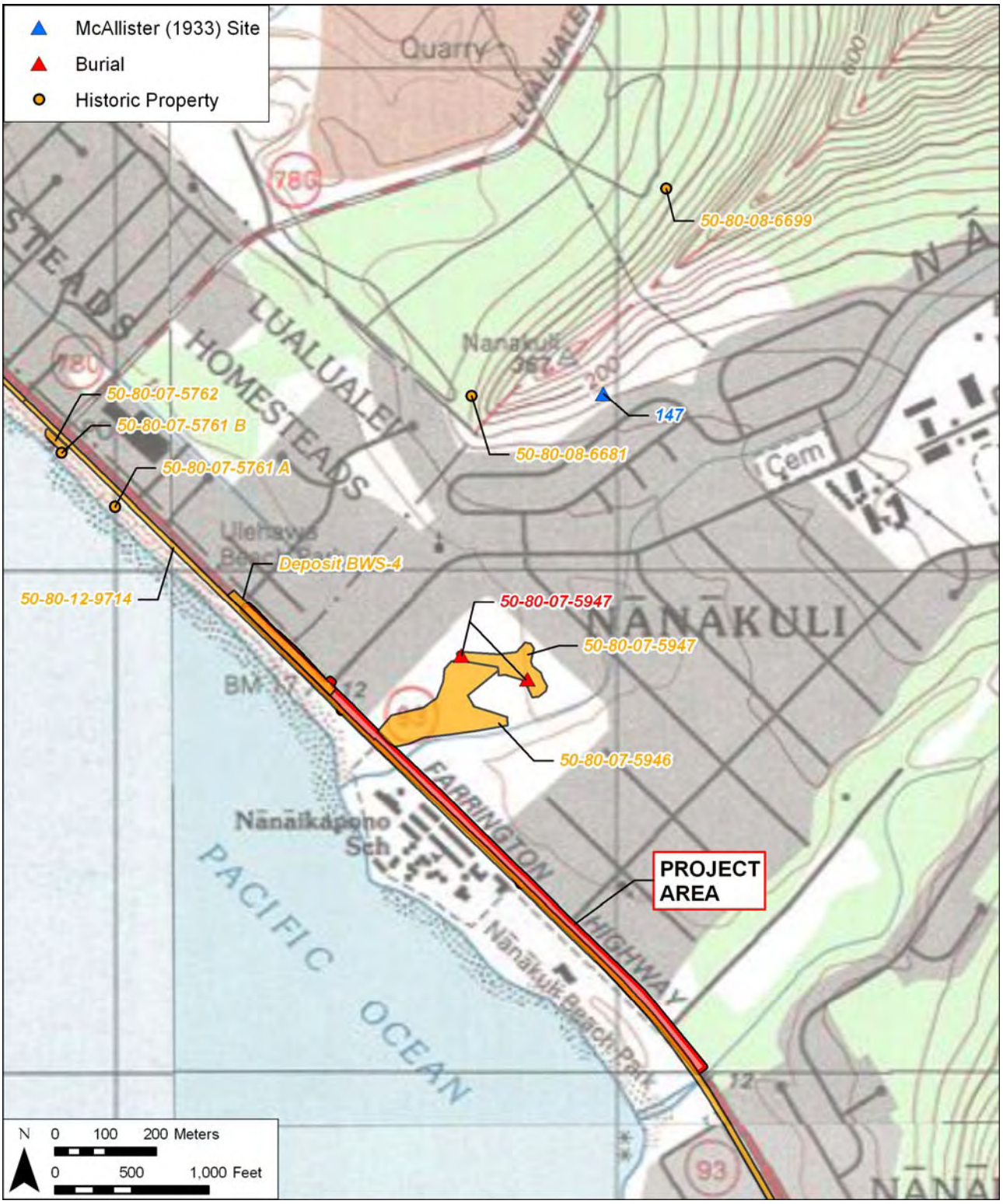

Figure 21. 1998 U.S. Geological Survey Wai‘anae and Schofield Barracks Quadrangle Map displaying previous archaeological sites in the vicinity of the project area

Table 1. Previous Archaeological Research Conducted in the General Vicinity

REFERENCE	LOCATION	DESCRIPTION AND RESULTS
McAllister 1933	Nānākuli and Lualualei Ahupua‘a	Island Wide Survey: McAllister recorded or near Site 147, ‘Ilihune Heiau, in Nānākuli
Handy 1940	Nānākuli Valley	Study of Nānākuli Valley. The remnants of abandoned terraces, stone platforms, and paving stones were observed in the upper valley.
Cordy et al. 1990	Nānākuli Ahupua‘a TMK 8-9	Status Report 3 of the archaeological inventory survey of Nānākuli Ahupua‘a; covered the undeveloped areas of the valley and is summarized in Cordy 1997.
Pak and Cordy 1990	Nānākuli Ahupua‘a TMK 8-9-07, 08	Status Report 4 of the archaeological inventory survey of Nānākuli *ahupua‘a;* covered the undeveloped areas of the valley and is summarized in Cordy 1997.
Cordy 1993	Nānākuli Ahupua‘a TMK 8-9	Lists significant historic sites observed during the archaeological inventory conducted between 1988 and 1990; summarized in Cordy 1997.
Sinoto and Pantaleo 1994	Nānākuli and Lualualei Ahupua‘a	Reconnaissance Survey: six candidate parcels for Nānākuli III Elementary School. Survey indicated extensive surface disturbance in the region. No surface historic properties were observed.
Ogden Environmental and Energy Services 1995	Nānākuli Ahupua‘a TMK 8-9	Archaeological Subsurface Testing: in conjunction with Milcon P-313, Range Operations Center Naval Undersea Warfare Engineering Station Detachment, Lualualei. No significant prehistoric or historic cultural deposits were identified. All strata had 20th century components which indicate recent land use.
Cordy 1997	Nānākuli Ahupua‘a TMK 8-9	Archaeological Inventory Survey Report: undeveloped portions of Nānākuli Valley (up to the Forest Reserve Line) revealed extensive ruins of agricultural sites, scattered permanent and temporary house sites, and possible religious structures in the upper portion of the valley. Very few sites were located in the lower portions of the valley. This report did not include the beach areas, as they have been urbanized, but did postulate that these sandy areas likely contain sites.
Dega 1998	Ulehaewa Beach Park	Letter report regarding archival research and field reconnaissance; observed WWII era infrastructure and the presence of a cultural layer in proximity to

