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Attorneys for Applicant
Mahi Solar, LLC

RECEIVED
21 JUN 16 P3:15
DEPT OF PLANNING AND PERMITTING
CITY & COUNTY OF HONOLULU

BEFORE THE PLANNING COMMISSION
OF THE CITY AND COUNTY OF HONOLULU

In the Matter of the Application of MAHI SOLAR, LLC.	FILE NO. 2020/SUP-7 (FK) APPLICANT'S FIRST LIST OF WITNESSES; FIRST LIST OF EXHIBITS; EXHIBITS "1" – "36"; CERTIFICATE OF SERVICE

APPLICANT'S FIRST LIST OF WITNESSES; FIRST LIST OF EXHIBITS

Applicant Mahi Solar, LLC, a Delaware limited liability company ("Applicant"), by and through its attorneys, McCorriston Miller Mukai MacKinnon LLP, hereby submits its First List of Witnesses; First List of Exhibits; Exhibits "1" – "36", in support of the State Special Use Permit that was accepted by the Department of Planning and Permitting for processing on or around April 9, 2021. These witnesses and exhibits may be used in support of Applicant's request for a State Special Use Permit. Applicant reserves all rights to identify additional fact witnesses and add rebuttal expert witnesses and exhibits.

LIST OF WITNESSES

NAME/TITLE/ORGANIZATION	SUBJECT MATTER	WRITTEN TESTIMONY
Wren Wescoatt	Project development	Yes; Exh. 12
Wren Wescoatt	Agricultural plan	Yes; Exh. 12
Wren Wescoatt	Community relations	Yes; Exh. 12
Tracy Camuso	Environmental and Land Use Planning	Yes; Exh. 14
Deron Lawrence	Biological resources	Yes; Exh. 20
Bob Rechtman, Ph.D.	Archaeological resources	Yes; Exh. 22
Lokelani Brandt	Cultural resources	Yes; Exh. 24
Josh Meyers	Project construction	Yes; Exh. 16
Paul Matsuda	Civil engineering	Yes; Exh. 18
Andy Stephens	Visualization Specialist III	Yes; Exh. 36
Kawika McKeague	Planning Principal	Yes; Exh. 35

LIST OF EXHIBITS

ATTACHMENTS TO SUP APPLICATION

EXHIBIT NUMBER	SUP APPLICATION ATTACHMENT	DESCRIPTION
1	A	Site Photos
2	B	Site Plan and Drawings, Prepared by Revamp Engineers and Walters, Kimura, Motoda, Inc., February 2021
3	C	Mahi Solar: Agricultural Plan, Prepared by Mahi Solar, LLC, March 2021
4	D	Mahi Solar Project Biological Resources Report and Mahi Solar Pueo Survey Addendum, Prepared by SWCA Environmental Consultants, October 2020 and November 2020
5	E	A Ka Pa`akai O Ka `Aina Analysis for the Longroad Energy Management, LLC Mahi Solar Facility, Prepared by ASM Affiliates, December 2020
6	F	An Archaeological Inventory Survey for the Mahi Solar Project Area, Prepared by ASM Affiliates, March 2021
7	G	View Study of Proposed Mahi Solar Farm, Kunia, O`ahu, Hawai`i, Prepared by G70, February 2021
8	H	Glare Analysis for the Mahi Longroad Energy Solar Project in O`ahu, Hawai`i, Prepared by Power Engineers, October 2020
9	I	Decommissioning Plan
10	J	Construction Traffic Assessment for the Proposed Mahi Solar Farm, Prepared by Fehr and Peers, November 2020

EXHIBIT NUMBER	DESCRIPTION
11	Resume of Wren Wescoatt
12	Written Direct Testimony of Wren Wescoatt
13	Resume of Tracy Camuso
14	Written Direct Testimony of Tracy Camuso
15	Resume of Josh Meyers
16	Written Direct Testimony of Josh Meyers
17	Resume of Paul Matsuda
18	Written Direct Testimony of Paul Matsuda
19	Resume of Deron Lawrence
20	Written Direct Testimony of Deron Lawrence
21	Resume of Bob Rechtman, Ph.D
22	Written Direct Testimony of Bob Rechtman, Ph.D.
23	Resume of Lokelani Brandt
24	Written Direct Testimony of Lokelani Brandt
25	Resume of Andy Stephens
26	Letter dated December 13, 2020, from ASM Affiliates to Longroad Energy Management, LLC re Archaeological Reconnaissance
27	Letter dated May 4, 2021, from Department of Transportation to Department of Planning and Permitting re SUP Application 2020/SUP-7
28	Letter dated May 10, 2021, from Historic Hawaii Foundation to Department of Planning and Permitting re SUP Application 2020/SUP-7
29	Makakilo/Kapolei/Honokai Hale Neighborhood Board No. 34 Meeting Agenda for May 26, 2021
30	Mililani/Waipio/Melemanu Neighborhood Board No. 25 Meeting Minutes for March 24, 2021
31	Waipahu Neighborhood Board No. 22 Meeting Agenda for May 27, 2021
32	Emails dated May 18, 2021, between G70 and Department of Planning and Permitting regarding response to Hawaii Historic Foundation Letter
33	Email dated May 17, 2021, from G70 to Department of Planning and Permitting regarding response to Department of Transportation Letter
34	Resume of Kawika McKeague
35	Written Direct Testimony of Kawika McKeague
36	Written Direct Testimony of Andy Stephens

DATED: Honolulu, Hawaiʻi, JUN 16 2021.

RANDALL F. SAKUMOTO
BRETT R. TOBIN

Attorneys for Applicant
MAHI SOLAR, LLC

BEFORE THE PLANNING COMMISSION
OF THE CITY AND COUNTY OF HONOLULU

In the Matter of the Application of MAHI SOLAR, LLC.	FILE NO. 2020/SUP-7 (FK) CERTIFICATE OF SERVICE

CERTIFICATE OF SERVICE

THE UNDERSIGNED HEREBY CERTIFIES that on this date, a true and correct copy of the aforementioned document was duly served upon the following by hand-delivery, addressed as set forth below:

PLANNING COMMISSION
Department of Planning and Permitting
City and County of Honolulu
650 South King Street, 7th Floor
Honolulu, Hawaiʻi 96813

DATED: Honolulu, Hawaiʻi, JUN 16 2021.

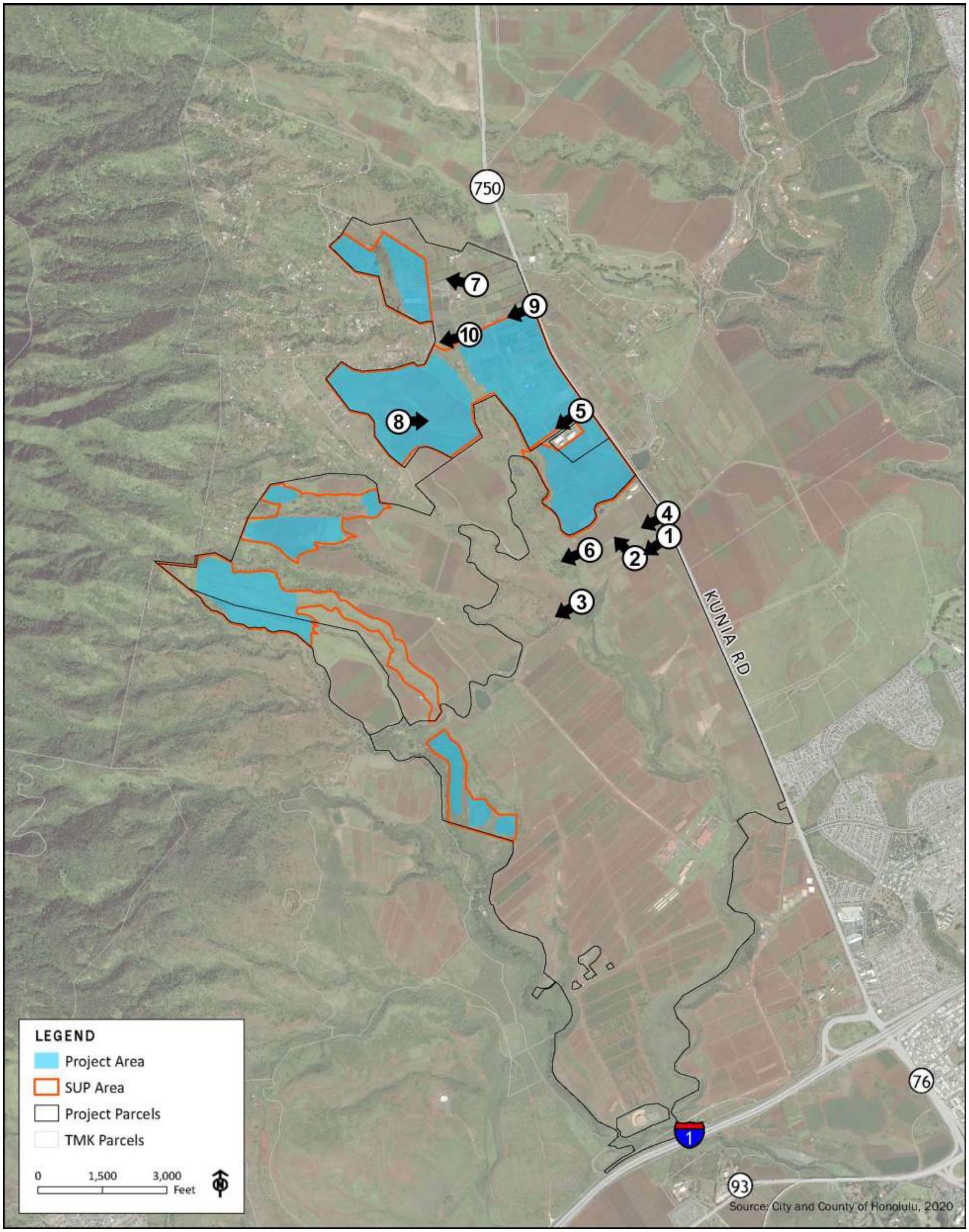
RANDALL F. SAKUMOTO
BRETT R. TOBIN

Attorneys for Applicant
MAHI SOLAR, LLC

412473.1

Appendix A

Site Photos



Site Photo Key Mahi Solar Project

1. Site Access #1 at Plantation Road Looking West (July 2020)

2. Site Access #1 at Plantation Road Looking North, Ag Structures in view (July 2020)

3. Plantation Road within Parcel 020 Looking West Towards Areas 1 & 2 (July 2020)

4. Kunia Road and Plantation Road, Looking West Towards Project Site (August 2020)

5. Site Access #2, Looking West (June 2019)

6. Existing Agricultural Area on TMK 9-2-004:010 looking West (July 2020)

7. Existing Ag on TMK 9-2-004:010, View from Future Area4C Looking West (July 2020)

8. Fallow Agricultural Land on TMK 9-2-004:010, View from Future Area4A Looking East (July 2020)

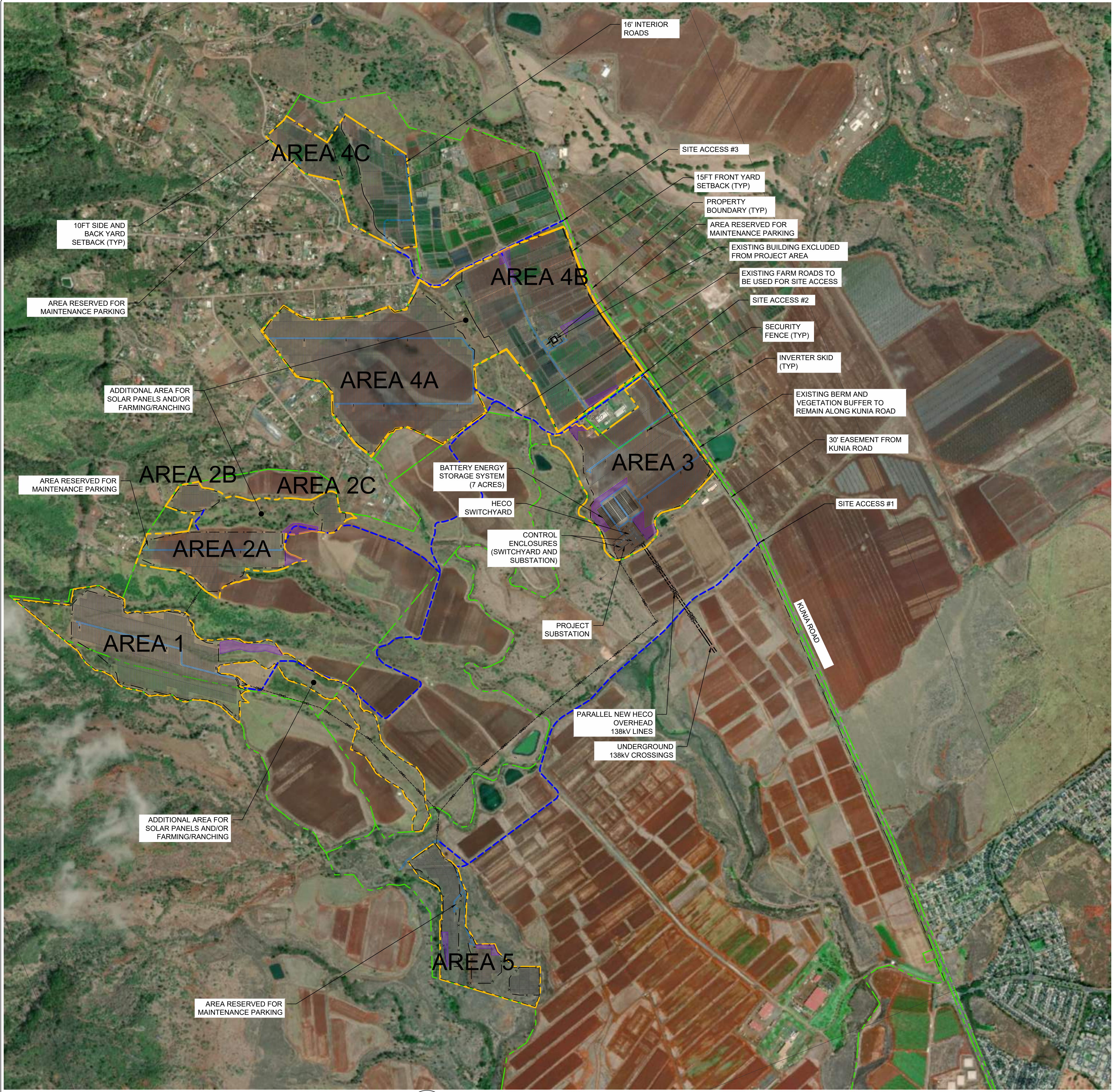
9. Site Access #3, Looking West (June 2019)