REFERENCE	LOCATION	DESCRIPTION AND RESULTS
		the northern end of the current project area.
Hammatt et al. 1999	Nānākuli Ahupua‘a	Archaeological Assessment: 15-acre parcel on the eastern, *mauka*, side of Farrington Highway. The parcel was formerly a portion of Camp Andrews, and pre-WWII installation. No pre-contact Hawaiian sites were noted during the survey.
McDermott and Hammatt 1999	Nānākuli Ahupua‘a TMK 8-9-08:3	Archaeological Inventory Survey: covered a proposed reservoir site at 242 ft. above sea level and the transmission main leading down to Farrington Highway. No significant historic properties were found.
McDermott and Hammatt 2000	57.65 Acre Ulehawa Beach Park Parcel, Lualualei Ahupua‘a TMK:8-7--05:01,03 and 05; 8-7-06:03; 8-7-07:01, 8-7-08:26.	Archaeological Inventory Survey: 4.85 kilometer long Ulehawa Beach Park extended as far south as the Lualualei and Nānākuli Ahupua‘a boundary approximately 250 m north of Nānāikapono School. Identified four historic properties: including SIHP # 50-80-12-9714, the tracks of the OR&L railroad; SIHP # 50-80-07-5761, three concrete WWII bunkers and two concrete foundations; and SIHP # 50-80-07-5762 and –5763 two discrete subsurface cultural layers
McDermott et al. 2001	Nānākuli Ahupua‘a TMK: 8-9-02:65	Archaeological Inventory Survey: 15-acre parcel on the eastern, *mauka*, side of Farrington Highway. The parcel was formerly a portion of Camp Andrews. Cultural and paleontological deposits and a human burial are reported. The remains of Camp Andrews were designated SIHP # 50-80-07-5946; the burial and paleontological deposits were designated SIHP # 50-80-07-5947.
Whitehead and Cleghorn 2003	Nānākuli Water System Improvements, Nānākuli Avenue	Archaeological Monitoring Report: no historic properties observed.
Yorck and Hammatt 2003	Nānākuli IV Elementary School Project, Nānākuli Ahupua‘a TMK: (1) 8-9-02:65	Archaeological Monitoring Report: no historic properties observed, other than what was previously documented during inventory survey.
Jones and Hammatt 2005	DHHL Subdivision in Nānākuli Ahupua‘a	Archaeological Monitoring Report: no historic properties observed.

REFERENCE	LOCATION	DESCRIPTION AND RESULTS
	TMK: [1] 8-9; 8-9-02:23, 36, 38; 8-9-03:63; 8-9-04:78, por. 79; 8-9-07:01	
LeSuer and Cleghorn 2005	Nānākuli Beach Park (Zablan Beach Park) Parking Lot Improvements	Archaeological Monitoring Report: no historic properties observed.
Ostroff and Desilets 2005	Waterline installation on Farrington Highway TMK 8-7-07, 08, 17, 26, 31, 33-35, 44 and 8-9-01, 02, 05-07	Archaeological Monitoring Report: identified five charcoal enriched sand deposits including BWS-4, which was documented in the current project area. No artifacts were observed in association with any of the deposits.
Cordy and Hammatt 2005	Fiber Optic Cable Installation at Ka Waihona O Ka Na‘auau Public Charter School	Archaeological Monitoring Report; no historic properties were observed.
Souza and Hammatt 2006	Fiber Optic Cable Installation along Farrington Highway from Nānākuli Avenue to Halimo Rd.	Archaeological Monitoring Report; no historic properties were observed.
O’Leary and McDermott 2006	Lualualei Ahupua‘a, southwestern slopes of Pu‘u Heleakalā	Archaeological Inventory Survey; a total of two historic properties identified including SIHP No. 50-80-08-6699 (pre-contact rock shelter) and SIHP No. 50-80-08-6681 (WWII concrete bunker)
Stein and Hammatt 2006	Nānākuli Ahupua‘a TMK: (1) 8-9-001:002	Archaeological Monitoring Report: no historic properties observed.
Hazlett et al. 2008	Nānākuli Ahupua‘a TMK: (1) 8-9-02:65	Data Recovery Report; documents pre-contact and historic cultural deposits, including two human burials. Extinct avifauna remains were also analyzed.
Yucha and Hammatt 2008	Nānākuli Ahupua‘a	Archaeological Monitoring Report; no historic properties observed.

REFERENCE	LOCATION	DESCRIPTION AND RESULTS
Jones and Hammatt in prep	Nānākuli Ahupua‘a TMK: (1) 8-9-01, 02, 05-07	Archaeological Monitoring Report; no historic properties observed, however monitoring is still in progress.

The first archaeological survey of Nānākuli Ahupua‘a was conducted in 1929 and 1930 by J. Gilbert McAllister as part of an island-wide survey of archaeological sites on O‘ahu. McAllister identified only one site in Nānākuli, the Ilihune Heiau. McAllister designated the Heiau as Site 147 and documented it as destroyed at the time of his survey. Ilihune Heiau was located at the mouth of Nānākuli Valley on the southeastern slope of Pu‘u Heleakalā, and its remnants were apparently used in the mid-1890s as a cattle pen (Sterling and Summers 1978). Site 147 would have been located northeast of the current project area (see Figure 21).

The next survey conducted in Nānākuli was performed by Handy in the 1930s. Through his systematic documentation of cultivated plants introduced to the islands before western contact, Handy also documented archaeological sites, including the remnants of Hawaiian habitation at the head of Nānākuli Valley. Handy observed abandoned terraces, stone platforms, and paving stones, and also documented his conversation with a local cowboy regarding settlement patterns in the area as well as the problematic issue of water (Handy 1940:83).

Between Handy’s published work in 1940 and the 1970s, there is a paucity of archaeological research on O‘ahu in general, but particularly the Leeward side of the island. As environmental legislature was passed at the state and national levels, the need for more cultural study and documentation became apparent. By the late 1980s, law makers were systematically pressing developers to consider historic properties when conducting ground disturbing activities. Therefore archaeological data, usually in support of development activities, is more readily available after about 1990.