10. Pālāwai Road View Towards Kunia Loa Ridge Farm Lands Looking West (August 2020)

Appendix B

Site Plan and Drawings Prepared by Revamp Engineers and Walters, Kimura, Motoda, Inc. February 2021

CONTENTS



1 - OVERALL SITE LAYOUT

1" = 800'

0' 400 800 1600

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

LEGEND

- TMK/PROPERTY LINE
- PROJECT AREA
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- PROPOSED OVERHEAD ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS
- TEMPORARY CONSTRUCTION LAYDOWN

PRELIMINARY - NOT FOR CONSTRUCTION

MOSS SOLAR

REVAMP ENGINEERING, INC.
1110 Nuuanu Ave.
Honolulu, HI 96817
www.revamp-eng.com

ENGINEER'S STAMP

CLIENT

longroad ENERGY

PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE

1	01/21/2021 ALTERNATE LAYOUT
2	01/29/2021 PER CLIENT COMMENTS
3	02/09/2021 FOR SUP
4	02/16/2021 FOR SUP
5	02/18/2021 PER CLIENT COMMENTS

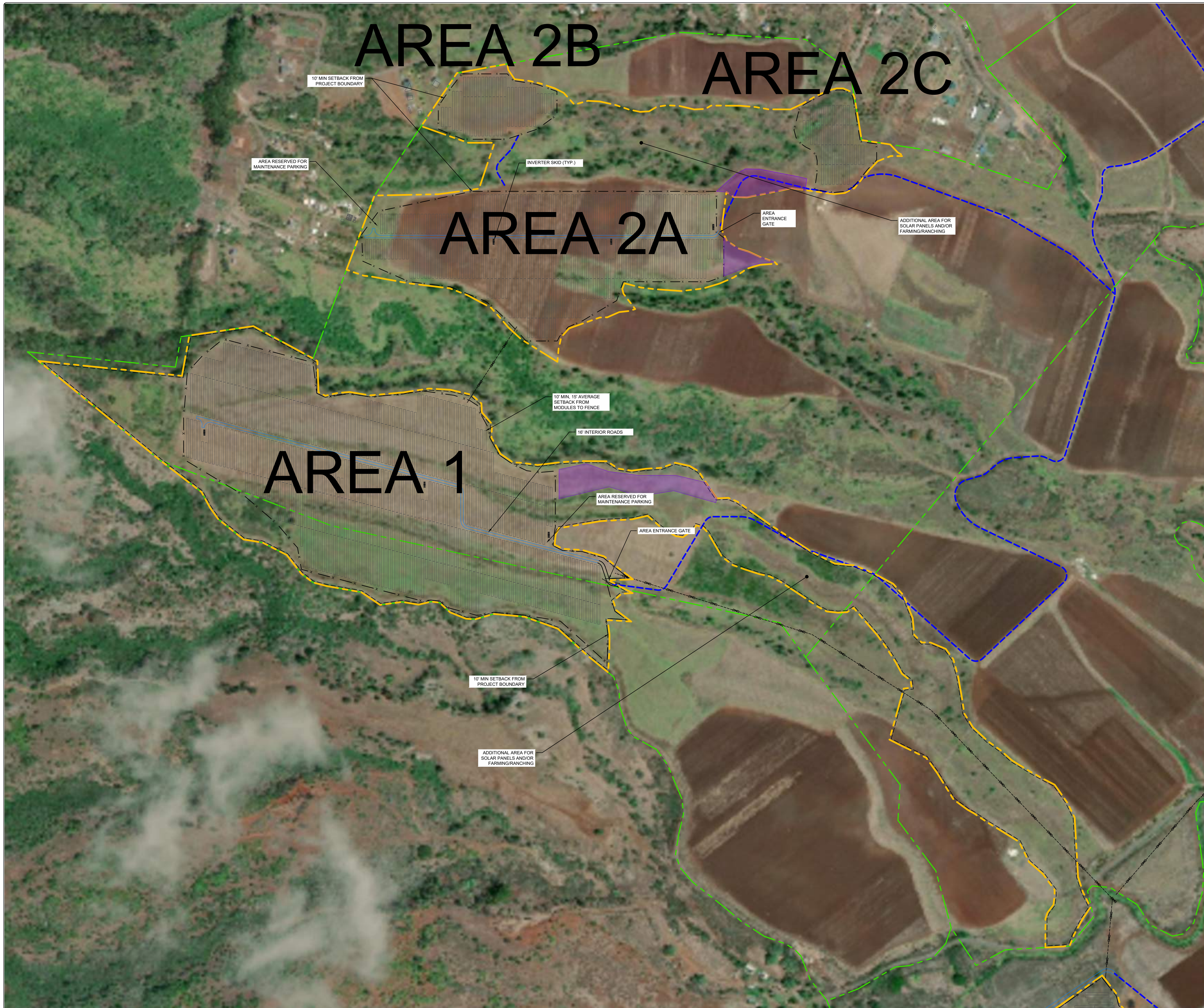
REVISION ISSUE

DRAWN BY: ET CHECKED BY: AAC

PROJECT NO.: 20105

DRAWING TITLE
OVERALL SITE LAYOUT

DRAWING NUMBER
FIGURE 1



1
-
AREAS 1 & 2
1" = 300'
0' 150 300 600

SHEET NOTES:

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LEGEND

- TMK/PROPERTY LINE
- PROJECT AREA
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- ROAD
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- PROPOSED OVERHEAD ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS
- TEMPORARY CONSTRUCTION LAYDOWN

PRELIMINARY - NOT FOR CONSTRUCTION

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3	02/09/2021	FOR SUP
4	02/16/2021	FOR SUP
5	02/18/2021	PER CLIENT COMMENTS

REVISION ISSUE

DRAWN BY: ET CHECKED BY: AAC

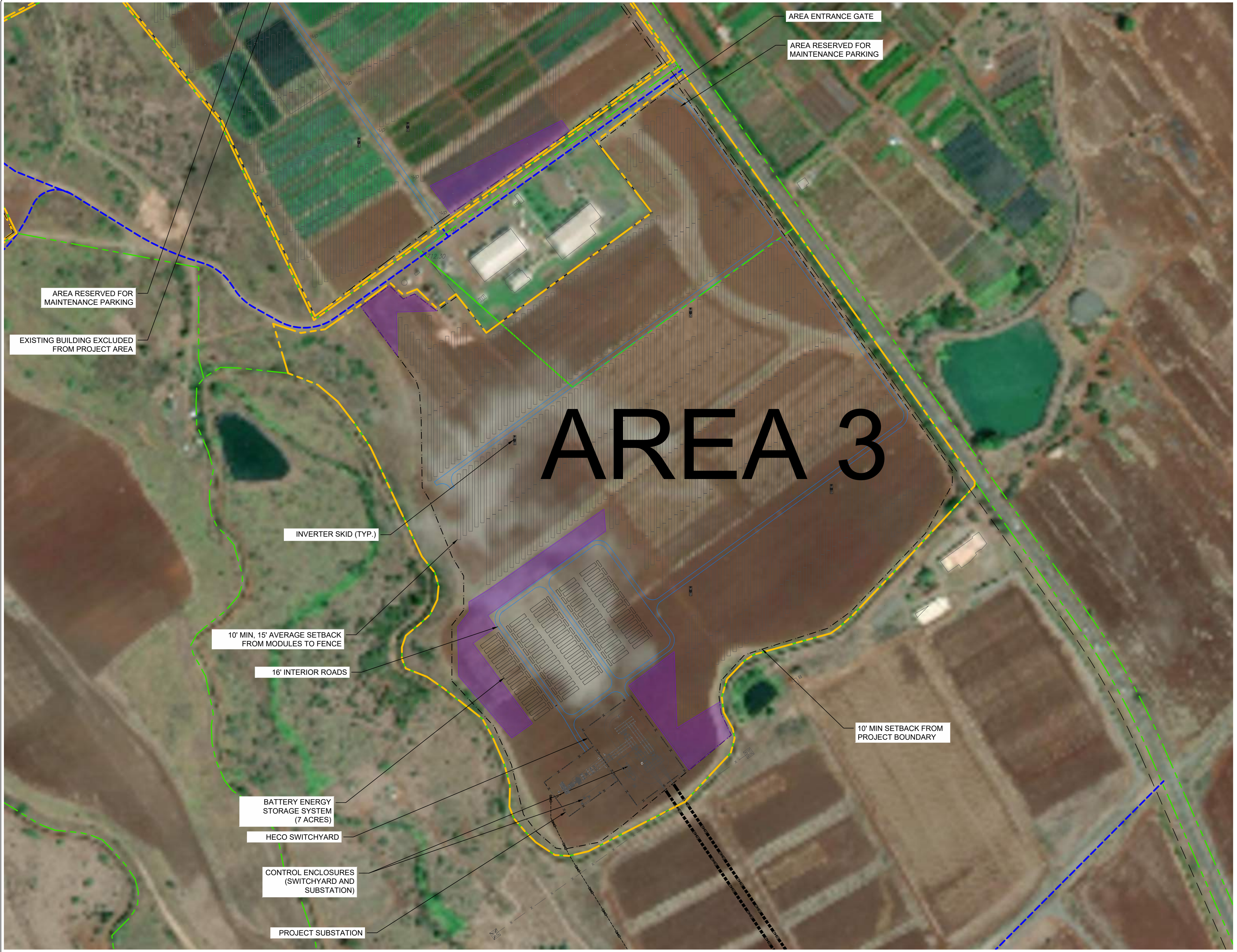
PROJECT NO.: 20105

DRAWING TITLE
AREAS 1 & 2
SITE PLAN
CLOSE-UP

DRAWING NUMBER
FIGURE 2

2/19/2021 3:55 PM

20105 - MOSS - MAHI - E200 - LAYOUTS - SUBSTATION RELOCATED.DWG



1 - AREA 3
1" = 200'
0' 100 200 400

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

LEGEND

— - —	TMK/PROPERTY LINE
— - —	PROJECT AREA
— · —	FENCE LINE
▭	ROAD
— OH —	EXISTING OVERHEAD ELECTRICAL
—(OHD)—	PROPOSED OVERHEAD ELECTRICAL
- - -	SETBACK
- - -	EXISTING ROAD FOR SITE ACCESS
▨	TEMPORARY CONSTRUCTION LAYDOWN

PRELIMINARY - NOT FOR CONSTRUCTION

N

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ENGINEER'S STAMP

CLIENT
longroad ENERGY

PROJECT NAME
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3	02/09/2021 FOR SUP
4	02/16/2021 FOR SUP
5	02/18/2021 PER CLIENT COMMENTS

REVISION ISSUE

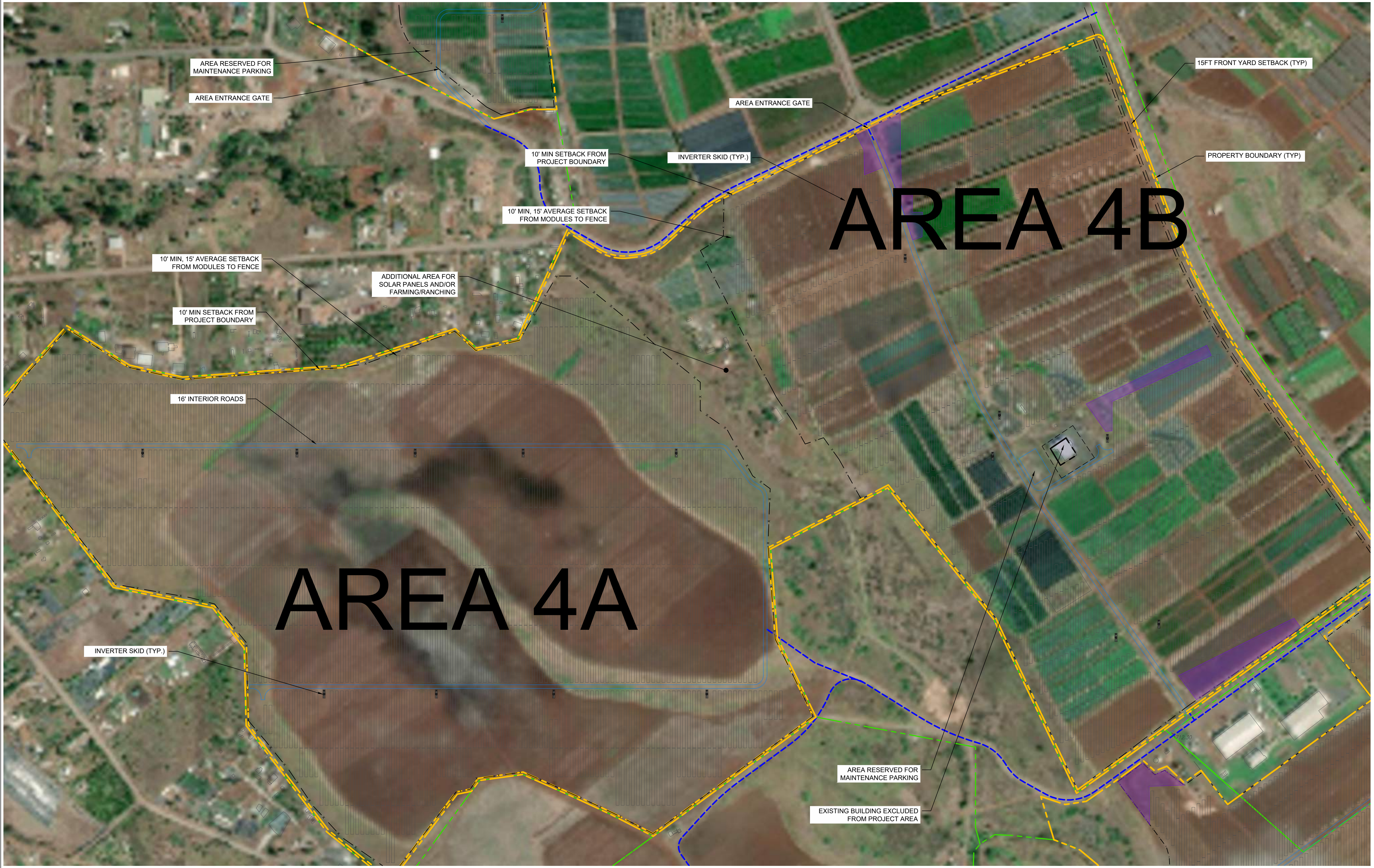
DRAWN BY: ET CHECKED BY: AAC
PROJECT NO.: 20105