Between 1988 and 1991 Cordy conducted an archaeological survey of undeveloped lands belonging to the Department of Hawaiian Home Lands (DHHL) in Nānākuli (Cordy 1990, Pak and Cordy 1990, Cordy 1993, Cordy 1997). Based on these survey findings, it is thought that Nānākuli Valley was initially settled as early as A.D. 1300 (Pak and Cordy 1990: 4). As a relatively dry and inhospitable area, Nānākuli was probably settled last among areas in the Wai‘anae District, and early habitation likely occurred along the sandy coast, as abundant marine resources were readily available. Today, these coastal areas, including the sand beach, low dunes and sand flats, have been significantly altered, and are covered by Nānāikapono Elementary School, Nānākuli Beach Park, Farrington Highway, nearby houses, and other structures *mauka* of the highway (Cordy 1997: 12).

Cordy reported that nearly all of the flat land, between the west and east branches of Nānākuli Stream, is covered with the ruins of agricultural fields (Pak and Cordy 1990: 2 and Cordy 1997: 8). The extensive nature of these ruins indicates the entire upper valley floor, as well as the side valley, was landscaped to catch water run-off and create soil pockets. In addition to ruins of agricultural fields, this survey recorded remnants of other large enclosures, permanent and temporary habitation sites, field shelters, and work areas (Cordy 1997: 8). Cordy’s fieldwork also identified 26 permanent habitation sites in the upper portion of Nānākuli Valley (Cordy 1990,

Pak and Cordy 1990, Cordy 1993, Cordy 1997). Only two possible religious sites were identified and include one small shrine and a large structure interpreted as a possible *heiau* (Cordy 1997: 10). The sites identified in Nānākuli are thought to be excellent examples of sites of their type in the Wai‘anae District and may reflect broad patterns of settlement and development of dry-land agriculture systems (Pak and Cordy 1990: 6). Cordy also notes that, "…although no sites were studied in the lower valley and along the sand shoreline, it should not be concluded that no sites are present here because these parts of Nānākuli are urbanized. Sites are still likely to be present in [this] area…" (Cordy1997: 14).

Aki Sinoto Consulting (Sinoto and Pantaleo 1994) conducted a reconnaissance survey of six parcels in Nānākuli as possible sites for Nānākuli III Elementary School. No historic properties were documented, however extensive surface disturbance in the region was observed.

In 1995, Ogden Environmental and Energy Services, Inc. conducted archaeological subsurface testing and a literature review in support of MILCON P-313, Range Operations Center, Naval Undersea Warfare Engineering Station (NUWES) Facility. This project area is located just south of Nānākuli Stream, on the *makai* side of Farrington Highway. No historic properties were observed. The authors observed that the central lowlands, including currently developed areas, were highly eroded and generally lack evidence of archaeological sites (Ogden Environmental and Energy Services, Inc. 1995: 9). If surface structures related to pre-contact agricultural pursuits did exist in the lower valley portions of Nānākuli Ahupua‘a, historic cattle ranching and development activities most likely eradicated them.

In 1998, Scientific Consulting Services, Inc. (Dega 1998) conducted field reconnaissance and archival research in support of the Ulehawa Beach Park Environmental Assessment. WWII era structures were observed as well as a cultural layer eroding out of a sand dune on the east side of the beach park near the OR&L railroad tracks. Dega observed these remnants near the Ulehawa Beach Park entrance just north of the current project area.

In 1999, Hammatt, McDermott, and Chiogioji (Hammatt et al. 1999) conducted a field assessment of a 15-acre parcel of land formerly part of the Camp Andrews military installation. Structural remnants associated with Camp Andrews infrastructure were observed. Filled in limestone sinkholes were also observed during pedestrian inspection and were thought to have been continuously filled in by Native Hawaiians and later by ranchers hoping to protect cattle from injury. The military likely continued to fill the sinkholes during their use of the parcel. Subsurface testing did not encounter any historic properties.

Cultural Surveys Hawai‘i (McDermott and Hammatt 1999) conducted an inventory survey of the proposed Wai‘anae 242 Reservoir and Access Road project area, on the northeast ridge of Pu‘u Mā‘ili‘ili. A total of two possible field shelters and a cave were investigated, but little evidence was observed to indicate these were traditional Hawaiian sites.

In 1999, McDermott and Hammatt (2000) conducted an inventory survey on a 57.65-acre parcel of Ulehawa Beach Park. A total of four historic properties were documented including SIHP # 50-80-12-9714, the tracks of the OR&L railroad; SIHP # 50-80-07-5761, three concrete WWII bunkers and two concrete foundations; and SIHP # 50-80-07-5762 and –5763 two discrete subsurface cultural layers. The subsurface cultural layers were encountered during test excavations which covered approximately 2% of the project area. The deposits consisted of midden (marine shell, fish bone, etc.) and both indigenous (fish hooks, volcanic and basalt

flakes) and historic (glass, metal, and concrete fragments) artifacts. Of particular interest was a nearly complete, barbless pearl shell fishhook with an unusually deep v-bend reminiscent of Marquesan or Tahitian hooks. This type of fishhook is considered atypical for Hawaiian fishhooks. Both cultural layers appeared to date to late pre-contact or very early post-contact times. The scant midden and artifact assemblages recovered indicate there is little evidence of permanent or recurrent habitation along the coastal area and further enforces the consensus that traditional Hawaiian settlement was concentrated inland. SIHP #s -5761 and -5762 are in close proximity to the northern end of the current project area, and SIHP # -9714, the OR&L Railroad, is present through the length of the current project area on the *makai* side of Farrington Highway (see Figure 21).

In 2001, CSH conducted an archaeological inventory survey at Nānākuli IV Elementary School, within former Camp Andrews lands just inland from Nānāikapono School (McDermott et al. 2001). Paleontological and cultural deposits were documented, as well as human remains within sinkholes of the raised reef limestone. The remains of Camp Andrews were designated SIHP # 50-80-07-5946, and the burial and paleontological deposits were designated SIHP # 50-80-07-5947.