DRAWING TITLE
AREA 3 & HV FACILITES SITE PLAN CLOSE-UP

DRAWING NUMBER
FIGURE 3

2/19/2021 3:57 PM

20105 - MOSS - MAHI - E200 - LAYOUTS - SUBSTATION RELOCATED.DWG



SHEET NOTES:

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2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

1 / - AREAS 4A & 4B

1" = 200'

0' 100 200 400

N

LEGEND

- TMK/PROPERTY LINE
- PROJECT AREA
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- PROPOSED OVERHEAD ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS
- TEMPORARY CONSTRUCTION LAYDOWN

PRELIMINARY - NOT FOR CONSTRUCTION

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2	01/29/2021	PER CLIENT COMMENTS
3	02/09/2021	FOR SUP
4	02/16/2021	FOR SUP
5	02/18/2021	PER CLIENT COMMENTS

REVISION ISSUE

DRAWN BY: ET CHECKED BY: AAC

PROJECT NO.: 20105

DRAWING TITLE

AREAS 4A & 4B SITE PLAN CLOSE-UP

DRAWING NUMBER

FIGURE 4

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

1 - AREA 4C

1" = 200'

0' 100 200 400

LEGEND

- TMK/PROPERTY LINE
- PROJECT AREA
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- PROPOSED OVERHEAD ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS
- TEMPORARY CONSTRUCTION LAYDOWN

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ENGINEER'S STAMP

CLIENT

longroad ENERGY

PROJECT NAME
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SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE

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2	01/29/2021	PER CLIENT COMMENTS
3	02/09/2021	FOR SUP
4	02/16/2021	FOR SUP
5	02/18/2021	PER CLIENT COMMENTS

REVISION ISSUE

DRAWN BY: ET CHECKED BY: AAC

PROJECT NO.: 20105

DRAWING TITLE
AREA 4C SITE PLAN CLOSE-UP

DRAWING NUMBER
FIGURE 5

1 - AREAS 5 AND HV FACILITIES

1" = 200'

0' 100 200 400

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

LEGEND

- TMK/PROPERTY LINE
- PROJECT AREA
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- PROPOSED OVERHEAD ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS
- TEMPORARY CONSTRUCTION LAYDOWN

PRELIMINARY - NOT FOR CONSTRUCTION

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PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE

1	01/21/2021	ALTERNATE LAYOUT
2	01/29/2021	PER CLIENT COMMENTS
3	02/09/2021	FOR SUP
4	02/16/2021	FOR SUP
5	02/18/2021	PER CLIENT COMMENTS

REVISION ISSUE

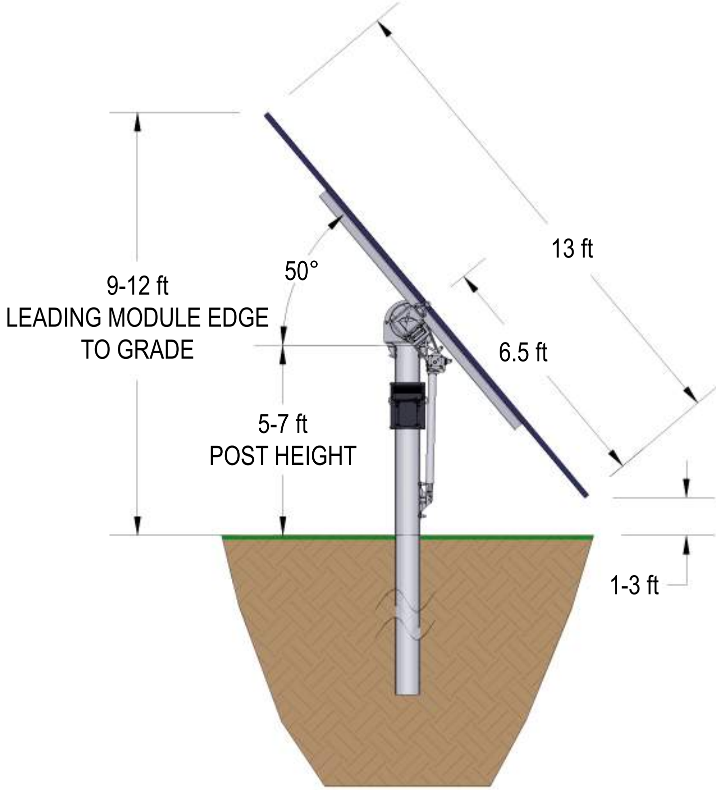
DRAWN BY: ET CHECKED BY: AAC

PROJECT NO.: 20105

DRAWING TITLE
AREA 5 SITE PLAN CLOSE-UP

DRAWING NUMBER
FIGURE 6

SOLAR PANEL
@ 50 DEG. TILT



SOLAR PANEL
@ 0 DEG. TILT

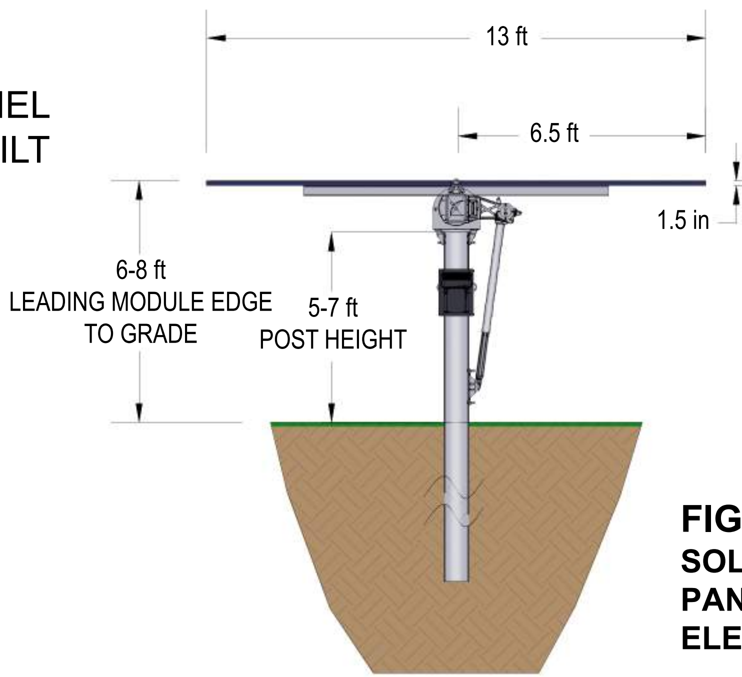
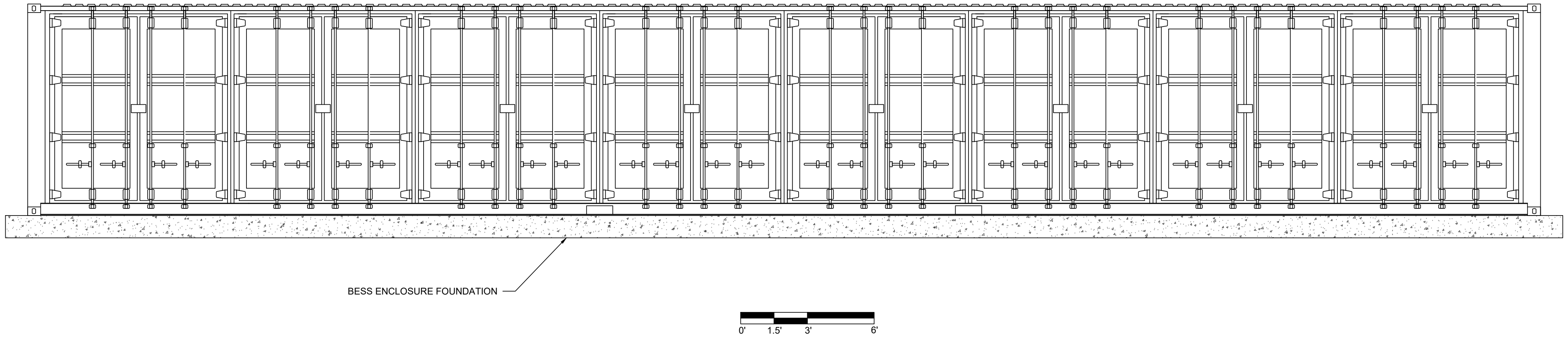
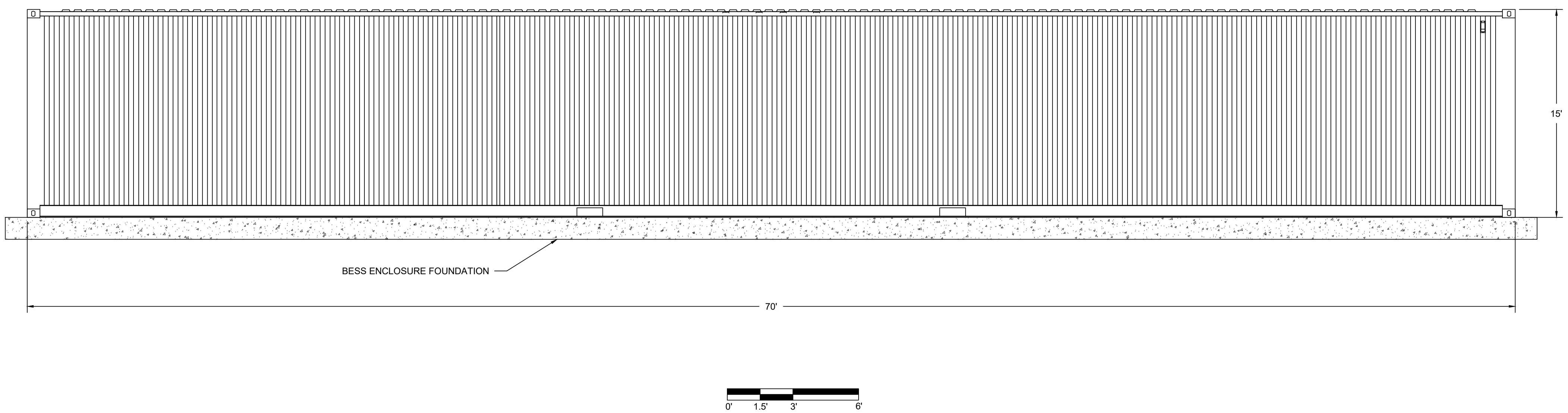


FIGURE 7
SOLAR PV PANEL ELEVATION





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ENGINEER'S STAMP

CLIENT

PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE

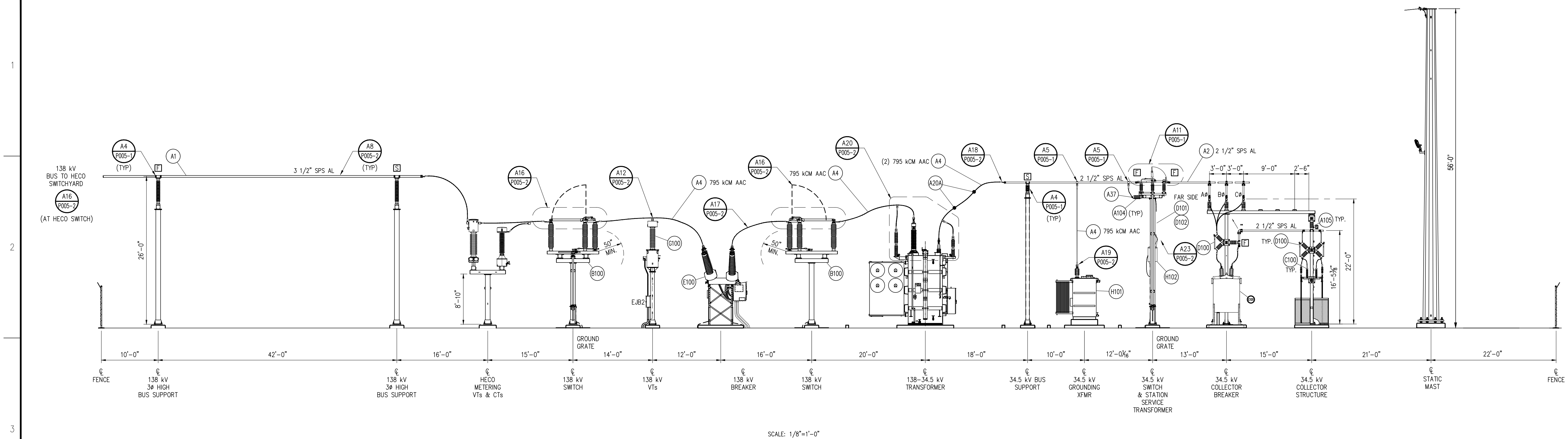
1	10/19/2020 BOD LAYOUT
2	11/09/2020 BOD FOR CUP

REVISION ISSUE

DRAWN BY: RO CHECKED BY: AAC
PROJECT NO.: 20105

DRAWING TITLE
BESS CONTAINER ELEVATION

DRAWING NUMBER
FIGURE 8



LEGEND

- (1 / P005-1) — INDICATES DETAIL 1; INDICATES DRAWING ON WHICH DETAIL APPEARS "HOS-D-P005-1"
- (A / P004-1) — INDICATES ELEVATION A; INDICATES DRAWING ON WHICH ELEVATION APPEARS "HOS-D-P004-1"
- EXP F S — BUS SUPPORT FITTINGS: EXPANSION, FIXED, SLIP

STRUCTURE DESIGN CRITERIA

138 kV CLEARANCE: (650 kV BIL)

LIVE PARTS: MIN ø–G=50"
MIN ø–ø=63"

TO GRADE: 13'-0" (BUS)
25'-0" (DRIVEWAY)

34.5 kV CLEARANCE: (200 kV BIL)

LIVE PARTS: MIN ø–G=13"
MIN ø–ø=18"

TO GRADE: 10'-0" (BUS)
22'-0" (DRIVEWAY)

NOTES

1. REFER TO MATERIAL LIST, DRAWING HOS-B-Z001 FOR BILL OF MATERIAL.
2. PLACE ALL BUS SUPPORT STANDS, SWITCH STANDS, DEAD ENDS AND STATIC MASTS ON LEVELING NUTS. BUS HEIGHTS ARE FROM BOTTOM OF BASE PLATE.
3. 6" OF SURFACE ROCK SHALL BE INSTALLED OVER SUBSTATION SURFACE, EXTENDING 5' BEYOND FENCE.

FILE LOCATION: G:\EPCS-477 MAHI SOLAR\100 CADD\110 WORKING\111 PHYSICAL\MAS-D-P004-1-2.DWG LAST SAVED BY: rjlarsen 7/28/2020 8:03 PM PLOTTED BY: Richard J. Larsen 7/28/2020 8:12 PM Tab:MAS-D-P004-1

"Engineering with Distinction" ECI ELECTRICAL CONSULTANTS, INC. BILLINGS, MONTANA

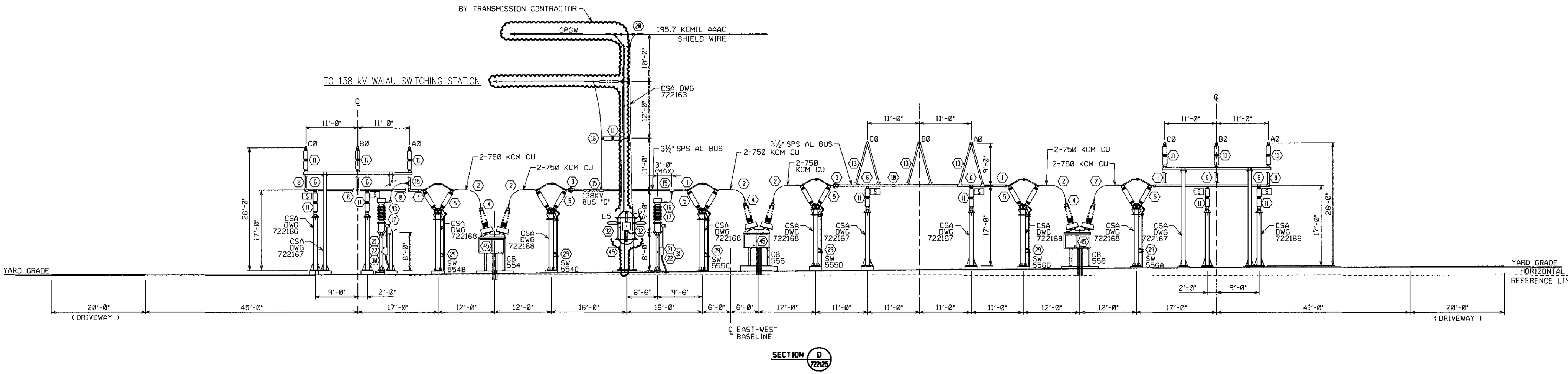
NO	REVISION	DATE	BY	APR
A	ISSUED FOR IRS STUDY		RJL	DTS

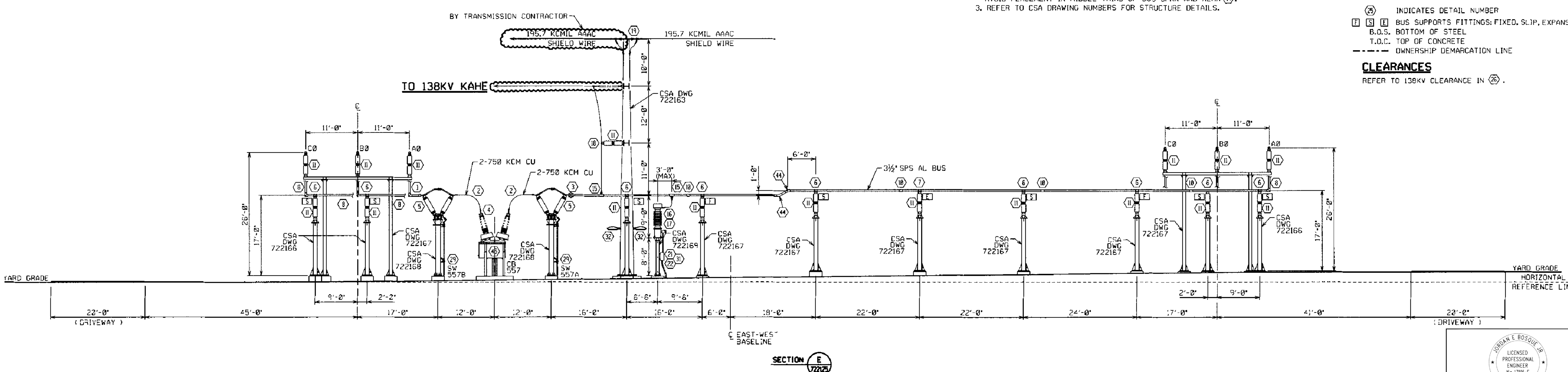
longroad ENERGY

ENGINEERING RECORD		DATE
DRAWN	LARSEN	04/30/20
DESIGNED	BOSQUE	–
CHECKED	McCOMISH	–
APPROVED	McCOMISH	–
DWG SCALE: NONE	PLT SCALE: 1:1 F.S. 1:2 H.S.	

FIGURE 9
SUBSTATION ELEVATION

DWG. NAME: MAS-D-P004-1 REVISION NO : A





NOTES

1. 397.5 KCM AAC DAMPING CONDUCTOR TO BE INCLUDED IN ALL 3.5" IPS AL BUS (12).
2. PLACE BUS SPLICES AS NEEDED, REFER TO (30).
   AVOID PLACEMENT IN MIDDLE THIRD OF BUS SPAN AND NEAR (14).
3. REFER TO CSA DRAWING NUMBERS FOR STRUCTURE DETAILS.

LEGEND

- (A / 7040) — INDICATES CUT VIEW / — DRAWING ON WHICH CUT APPEARS
- (25) INDICATES DETAIL NUMBER
- F S E BUS SUPPORTS FITTINGS: FIXED, SLIP, EXPANSION
- B.O.S. BOTTOM OF STEEL
- T.O.C. TOP OF CONCRETE
- — - — OWNERSHIP DEMARCATION LINE

CLEARANCES

REFER TO 138KV CLEARANCE IN (25).

JORDAN E. BOSQUE JR. LICENSED PROFESSIONAL ENGINEER No. 17906-E HAWAII, U.S.A.

7/31/2020

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION, AND CONSTRUCTION OF THIS PROJECT WILL BE UNDER MY OBSERVATION. "OBSERVATION OF CONSTRUCTION" IS DEFINED IN CHAPTER 16-115, HAWAII ADMINISTRATIVE RULES, ENTITLED "PROFESSIONAL ENGINEERING, ARCHITECTS, SURVEYORS AND LANDSCAPE ARCHITECTS".

SIGNATURE — LIC. EXP. DATE 4/30/2022

FILE LOCATION: G:\EPCS-477 MAHI SOLAR\100 CADD\110 WORKING\111 PHYSICAL\MAS-D-P004-1-2.DWG LAST SAVED BY: rlarsen 7/28/2020 8:35 PM PLOTTED BY: Richard J. Larsen 7/31/2020 5:08 PM Tab:MAS-D-P004-2

"Engineering with Distinction" ECI ELECTRICAL CONSULTANTS, INC. BILLINGS, MONTANA

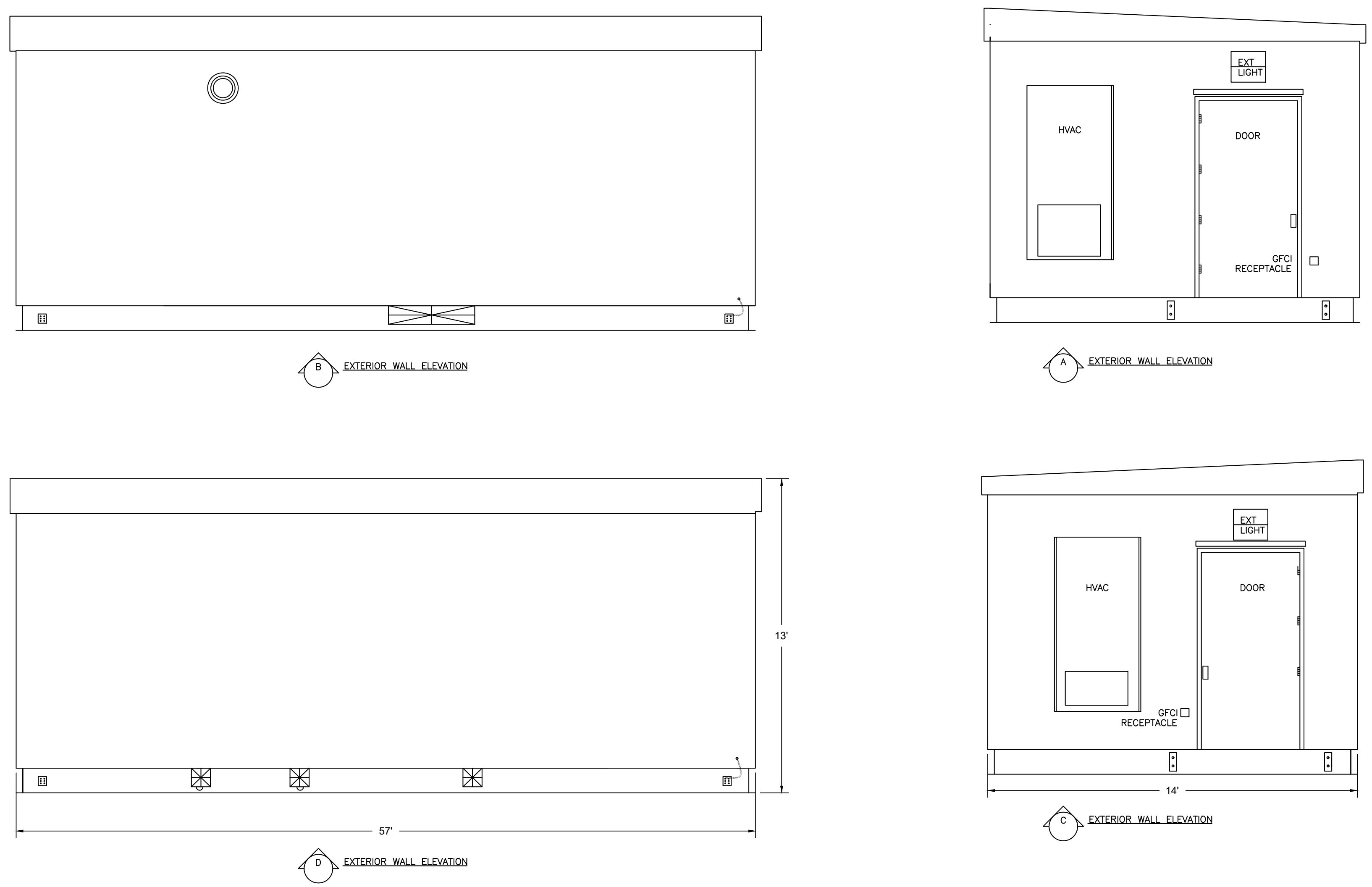
NO	REVISION	DATE	BY	APR
A	ISSUE FOR IRS STUDY	07/28/20	RJL	DTS

longroad ENERGY

ENGINEERING RECORD		DATE
DRAWN	LARSEN	04/30/20
DESIGNED	BOSQUE	–
CHECKED	McCOMISH	–
APPROVED	McCOMISH	–
DWG SCALE: NONE	1:1 PLT SCALE: 1:1 F.S. 1:2 H.S.	