As part of mitigation commitments related to construction of Nānākuli IV Elementary School, CSH conducted further data recovery investigation of SIHP # 50-80-07-5947, the sinkholes and associated cultural deposits (Hazlett et al 2008). As a result of this investigation, additional human remains were documented as well as analysis of faunal, soil, pollen and charcoal samples.

Archaeological monitoring was conducted at the Nānākuli IV Elementary School parcel in 2002 in support of ground disturbing activities related to construction of the school (Yorck and Hammatt 2003). No additional historic properties were observed, other than those that were documented during the inventory survey.

More recent studies at Ka Waihona O Ka Na‘auau Public Charter School (Cordy and Hammatt 2005), the Community Learning Center of Nānākuli (Yucha and Hammatt 2008), the Nānākuli Beach Park parking lot (Le Seur and Cleghorn 2005), and Nānākuli Beach Park Recreation Center Project (Stein and Hammatt 2006) reported minimal finds.

In 2005 Garcia and Associates (Ostroff and Desilets 2005) monitored installation of a water line along Farrington Highway between Hakimo Road and Haleakalā Avenue. As a result, five charcoal enriched sand deposits were identified. No artifacts were observed in association with any of the deposits. This project area overlaps the current project area between Haleakalā Avenue and Helelua Street; one of the charcoal deposits identified, BWS-4, is also present between these streets. BWS-4 was described as, “a layer of charcoal-enriched beach sand…located underneath both the Waianae-bound and Honolulu-bound lanes of Farrington Highway” (Ostroff and Desilets 2005: 32). No cultural material was observed in association with this layer, however radiometric dating indicates a 2-sigma calibrated date range of A.D. 1150-1410, while AMS dating indicates a 2-sigma date range of A.D. 1270-1410 (Ostroff and Desilets 2005: 32).

O’Leary and Hammatt (2006) conducted an archaeological inventory survey on the southwestern slopes of Pu‘u Heleakalā and identified a pre-contact rockshelter (SIHP # 50-80-08-6699) and a WWII concrete bunker (SIHP # 50-80-08-6681). Though this project was

conducted in Lualualei Ahupua‘a it is in relatively close proximity to the northern end of the current project area.

Other recent street-related projects in Nānākuli Ahupua‘a for fiber optic installation (Jones and Hammatt 2005, Souza and Hammatt 2006) and water improvements (Whitehead and Cleghorn 2003) reported no historic properties.

In 2008, Cultural Surveys Hawai‘i began an archaeological monitoring program in support of water system improvements along Farrington Highway (Jones and Hammatt in prep.). The project area is present along Farrington Highway, between Hakimo Rd. on the northern end and extending south through Nānākuli Ahupua‘a and the current project area, to Ali‘i Nui Dr. in Honouliuli Ahupua‘a. On site monitoring began in June 2008, but was switched to on-call monitoring as the stratigraphy encountered during excavation activities was primarily imported fill material over coral shelf. To date, no historic properties have been observed.

2.4 Background Summary

Cordy has provided a synthesis of the settlement patterns and prehistory of the Wain‘anae District that place the settlement of Nānākuli into the wider context of the settlement of O‘ahu. The windward side of O‘ahu was found most appealing to early inhabitants because of well-watered agricultural lands, abundant marine resources and close proximity to forest resources. Foraging trips to the dryer areas of the island would have occurred, and were most likely associated with, recurrent temporary habitation used during resource procurement. The rich marine resources of the Wai‘anae District, particularly the fishing grounds off shore, would have been a strong draw for early O‘ahu inhabitants. As population in the windward areas increased, permanent settlements began to populate the well watered regions of the leeward side as well. Eventually, with further population expansion, permanent settlement spread to the less watered regions of the leeward side, which included much of the Wai‘anae District and all of the current project area (Cordy 1997, Cordy 1998: 1-6).

Based on available evidence, it appears that the pre-contact settlement pattern within Nānākuli Ahupua‘a had three basic zones: coastal, intermediate, and upland. The most fruitful were near the sea and in the upland mountains, where there was sufficient rainfall for agriculture and forest resources. The intervening lands between the sea and the mountains were dry scrubland. Although potentially useful for dry land agriculture in the wet winter months, there is little evidence to indicate Native Hawaiians intensively utilized this area. The settlement pattern prior to western contact for this appears to be dispersed residences concentrated at the sea and in the mountains. Prior research indicates one residence per family. It is suggested by an account provided by Pukui (cited in McGrath et al. 1973: 10), that there existed an informal exchange network whereby coastal dwellers traded marine resources for the agricultural and forest resources of inland dwellers, and vice versa.

Archaeological investigations of the upland portions (*mauka*) of Nānākuli Valley have located the remains of habitation, agricultural, and ceremonial structures (Sterling and Summers 1978; Pak and Cordy 1990; Cordy 1997). The extensive archaeological survey of the *mauka* portions of these valleys is offset by a relative paucity of archaeological investigation in their coastal portions, primarily due to existing development. However, based on information from long-time

residents of the area, traditional accounts and context, it is likely that the coastal areas of Nānākuli contain cultural deposits related to habitation, including human burials.

Available radiocarbon dates indicate that by A.D. 600-800, there was temporary coastal habitation on the Wai‘anae coast. This dated sample comes from the area fronting Pōka‘ī Bay, one of the only areas along the Wai‘anae Coast to have a perennial stream reach the coast, and undoubtedly one of the more attractive areas for early temporary and later, permanent settlement (Cordy 1998: 6). Radiocarbon dates from permanent inland habitation contexts within Nānākuli indicate that permanent settlement began by A.D. 1200-1400 (Cordy 1997: 9).

The earliest documented dates for coastal settlement in proximity to the current project area may come from the BWS-4 sample, which yielded a date range of A.D. 1150-1410 (Ostroff and Desilets 2005)—although it should be noted that this date comes from a charcoal enriched sand layer that did not appear to have associated cultural material (artifacts or midden); further documentation of this layer may determine if this charcoal enriched layer is indeed the result of human habitation. If this layer did result from human habitation, the date range is in keeping with Cordy’s inland permanent settlement of A.D. 1200-1400 for Nānākuli and lends some credence to the idea that small, temporary habitations associated with marine resource procurement were present along the coast line, while permanent settlement occurred in the upper valley closer to permanent water sources. The current project area is less watered than the area of Pōka‘ī Bay; however, the marine resources were likely equally abundant in both areas. The later date range of A.D. 1150-1410 seems logical as areas with better resources of permanent water, such as Pōka‘ī Bay would have been settled first, with less watered areas settled later in response to population growth.