FIGURE 10
SWITCHYARD ELEVATION

DWG. NAME: MAS-D-P004-2 | REVISION NO: A



PRELIMINARY - NOT FOR CONSTRUCTION

MOSS SOLAR

REVAMP
ENGINEERING, INC.
1110 Nuuanu Ave.
Honolulu, HI 96817
www.revamp-eng.com

ENGINEER'S STAMP

CLIENT

PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE

1	10/19/2020 BOD LAYOUT
2	11/09/2020 BOD FOR CUP

REVISION ISSUE

DRAWN BY: RO CHECKED BY: AAC

PROJECT NO.: 20105

DRAWING TITLE
CONTROL ENCLOSURE ELEVATION

DRAWING NUMBER
FIGURE 11

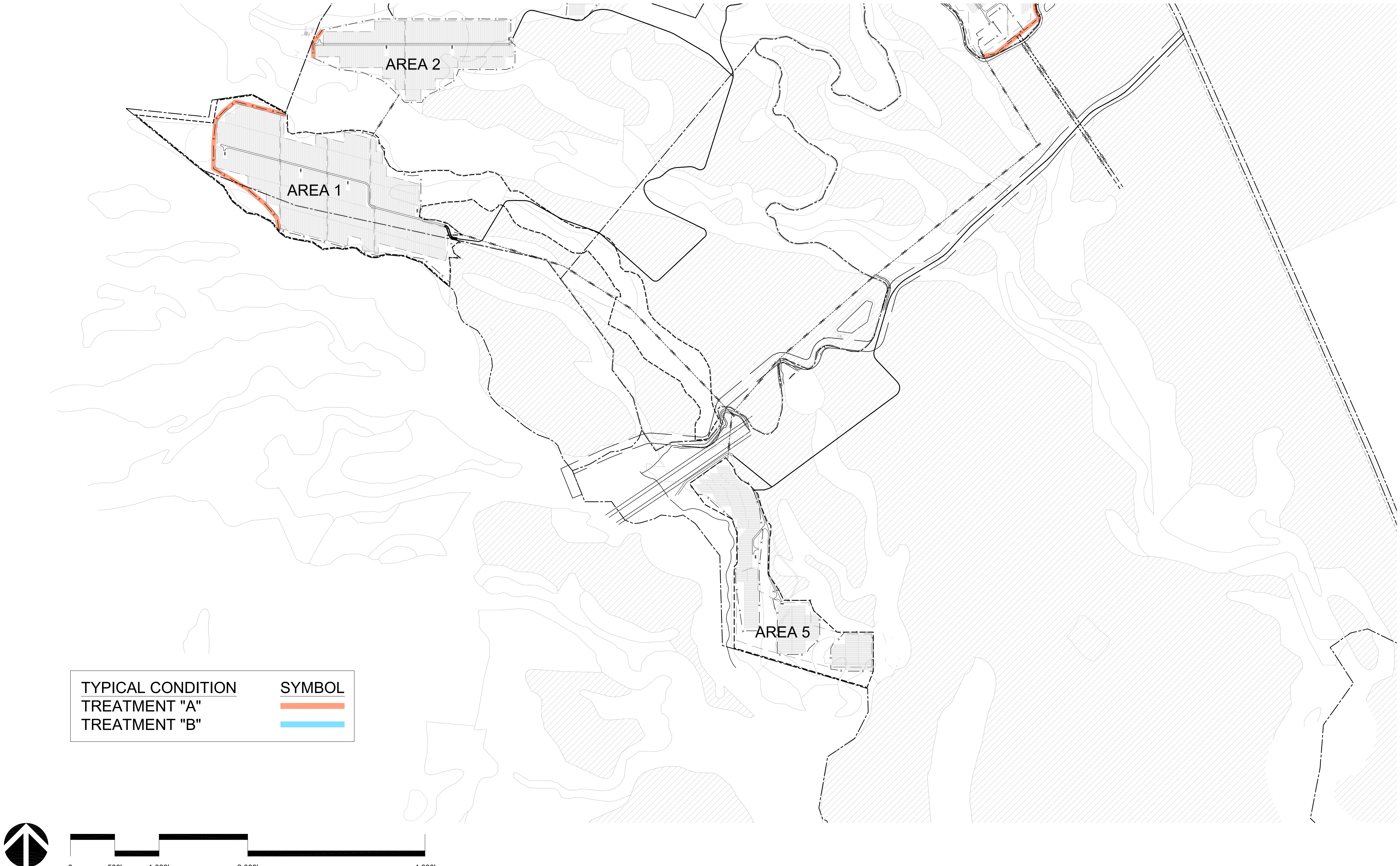


FIGURE 12

OVERALL LANDSCAPE SITE PLAN - AREAS 1 AND 5

G70 | longroad ENERGY

MAHI SOLAR

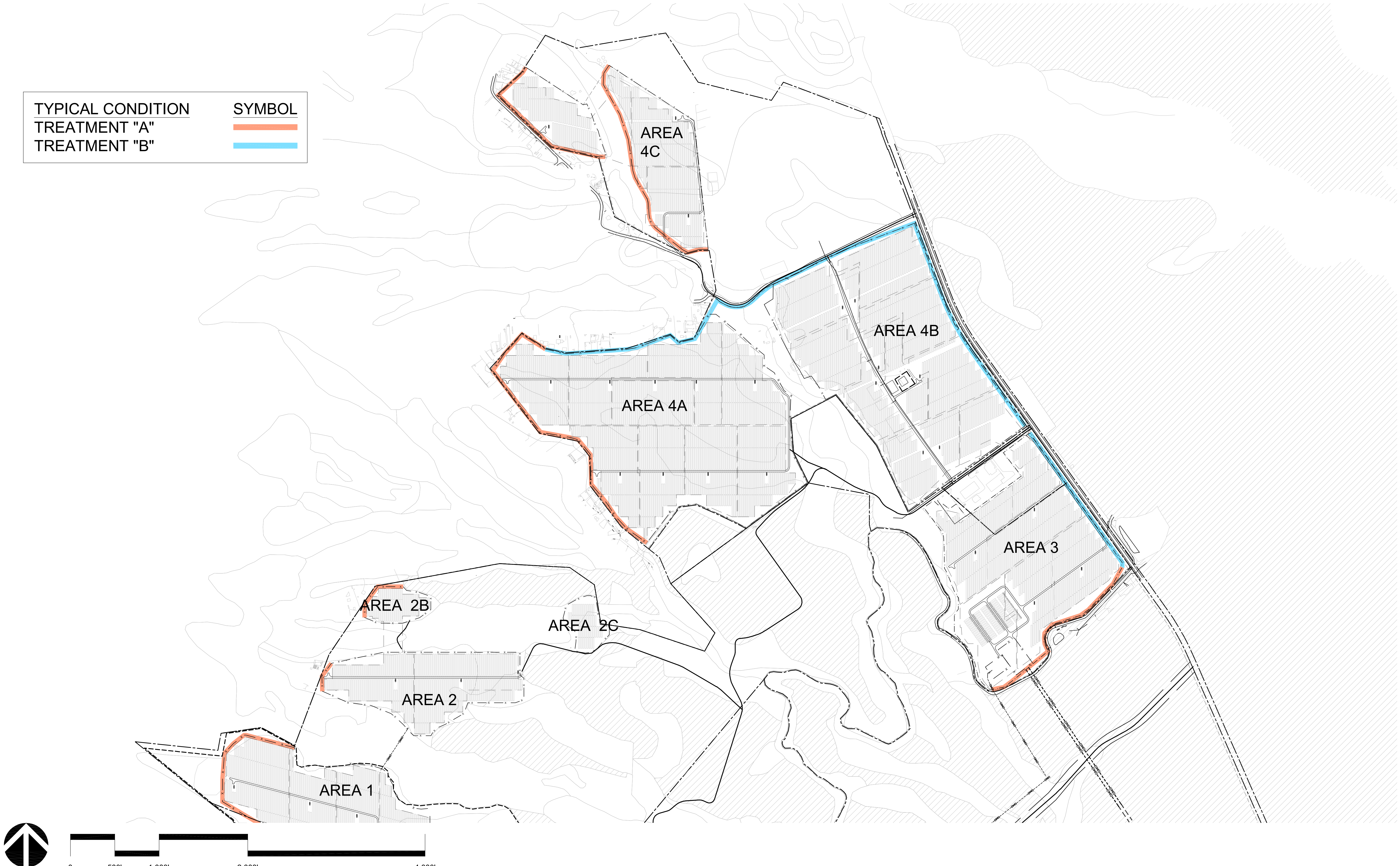


FIGURE 13

OVERALL LANDSCAPE SITE PLAN - AREAS 2, 3, 4A, 4B AND 4C

MAHI SOLAR

G70 longroad ENERGY

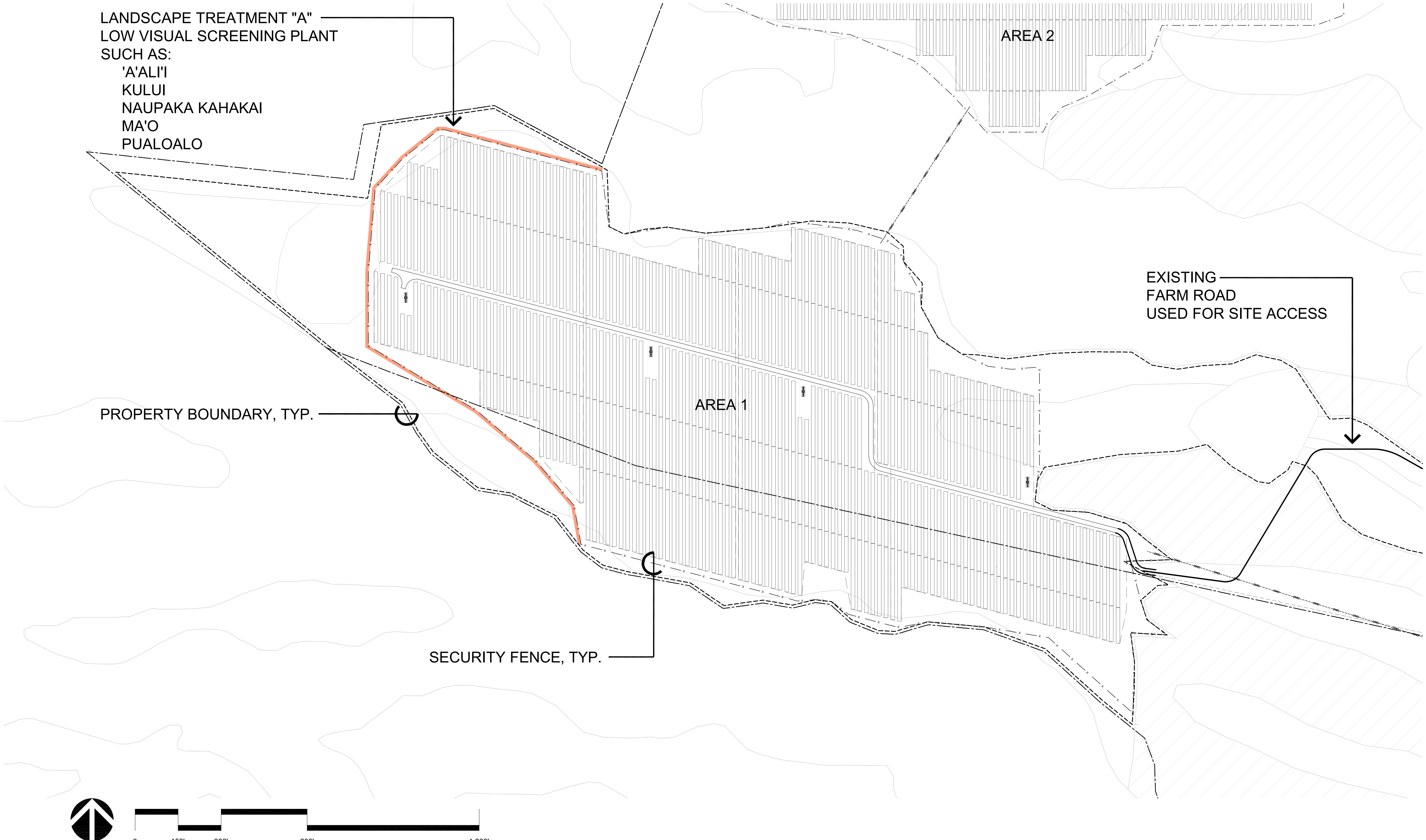


FIGURE 14

AREA 1: CONCEPTUAL LANDSCAPE PLAN

MAHI SOLAR

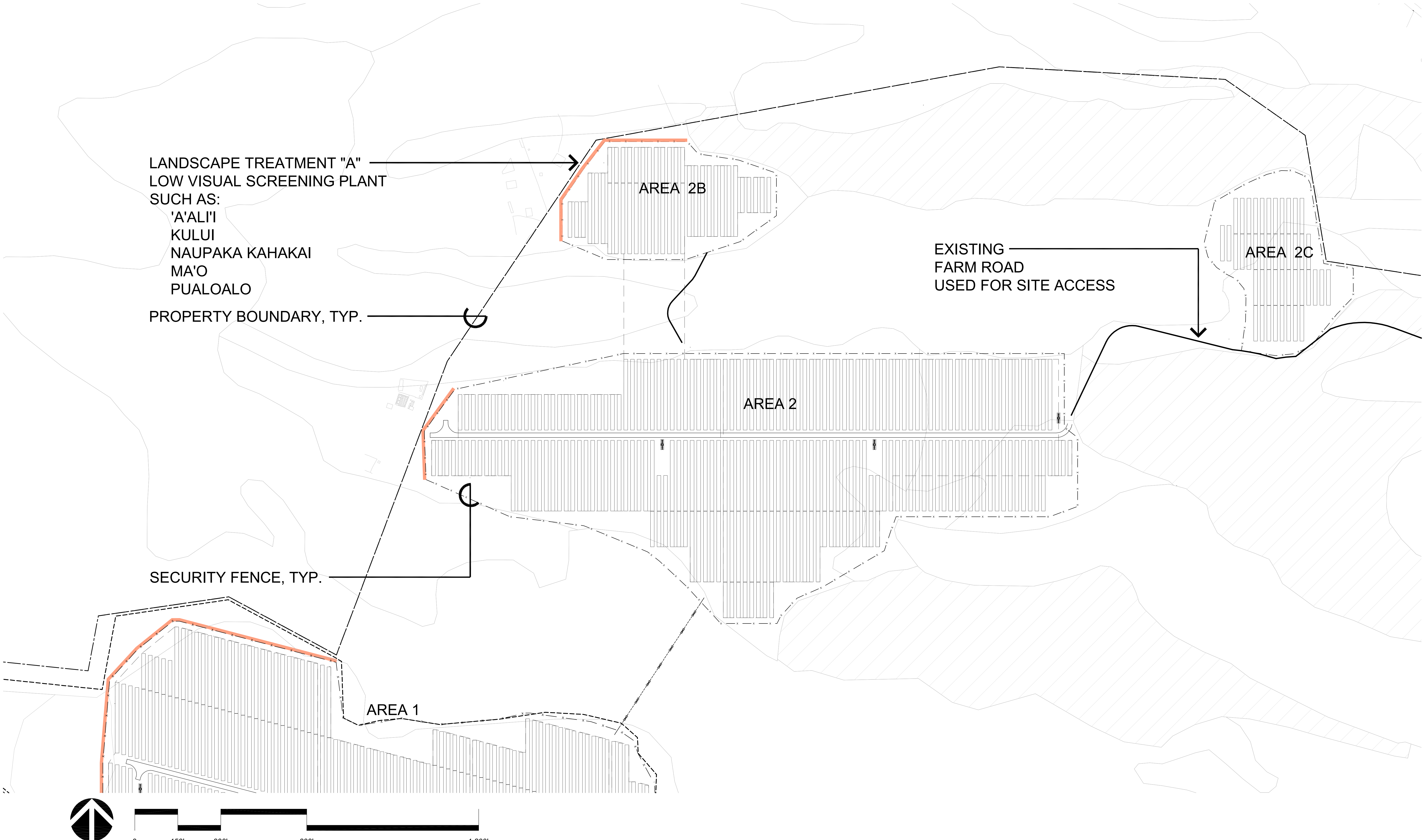


FIGURE 15

AREA 2: CONCEPTUAL LANDSCAPE PLAN

MAHI SOLAR

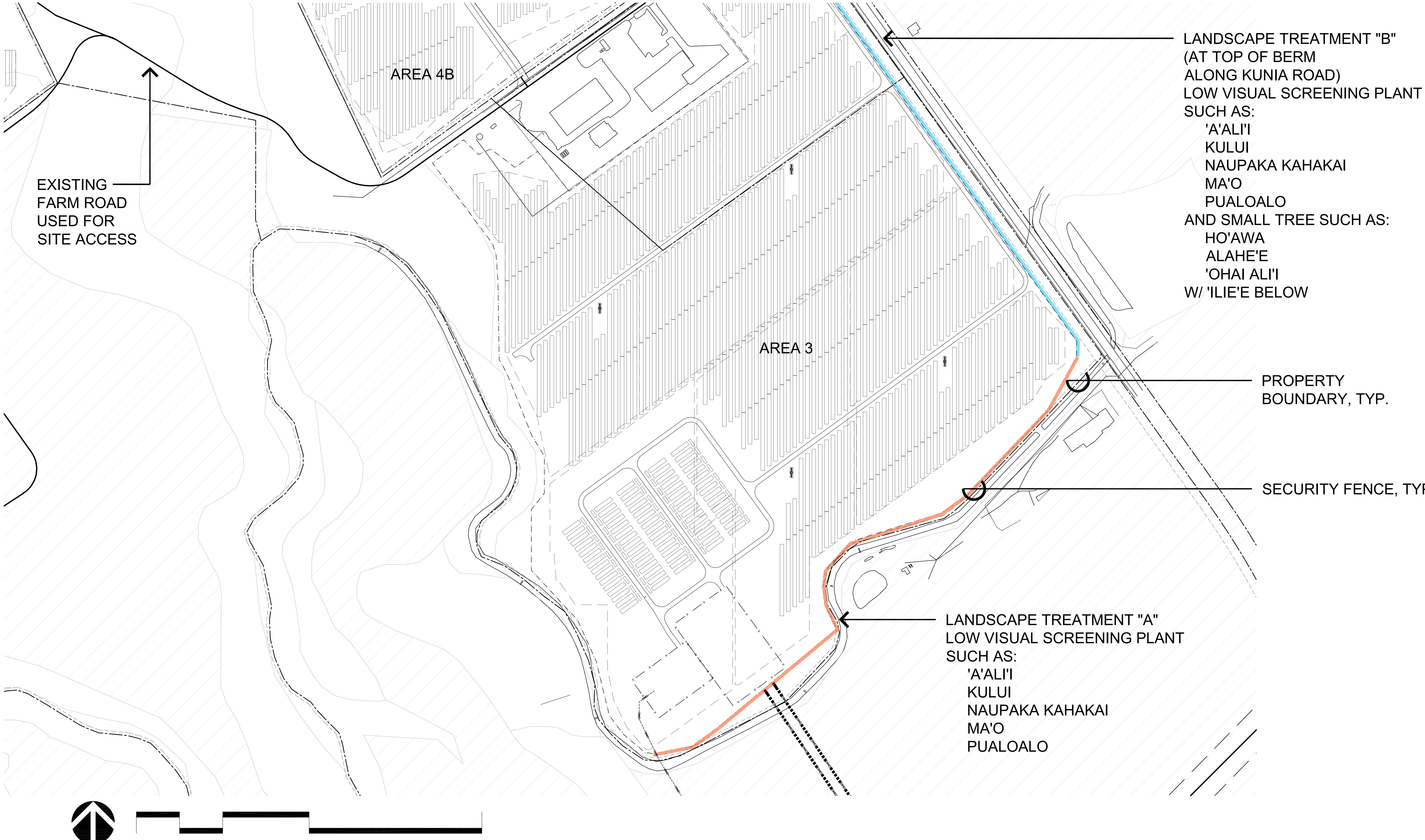

AREA 4B
AREA 3
EXISTING FARM ROAD USED FOR SITE ACCESS
LANDSCAPE TREATMENT "B" (AT TOP OF BERM ALONG KUNIA ROAD) LOW VISUAL SCREENING PLANT SUCH AS:
'A'ALI'I
KULUI
NAUPAKA KAHAKAI
MA'O
PUALOALO
AND SMALL TREE SUCH AS:
HO'AWA
ALAHE'E
'OHAI ALI'I
W/ 'ILIE'E BELOW
PROPERTY BOUNDARY, TYP.
SECURITY FENCE, TYP
LANDSCAPE TREATMENT "A" LOW VISUAL SCREENING PLANT SUCH AS:
'A'ALI'I
KULUI
NAUPAKA KAHAKAI
MA'O
PUALOALO
0
150'
300'
600'
1,200'