Oral traditions emphasize impoverished conditions of early post-contact Nānākuli where it was said that no one had food or water to share and crops were always bad. By the mid-1800s, the traditional Native Hawaiian lifestyle in Nānākuli Valley was in decline. After the sandalwood trade ended circa 1829, large tracts of lands were leased out to foreigners and the Native Hawaiian population of Nānākuli further deteriorated from encroachment and western disease. The local population also shifted from a rural lifestyle to more urban areas during this time period. The introduction of sugar plantations, cattle ranching, and the construction of the OR&L railroad, which was linked to Wai‘anae in 1895, brought more foreigners. Based on the scarcity of LCAs claimed within Nānākuli Ahupua‘a and early population figures, it appears the Native Hawaiian population was quite low in the latter half of the 19th century.

Population numbers slowly increased when homesteading was instituted in the early 1900s. Military use of the land began in 1917 and WWII greatly affected the landscape of the Wai‘anae coast by placing bunkers, gun emplacements and barbed wire along the coast line. Evidence of this infrastructure has been documented in the vicinity of the current project area in Ulehawa Beach Park, the Nānākuli IV Elementary School Parcel, and on the lower slopes of Pu‘u Heleakalā. Population growth after WWII saw increased development of Nānākuli, including homesteading through the Division of Hawaiian Homesteads (DHHL). Subsequent infrastructure improvements, including utilities and an improved transportation corridor, have brought further population growth to the area in recent years.

Section 3 Results of Fieldwork and Background Research

3.1 Field Inspection

One archaeologist, Kendy Altizer, B.A. completed the field inspection on May 20, 2009, which required one person-day. All fieldwork was conducted under CSH's annual archaeological permit No. 09-20 issued by SHPD per HAR Chapter 13-282, and also under the general supervision of Hallett H. Hammatt, Ph.D. (principal investigator). The field inspection served to confirm that the project area is in an urban built environment and will impact a portion of the OR&L Railroad, SIHP # 50-80-12-9714, as well as a portion of Farrington Highway.

3.1.1 OR&L Railroad (SIHP # 50-80-12-9714)

As discussed in the Historic Background Section, above, Dillingham began construction of the OR&L in 1889. The section of the OR&L adjacent to the current Farrington Highway project area is listed on the National Register of Historic Places, under significance Criteria A (associated with events that have made a significant contribution to the broad patterns of our history), B (associated with the lives of persons significant in our past, and C (embody distinctive characteristics of a type, period, or method of construction). The tracks are in place today and portions of the railway, further south of the current project area, at least until recently, were still used by the Hawaiian Railway Society train tours. According to the National Register of Historic Places nomination form on record at the SHPD/DLNR, the OR&L right-of-way currently listed on the National Register consists of 25.5 miles of raised roadbed 40 feet wide running from Hālawa Stream at Pearl Harbor on the easternmost end, to the intersection of Farrington Highway and Auyong Homestead Road in Nānākuli at the northwestern-most point. The railroad is a narrow gauge (36 inches inside dimension).

The railroad tracks at the intersection of Farrington Highway and Haleakalā Avenue appear to be in overall good condition (

Figure 22). Grass has overgrown the tracks in some areas; however railroad ties and base course are still visible in most areas. This section of the track is separated from the highway by a low lava rock berm, one course high (Figure 23). The distance between the berm and the *makai* edge of Farrington Highway is approximately 6 ft., and the tracks are approximately 12 ft. from the *makai* edge of the road. The berm elevates the tracks approximately 2 ft. above the road surface in this area (Figure 24).

The railroad tracks at the intersection of Farrington Highway and Nānākuli Avenue appear to be in similar condition, on the southern side of the intersection, as that observed at the intersection Farrington Highway and Haleakalā Avenue (Figure 25). The berm is approximately 10 ft. from the *makai* edge of the road, and the tracks are approximately 14 ft. from the *makai* edge of the road. The tracks on the northern side of Nānākuli Avenue are at a similar elevation to the road surface, there is no visible berm in this area, and the grass is cleared in this section of track. The ties and base course are more visible in this section of track, though sand is partially covering them. A bus stop is present on this side of Nānākuli Avenue, between Farrington Highway and the railroad tracks.

3.1.2 Farrington Highway

Farrington Highway, which extends through the length of the project area, is oriented roughly northwest by southeast, and continues outside the project area along the Wai‘anae Coast. The portion of Farrington Highway within the project area measures approximately 4,347 ft. long (NW-SE) by 33 ft. wide, including shoulders (NE-SW). Construction of this portion of road included grading with subsequent asphalt paving. The road surface is painted with two solid white lines marking the road boundaries, while double solid yellow lines divide the road into two lanes of opposing traffic. The road is asphalt paved and the shoulders are gravel and sand base course. There is a small bus stop shelter on the *makai* side of the road, northeast of the Nānākuli Beach Park parking lot. Overhead utility lines are present and strung between creosote-treated wooden utility poles. Based on background research, Farrington Highway is an important subsurface utilities corridor, with water, sewer, and fiber optic lines within the highway's right-of-way.

Originally constructed in the early 20th Century, portions of Farrington Highway within the project area have been greatly modified in the last 30 or 40 years with the addition of traffic lanes and roadway appurtenances. A World War II photograph of Farrington Highway shows its original construction as a two-lane asphalt road (Figure 19), whereas recent photos of the current project area illustrate that the highway has been upgraded to include four traffic lanes, accompanying appurtenances, and a bus stop (Figure 9, Figure 10, and Figure 25). These upgrades to Farrington Highway have altered its integrity, as it pertains to the National and State Registers of Historic Places criteria. Because it has been so extensively modified from its original construction, this portion of Farrington Highway no longer displays integrity of design, setting, materials, workmanship, feeling, or association. Therefore, it no longer has the integrity to convey its significance as a portion of the Territorial Highway System. Though a portion of Farrington Highway, located further north along the Waianae coastline in Mākaha, has been determined eligible to the National and State Register under Criterion D for its information content (SIHP # 50-80-07-6824-McDermott and Tulchin 2006), the portion of Farrington Highway in the current project area would likely not be eligible under any criteria because it no longer retains integrity.