FIGURE 16

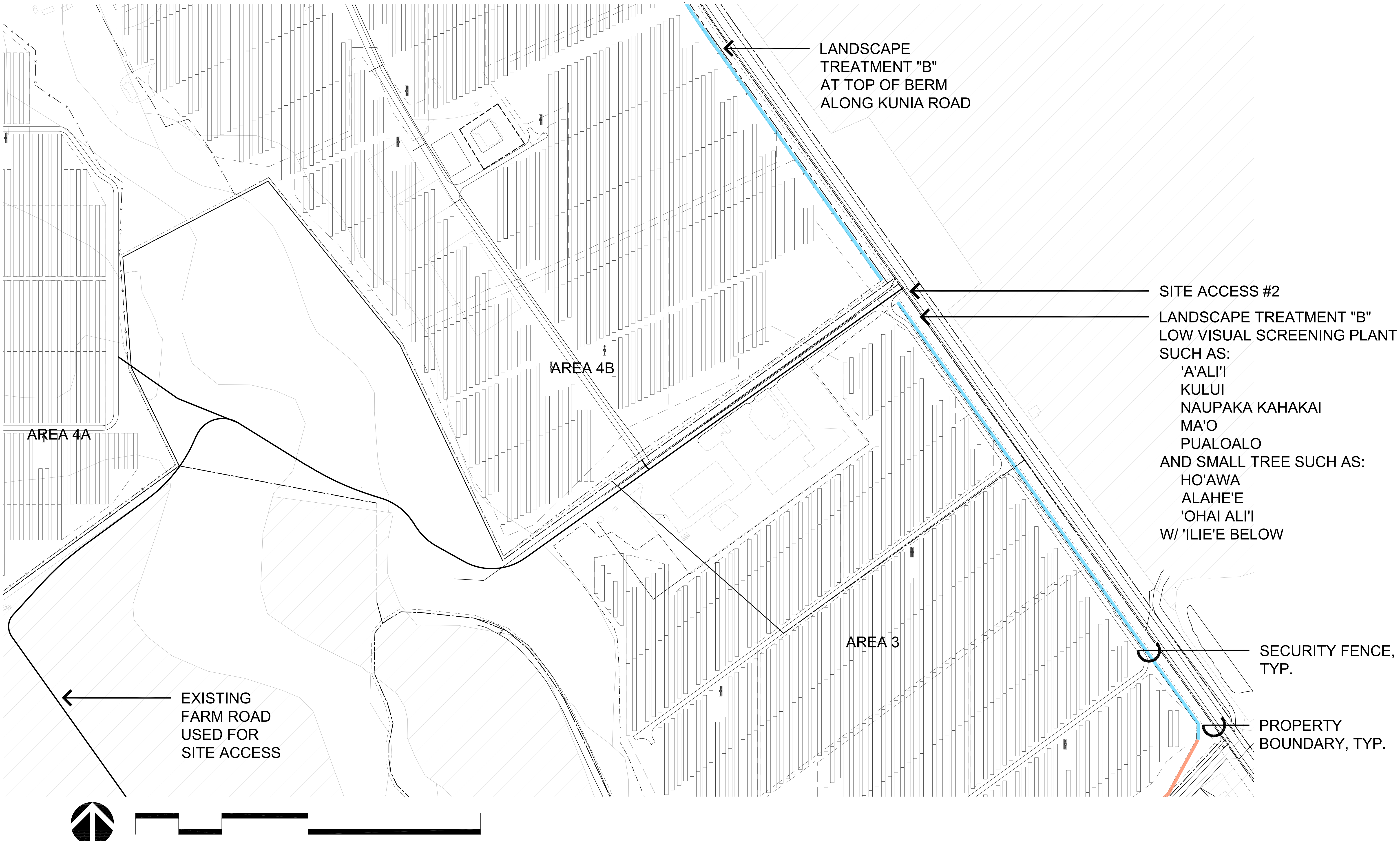


FIGURE 17

G70 longroad ENERGY

AREA 3 AND 4B SOUTH AT SITE ACCESS #2: CONCEPTUAL LANDSCAPE PLAN

MAHI SOLAR

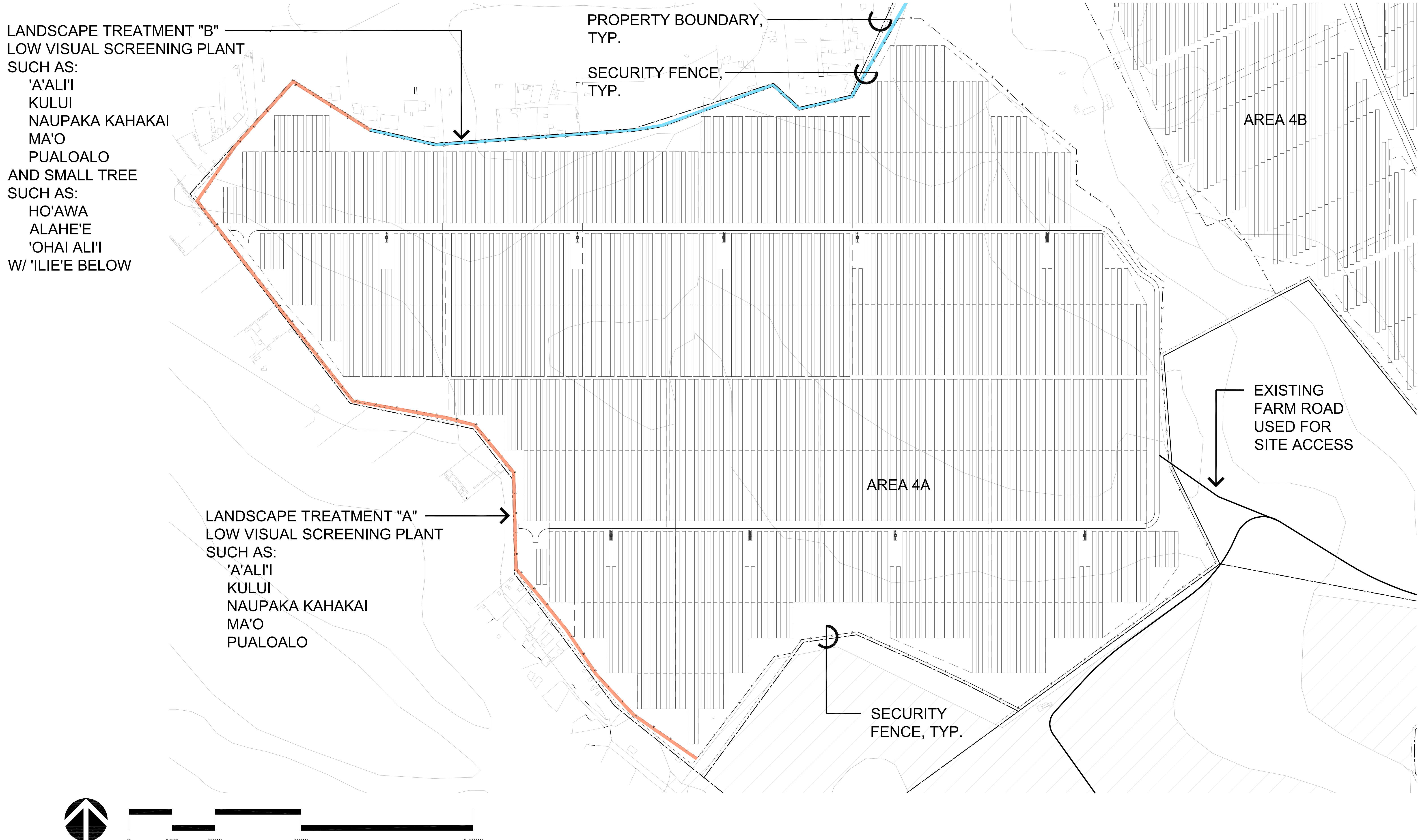


FIGURE 18

AREA 4A: CONCEPTUAL LANDSCAPE PLAN

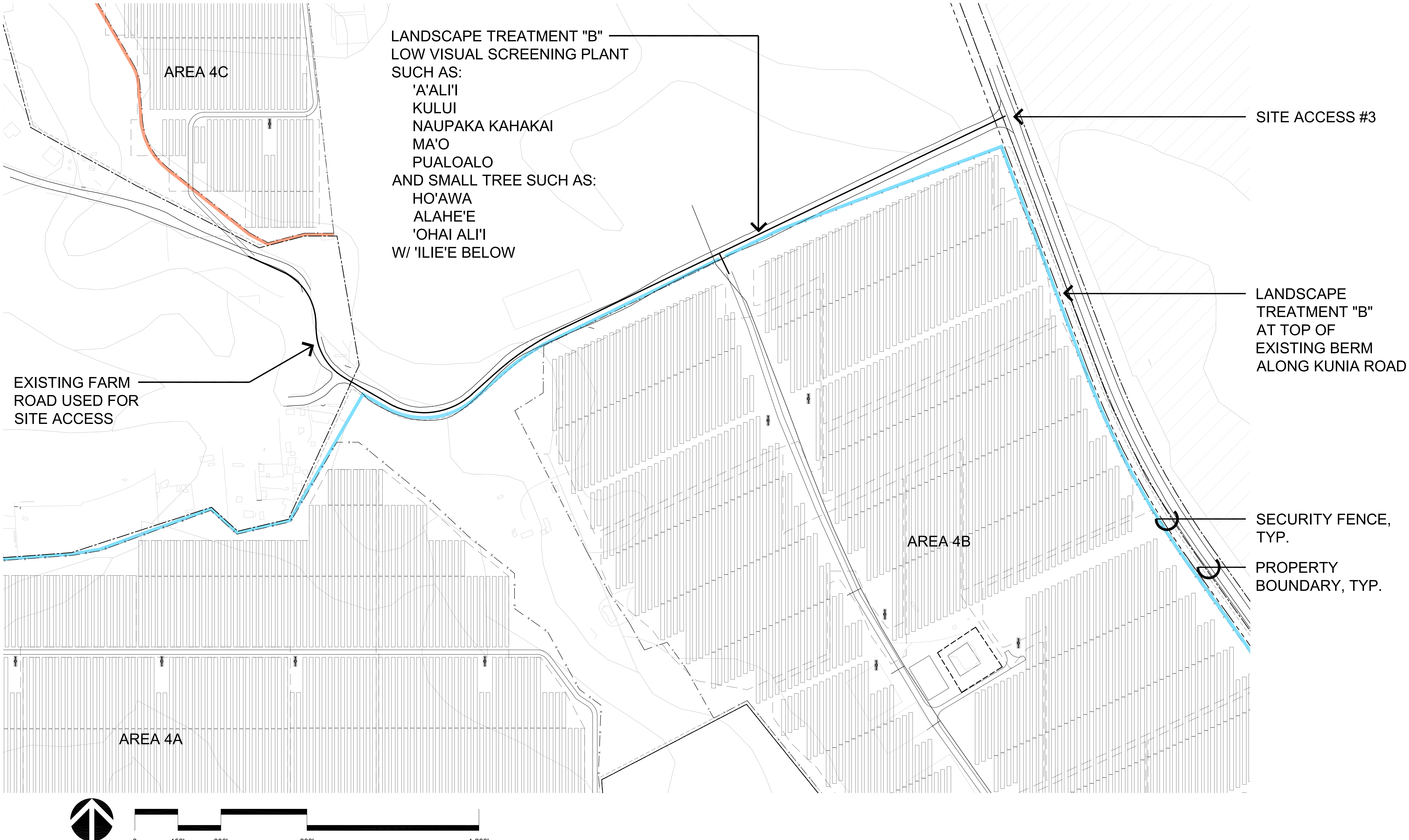


FIGURE 19

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AREA 4B AT SITE ACCESS #3: CONCEPTUAL LANDSCAPE PLAN

MAHI SOLAR

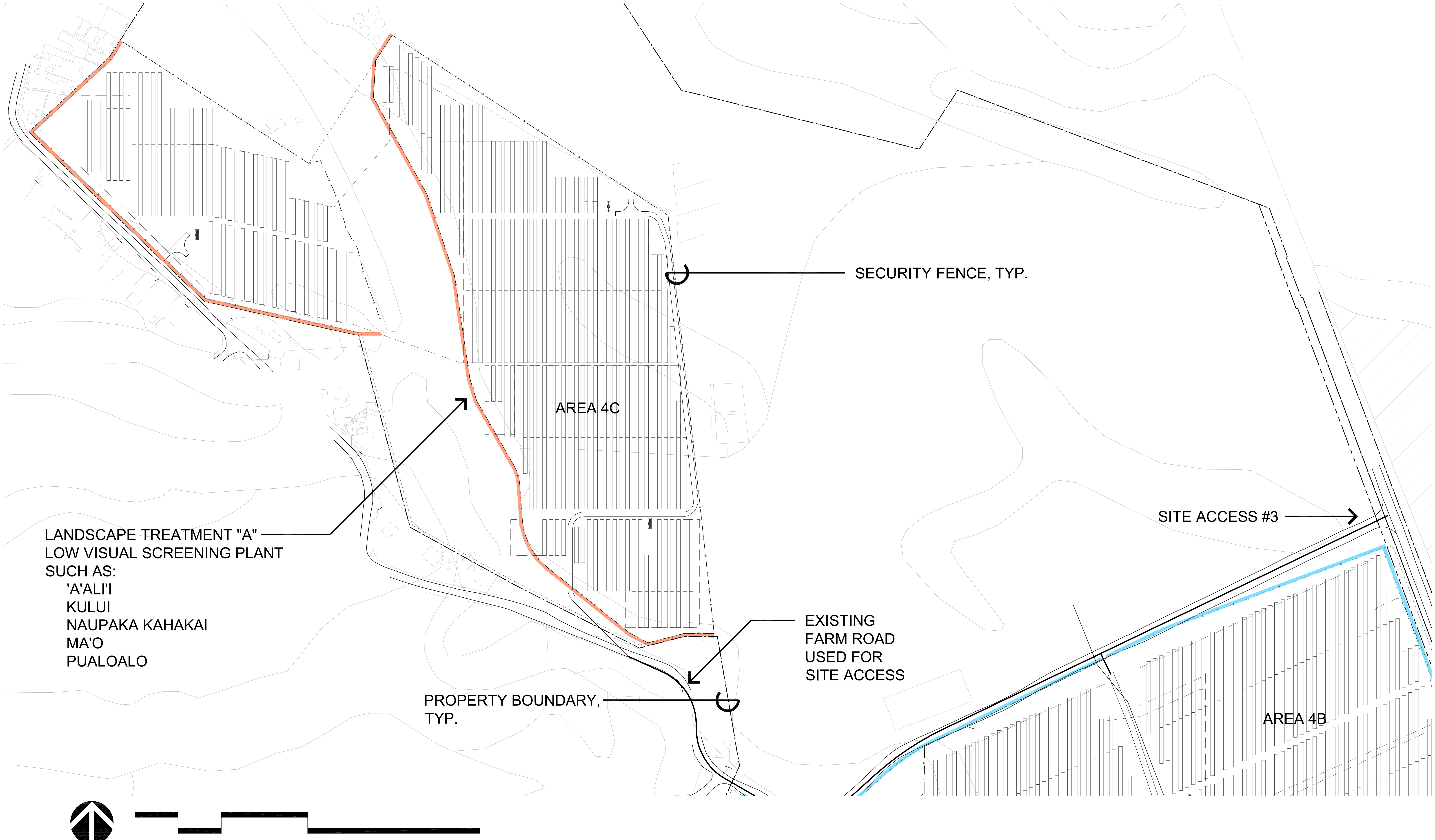
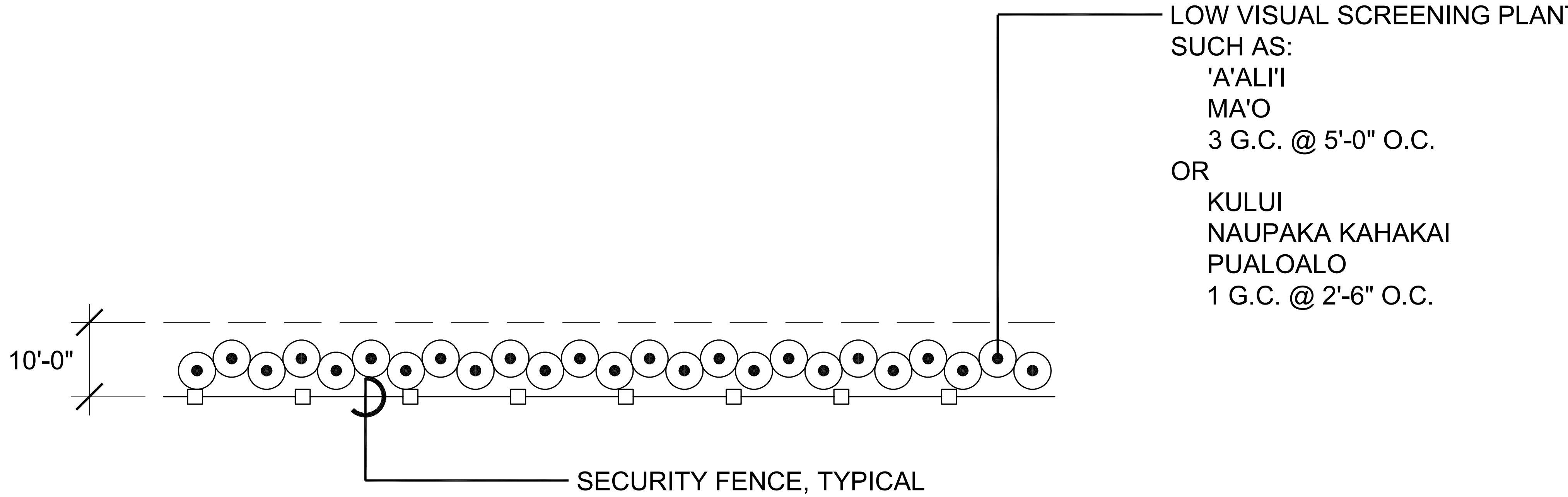


FIGURE 20

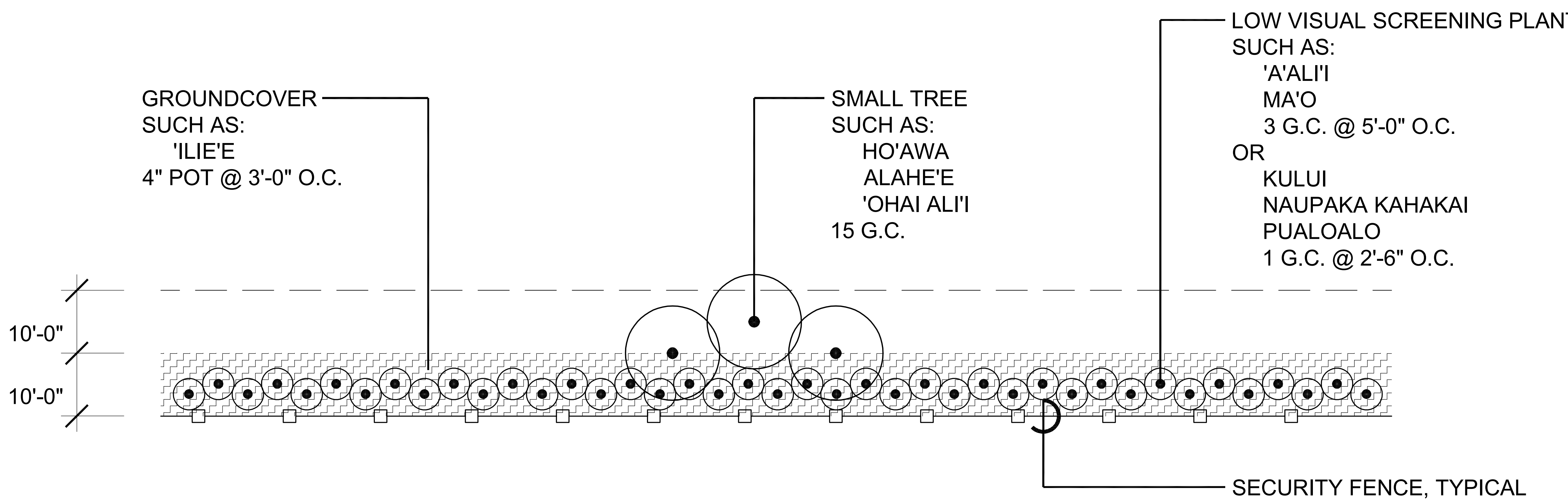
G70 longroad ENERGY

AREA 4C: CONCEPTUAL LANDSCAPE PLAN

MAHI SOLAR



TREATMENT "A": LOW VISUAL SCREENING PLANTS
scale: 1" = 20'-0"