3.1.3 Potential Subsurface Archaeological Deposits

A previously recorded portion of what has been interpreted as a subsurface cultural layer containing evidence of pre-contact Native Hawaiian habitation was documented at the northern end of the project area between Haleakalā Avenue and Helelua Street (Ostroff and Desilets 2005). The cultural layer was described as, "a layer of charcoal-enriched beach sand…located underneath both the Waianae-bound and Honolulu-bound lanes of Farrington Highway" (Ostroff and Desilets 2005: 32). No cultural material was observed in association with this layer, however radiometric dating indicates a 2-sigma calibrated date range of A.D. 1150-1410, while AMS dating indicates a 2-sigma date range of A.D. 1270-1410 (Ostroff and Desilets 2005: 32). It does not appear that this deposit was assigned a SIHP number, or evaluated for National or Hawai‘i Register eligibility; however, this subsurface layer, if it is indeed the result of human habitation, is likely significant under Criterion D for the archaeological information it contains.

Other previously documented subsurface cultural layers are also present in the area. These include SIHP #s 50-80-08-5762 and -5763 in Ulehawa Beach Park, and SIHP # 50-80-07-5947

in the Nānākuli IV Elementary School parcel. These sites all contain evidence of pre-contact Native Hawaiian habitation. SIHP #s 50-80-08-5762 and -5763 are significant under Criterion D and SIHP # 50-80-07-5947 is significant under Criteria D and E (Hawaii Register only).

WWII era infrastructure has also been documented as SIHP # 50-80-07-5761, significant under Criteria A and D, in Ulehawa Beach Park and SIHP # 50-80-07-5946, significant under Criterion D, in the Nānākuli IV Elementary School parcel. Based on this evidence, it is possible that subsurface cultural material related to military use of the area could be encountered during ground disturbing activities related to project construction.

It is also important to note that, while there is evidence to indicate subsurface cultural deposits may be found in the project area, other projects have occurred within the current project area footprint, as well as in its vicinity, which have reported no significant finds (see Table 1, Figure 20) (Whitehead and Cleghorn 2003, Jones and Hammatt 2005, Cordy and Hammatt 2005, Souza and Hammatt 2006, Stein and Hammatt 2006; Yucha and Hammatt 2008).

Figure 22. Portion of the OR&L railway and Farrington Highway that will be impacted by the current project, view north

Figure 23. Portion of the OR&L railroad showing basalt siding, view north

Figure 24. Portion of the OR&L railroad showing rail and ties still in place, view west

Figure 25. Farrington Highway at its intersection with Haleakalā Avenue, view northeast

Section 4 Summary and Recommendations

4.1 Summary

The following discussion and recommendations are intended to facilitate project planning and support the project's required historic preservation review process, consultation, and compliance. This discussion is based on the results of this investigation, the preliminary results of the project's companion CIA investigation (Lincoln and Hammatt 2009), and CSH's communication with agents for the project proponents regarding the project's potential impacts to the cultural resources described in the Results of Fieldwork (Section 3).

The project is located along 4,347 linear feet of Farrington Highway on the leeward side of O‘ahu Island in Nānākuli Town between Helelua Street and Nānākuli Stream, Nānākuli and Lualualei Ahupua‘a, Wai‘anae District, O‘ahu Island. The project involves widening the portion of Farrington Highway from Helelua Street to the northwestern bank of Nānākuli Stream in order to accommodate an auxiliary lane. The auxiliary lane would facilitate left turns at Nānākuli Avenue and Haleakalā Avenue, as well as improve overall intersection performance and safety. Other proposed improvements include utility relocations, a shared use path along the *makai* side of the highway, highway lighting, and drainage. Widening would occur on the *makai* portion of the highway, however, some sidewalk and drainage improvements would also occur on the *mauka* portion of the project area.

Ground disturbance is estimated for approximately 25% of the project area. Ground disturbance would include excavation, scraping, grading, and leveling to allow for re-paving and construction of the widened facilities. A shared use bike path is proposed for construction on the *makai* side of the roadway. Bus stops would be relocated. Some leveling and build-up for the curbs and sidewalk would occur on the *mauka* side. A portion of State Inventory of Historic Properties (SIHP) # 50-80-12-9714, the O'ahu Rail and Land Company (OR&L) Railroad tracks, would be relocated.

Because of FHWA funding, this project is a federal undertaking requiring compliance with Section 106 of the National Historic Preservation Act (NHPA), the National Environmental Policy Act (NEPA), and the federal Department of Transportation Act (DTA). As an HDOT project within state right-of-way, the project is also subject to Hawai‘i State environmental and historic preservation review legislation, Hawai‘i Revised Statutes [HRS] Chapter 343 and HRS 6E-8/Hawai‘i Administrative Rules [HAR] Chapter 13-13-275, respectively.

This investigation is not an archaeological inventory survey, per the requirements of HAR Chapter 13-276; however, through detailed historical, cultural, and archaeological background research, and a field inspection of the project area, this investigation identifies cultural resources that may be affected by the project. The document is intended to facilitate the project's planning and support the project's historic preservation compliance. Based on results, cultural resource management recommendations are presented. A companion cultural impact assessment (CIA) study (Lincoln and Hammatt 2009), prepared to support the project's Hawai‘i state environmental review, per the guidelines of the Hawai‘i State Department of Health's Office of Environmental Quality Control "*Guidelines for Assessing Cultural Impacts*", further evaluates

the project’s potential impacts to cultural resources. Both documents will support the project’s historic preservation consultation effort.

Fieldwork was conducted on May 20, 2009 by CSH archaeologist Kendy Altizer, B.A. Fieldwork required one person-day to complete and was conducted under the general supervision of Hallett H. Hammatt, Ph.D. (principle investigator).

This investigation identified three cultural resources/historic properties that will or may be affected by the proposed project: The section of the OR&L Railroad (SIHP # 50-80-12-9714) adjacent to the current Farrington Highway project area is listed on the National Register of Historic Places, under significance Criteria A, B and C.

Farrington Highway was constructed in the 1930s as part of the Territorial Highway System. A Portion of Farrington Highway, further north along the Wai‘anae Coastline, has been previously documented as SIHP# 50-80-7-6824 (McDermott and Tulchin 2006).

A previously recorded portion of what has been interpreted as a subsurface cultural layer containing evidence of pre-contact Native Hawaiian habitation was documented at the northern end of the project area between Haleakalā Avenue and Helelua Street(BWS-4 –Ostroff and Desilets 2005). It does not appear that this deposit was assigned a SIHP number, or evaluated for National or Hawai‘i Register eligibility; however, this cultural layer, if it is indeed the result of human habitation, is likely significant under Criterion D.

In addition, based on background research and prior archaeological investigations in the project area’s vicinity, there is the potential for encountering additional pre-contact and post-contact subsurface cultural deposits related to traditional Native Hawaiian land use and habitation, historic military use of the area, and/or human remains.

4.2 Recommendations

Originally constructed in the early 20th Century, portions of Farrington Highway within the project area have been greatly modified in the last 30 or 40 years with the addition of traffic lanes and roadway appurtenances. Additionally, the setting of this portion of Farrington Highway has been altered since the highway was constructed. Accordingly, this portion of Farrington Highway does not contain integrity of design, setting, materials, workmanship, feeling, or association. It would most likely not be considered eligible to either the National or Hawai‘i Register of Historic Places because it lacks the integrity to convey its significance under any of the significance criteria.

Current construction plans indicate the portion of the OR&L (SIHP # 50-80-12-9714) within the current project area would be relocated by construction activities. This proposed relocation will likely represent a “use” of a significant historic site (the OR&L) under Section 4(f) of the DTA. Accordingly, a Section 4(f) Evaluation will most likely need to be prepared as part of the project’s NEPA documentation. Current construction plans indicate the portion of the OR&L (SIHP # 50-80-12-9714) located in the current project area would be relocated by construction activities. Under federal historic preservation legislation, a project specific effect determination of “adverse effect” may be warranted for the proposed road widening project; however in consultation with SHPD, it was determined that the track relocation would remain within the historic OR&L right-of-way and would not affect its historic value (Appendix A). Therefore, the

proposed project would have No Adverse Effect on the portion of the OR&L (SIHP # 50-80-12-9714) located in the current project area.

Because there are multiple different projects being conducted in the area that have a possibility of impacting the OR&L, a multi-project Programmatic Agreement (PA) for the OR&L railroad treatment is under development among SHPD, FHWA, HDOT, (understood as the land owner of the right-of-way), and the Hawaiian Railway Society. Before construction begins for the Farrington Highway intersection improvements at Nānākuli Avenue and Haleakalā Avenue, the appropriate agreement should be in place and should detail the exact nature of impact to the OR&L, and the appropriate treatment of this National Register-listed historic property. The agreement would stipulate the obligations of each party and time frames for any work to be undertaken.

In addition, the proposed project may impact a portion of a previously recorded subsurface cultural layer containing evidence of pre-contact Native Hawaiian habitation present at the northern end of the project area between Haleakalā Avenue and Helelua Street. There is also a possibility of encountering previously unidentified subsurface cultural deposits related to traditional Native Hawaiian land use and habitation, historic military use of the area, and/or human remains.

Under Hawai‘i State historic preservation review legislation (HAR Chapter 13-275), a project effect recommendation of “effect, with proposed mitigation commitments” is likely warranted. Proposed mitigation commitments may include an archaeological inventory survey and/or an archaeological monitoring program. Accordingly, it is recommended that project proponents consult with SHPD regarding the need for an archaeological inventory survey with a subsurface testing component and/or an archaeological monitoring program during construction. An inventory survey could further document and more formally evaluate the National and Hawai‘i Register eligibility of this portion of Farrington Highway as well as document the extent of the potential cultural layer present in the northern end of the project area. However, an inventory survey in this portion of Farrington Highway would disrupt traffic flow in an already heavily congested area. In addition, safety of local residents, pedestrians, motorists, and the field crew is a concern. For these safety reasons there is a precedent for roadwork, including utility installation, along this stretch of Farrington Highway to be conducted under archaeological monitoring programs without prior archaeological inventory survey investigations (Ostroff and Desilets 2005, Jones and Hammatt 2005, Souza and Hammatt 2006, Yucha and Hammatt 2008, Jones and Hammatt in prep.). Therefore, a comprehensive archaeological monitoring program may be a safer, more viable cultural resource management alternative. This program would help mitigate the potential disturbance of human remains, and/or document the extent of significant archaeological deposits that may be present in the area, but would not disrupt traffic unduly or pose a potential safety risk. Consultation with SHPD will resolve the appropriateness of the archaeological monitoring program as a mitigation measure.

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Appendix A Scoping and Coordination Meeting Minutes

Farrington Highway Intersection Improvements
at Nanakuli Avenue and Haleakala Avenue
State Historic Preservation Division (SHPD) Scoping and Coordination Meeting Minutes
Proj. No.: 93A-01-05

Date, Time, & Place:

Friday, June 18th, 2009. 10:00am – SHPD Conference Room, 601 Kamokila Blvd., 5th Floor, Kapolei

Attendance:

Pua Aiu (DLNR-SHPD)

Nancy McMahon (DLNR-SHPD)

Ross Stephenson (DLNR-SHPD)

Henry Kennedy (HWY-DS)

Gerald Andrade (PB)

Rachel Adams (PB)

MEETING PURPOSE: Follow-up in gathering additional archaeological scoping input from Nancy and to continue coordination with DLNR-SHPD for the Programmatic Agreement and the project’s proposed OR&L track relocation.

SUMMARY OF MEETING

- Introductions.
- PB provided a project recap and update:
  - At the initial scoping meeting in March, it was agreed that a Programmatic Agreement (PA) was appropriate due to multiple projects in the corridor affecting the same historic resource.
  - HDOT verified that Leeward Bike Plan and Farrington Highway Intersection Improvements Project are the only two HDOT projects programmed for this corridor for the next 10 years.
  - HDOT met with the Dept. of Hawaiian Home Lands (DHHL) and

verified that widening on the mauka side of roadway is not feasible due to narrow setbacks for DHHL homes.

- HDOT met with the Hawaiian Railway Society (HRS), upon meeting with HRS, there are a few issues that need to be coordinated with DLNR-SHPD.

- The group discussed the outcome and issues raised as a result of HDOT’s meeting with HRS:
  - Track Relocation
    - HRS indicated support for relocation as long as the OR&L is able to remain on the National Register.
    - Nancy indicated that moving the tracks could affect the OR&L’s historic value. Upon reviewing the cross-sections of the conceptual design, Nancy verified that the proposed track re-locations of ~10ft makai from centerline to centerline would still be within the historic corridor and therefore would not affect its historic value.
  - Corridor Limits for the PA
    - Corridor limits for the PA will cover the limits of the Farrington Highway Improvements Project and the Leeward Bike Plan - - from Nanakuli Stream to Lualualei Road. DLNR-SHPD concurred.
  - HDOT and PB explained HRS support for phased approach to track relocation.
    - PB indicated that the approach was suggested by HRS so that the costs of OR&L relocation would not prohibit the project from moving forward.
    - PB mentioned that the existing tracks would be removed and the corridor would be maintained. Once HRS is ready to expand, then the operable/relocated tracks could be constructed by HRS. The interim condition would have interpretive signs, educating the community and visitors about the history of the corridor.

- Ross will check with Washington D.C. to verify that the corridor could be maintained as a de facto site, without tracks laid during the interim, until HRS is ready to expand operations to this area.
- DLNR-SHPD advised that interpretive signs must be developed in accordance with the recognized standards, and the plaques must be placed every so many feet along the corridor in accordance with those standards. Ultraviolet light (UVA) issues also need to be considered for signage.
- DLNR-SHPD indicated that the community must be involved in developing the sign content. Pua advised working with the DHHL Community Association.
- HDOT indicated that with this approach, HDOT could provide the theoretical amount of materials to HRS now to warehouse for future construction or track preservation at other locations. Materials put down for relocation within the Farrington corridor would likely be new rather than re-used from the existing due to deteriorated conditions.
- DLNR-SHPD considered what could be salvaged from the existing railroad and agreed that while the rails and ties may be too deteriorated, the spikes were rather indestructible and advised that they should be salvaged.

o Crossings and encased tracks

- PB indicated that for consistency with FHWA standards, railroad crossings may need to be added at 2-3 driveways where the tracks cross the beach access points, etc., depending on FHWA guidelines. Rails and ties in these locations would be encased. [Note: Further coordination with HRS indicates that for railroad crossings of this size, only a railroad crossing sign will be required.]
- DLNR-SHPD did not see a problem with encased tracks, and suggested that this be done at the time of the roadway

widening since those driveways would need to be reconstructed anyway. HRS could then link with those existing rails when they are ready. HDOT agreed.

- DLNR-SHPD expressed concern that track relocation in front of the old Nanaikapono School could create future conflicts with operation of a de facto pull-out for the charter school.
- HDOT is still at the early stages of the environmental review process and will be coordinating these issues with DHHL, HRS, and the charter school.

- Other Potential Archaeological Impacts/Issues
  - Nancy indicated the concrete berms on which the tracks are on should be considered and included for data recovery during construction.
  - Consulted parties for the PA to include the Hawaiian Railway Society and the Historic Hawaii Foundation.

ACTION ITEMS

PB:

- Coordinate with HECO and sewer utilities to confirm relocation options.
- Coordinate with DHHL, HRS and other stakeholders on possible relocation of bus pull-out and other solutions.
- Initiate/invite Historic Hawaii Foundation to comment.

SHPD-DLNR:

- Verify with Washington D.C. that the corridor could be maintained as a de facto site in the interim.

Farrington Highway Intersection Improvements
at Nanakuli Avenue and Haleakala Avenue Project
DRAFT State Historic Preservation Coordination Meeting Minutes
Proj. No.: 93A-01-05

Wednesday, August 5th, 2009, 2:00 pm

601 Kamokila Blvd., 5th Floor

ATTENDANCE:

Pua Aiu (DLNR-SHPD)

Nancy McMahon (DLNR-SHPD)

Ross Stephenson (DLNR-SHPD)

Ed Sniffen (HWY-DS)

Henry Kennedy (HWY-DS)

Gerald Andrade (PB)

Rachel Adams (PB)

MEETING PURPOSE: To follow-up with SHPD based on continued coordination with the Hawaiian Railway Society for relocation of historic railroad and determine historic preservation requirements.

SUMMARY OF MEETING

- Discussion of previous assumptions – HDOT initially approached the conceptual design with the idea that the historic O,R&L tracks could be relocated to an operational condition. However, as HDOT delved into the design, there was the realization of constraints that would make this unattainable.
- Discussion of Project Constraints - Given the safety clearance and space requirements for the auxiliary lane, shared-use bike path, utilities, and gutters, the allowance for the railroad would be an 8ft corridor, which is not enough to create an operational condition.
- Discussion of Alternatives Considered
  - Widening on the Mauka side could not be considered due to the shallow setbacks for the homes. Pedestrian facility is needed on the makai side.
  - Shared-use path is in demand for this area and would provide continuity for the Leeward Bike Plan Project that extends to

Lualualei Rd. In addition, reducing to a widened sidewalk would not provide the necessary right of way for an operational alignment.

- HDOT indicated that this scenario was presented to the Hawaiian Railway Society (HRS), who was accepting of the 8-foot corridor. HDOT relayed that HRS understood that they would not be able to fully utilize this “nostalgic” railroad alignment, but thought they may be able to run their speed car through this area and were satisfied with this outcome given the circumstances. Both HDOT and HRS are committed to retaining the railroad’s standing on the National Register of Historic Places.
- DLNR-SHPD (Ross Stephenson) called HRS (Robert Yatchmenoff) to verify the agreement, who confirmed, given the constraints of the corridor.
- DLNR-SHPD expressed the following:
  - Why is shared use path a higher priority than the operational railroad?
  - Requested that HDOT look into locating shared-use path through Ka Waihona Charter School to provide clearance for potential railroad operations. HDOT agreed to look further into this alternative.
  - For maintaining on the historic register – as long as the railroad is relocated within the right-of-way then it’s fine.

<u>ACTION ITEMS</u>

HDOT & PB:

- HDOT & PB to consider locating shared-use path further makai within the City Parks and Ka Waihona Charter School property.