TREATMENT "B": SMALL TREES AND LOW VISUAL SCREENING PLANTS WITH GROUNDCOVER BELOW
scale: 1" = 20'-0"

FIGURE 21

TYPICAL LANDSCAPE CONDITION: TREATMENT "A" AND "B"

HO'AWA (PITTOSPORUM CONFERTIFLORUM)

ALAHE'E (PSYDRAX ODORATA)

'OHAI ALI'I (CAESALPINIA PULCHERRIMA)

FIGURE 22

'A'ALI'I (DODONAEA VISCOSA)

KULU'I (NOTOTRICHIUM SANDWICENSE)

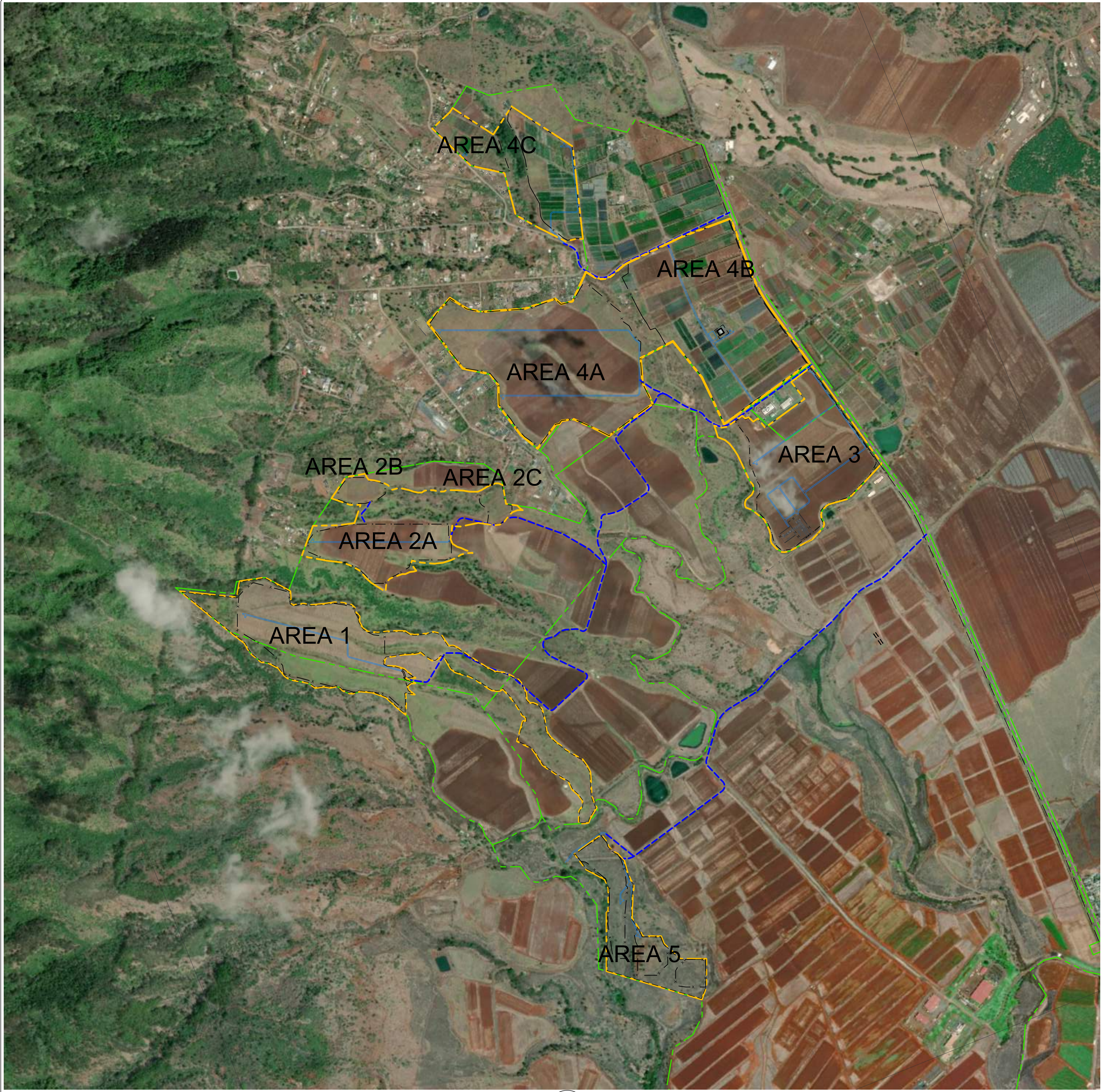
NAUPAKA KAHAKAI (SCAEVOLA SERICEA)

MA'O (GOSSYPIUM TOMENTOSUM)

PUALOALO (HIBISCUS ARNOTTIANUS)

'ILIE'E (PLUMBAGO ZEYLANICA)

FIGURE 23



1
-
OVERALL SITE LAYOUT
1" = 800'
0' 400 800 1600

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

LEGEND

- TMK/PROPERTY LINE
- PROJECT AREA
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- PROPOSED OVERHEAD ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS

PRELIMINARY - NOT FOR CONSTRUCTION

MOSS SOLAR

REVAMP ENGINEERING, INC.
1110 Nuuanu Ave.
Honolulu, HI 96817
www.revamp-eng.com

ENGINEER'S STAMP

CLIENT
longroad ENERGY

PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE

1	01/21/2021 ALTERNATE LAYOUT
2	01/29/2021 PER CLIENT COMMENTS
3	02/09/2021 FOR SUP
4	02/16/2021 FOR SUP
5	02/18/2021 PER CLIENT COMMENTS

REVISION ISSUE

DRAWN BY: ET CHECKED BY: AAC

PROJECT NO.: 20105

DRAWING TITLE
CIRCULATION PLAN

DRAWING NUMBER
FIGURE 24

2/19/2021 4:01 PM

20105 - MOSS - MAHI - E200 - LAYOUTS - SUBSTATION RELOCATED.DWG

Appendix C

Mahi Solar: Agricultural Plan
Prepared by Mahi Solar, LLC
March 2021

Mahi Solar: Agricultural Plan

March 2021

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Contents

List of Figures

List of Tables

Appendices

1.0 Executive Summary

Mahi Solar is a 120 MW utility-scale solar project proposed in Kunia, Oʻahu, being developed by Longroad Energy and scheduled to begin operation in 2023 (**Figure 1**). When completed, Mahi Solar will be the largest clean energy project in the state, able to produce enough electricity to power 37,000 Oʻahu households, avoid burning 22 million gallons of oil each year, and save consumers an estimated $175 million in lower power costs over its lifetime. Located primarily on Land Study Bureau (LSB) Class B agricultural land, Mahi Solar will also put most of its project area into local agriculture. This agricultural plan, developed with input from local farmers, proposes to implement an "Agrivoltaic" program to find new ways to use our limited land resources productively for both agriculture and energy.

Figure 1
Project Location

The Agrivoltaic Program will include three phases. First, the research phase will be conducted at an existing solar farm by the Hawaiʻi Agriculture Research Center (HARC) to study what kinds of crops will grow well in Hawaiʻi in the unique conditions of a solar farm. Second, the farming phase will provide land and water to local farmers and ranchers at the solar project to grow out these crops or livestock at commercial scale. In the third phase, the project will share data collected on agrivoltaic farming operations with the agriculture and solar industries to improve the cooperative benefit and dual use of land for energy and farming in the future. **Figure 2** illustrates the three phases of the Agrivoltaic Program:

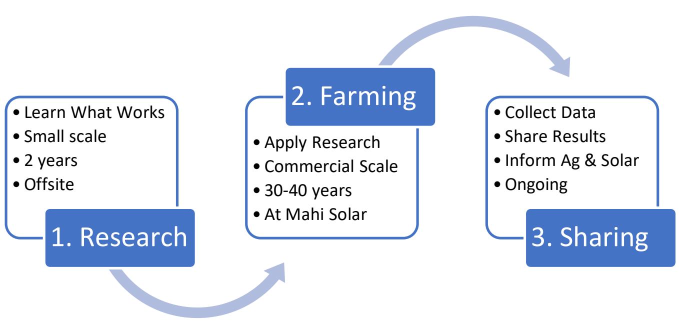

Figure 2
Agrivoltaic Program Phasing

This Agrivoltaic Program will actually put *more* land into productive agriculture and food production than currently exists at the site. Of the 620-acre proposed project area, current uses (**Figure 3**, below left), include only 306 acres in active agriculture and only 98.8 acres in food production. The proposed plan (**Figure 4**, below right) would put 610 acres of the solar farm (excluding the high-voltage areas at the substation/switchyard/battery energy storage (BESS) area) into active agriculture and 488.9 of those acres into local food production. The Mahi Solar project will be investing in local agriculture and increasing the number of acres actively farmed.

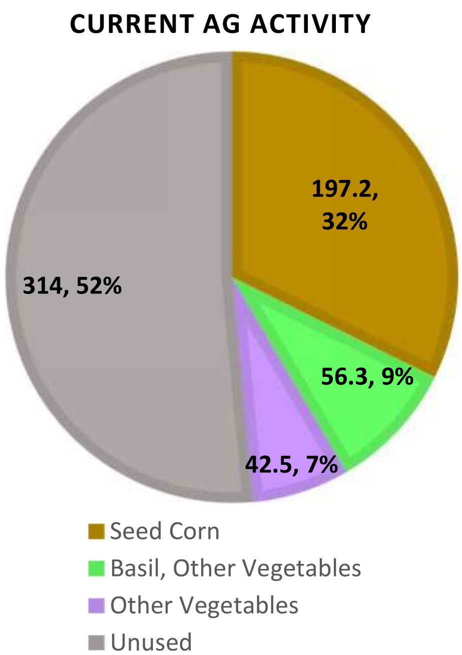

Figure 3
Current Agricultural Activity Chart (acreage and percentage of project site)

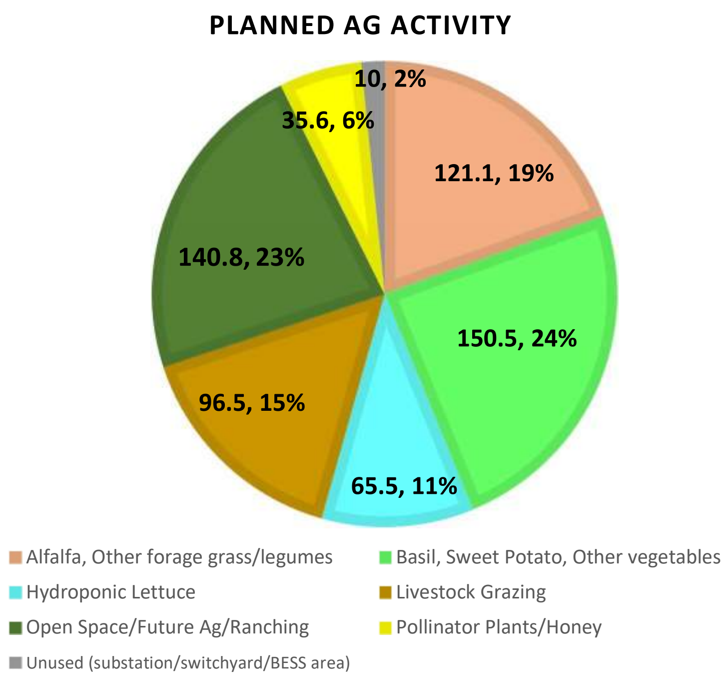

Figure 4
Planned Agricultural Activity Chart (acreage and percentage of project site)

Several commercial farmers and ranchers are already interested in participating in the Agrivoltaic Program, including HARC, Hartung Brothers (alfalfa forage), and Oʻahu Grazers (livestock grazing) (see letters of intent provided in **Appendix A**). HARC has also documented interest from Kunia Country Farms (hydroponic lettuce), Alluvion (nursery products), Fat Law Farms (basil), and Island Bee Removals (honey production) (**Appendix B**). Even prior to the research phase, farmers with experience in Kunia believe that solar-compatible crops and livestock can be successful between and under the solar panels. Some of the proposed activities include the following: hydroponic lettuce, which could yield $20,000 per acre per year; basil, which could yield $7,000 per acre per year; alfalfa, which could yield $4,000 per acre per year; and, lamb, which could yield $700 per acre per year, as well as pollinator-friendly plants to support honey production. While the final allocation of land will be determined after the solar project is completed, **Table 1** below presents a preliminary table of likely uses for the project area:

Table 1: Master Agricultural Use Table

Area #	Acreage	IAL	Planned Ag Activity	Potential Yield/Year	Planned Food Production	Planned Infrastructure
1	63.3	No	Livestock Grazing	$70,000	Yes	Water, Fencing, Roads
2a	33.2	No	Livestock Grazing	$56,000	Yes	Water, Fencing, Roads
2b	5.7	No	Pollinator plants/Honey	TBD	Yes	Water, Fencing, Roads
2c	4.9	No	Pollinator plants/Honey	TBD	Yes	Water, Fencing, Roads
3	65.5	No	Hydroponic Lettuce	$3,800,000	Yes	Water, Electricity
4a	121.1	No	Alfalfa, Other forage grass/legumes	$450,000	No	Water, Fencing, Roads
4b	56.3	No	Basil, Sweet Potato, Other vegetables	$562,500	Yes	Water, Fencing, Roads
4b	51.7	No	Basil, Sweet Potato, Other vegetables	$637,500	Yes	Water, Fencing, Roads
4c	42.5	No	Basil, Sweet Potato, Other vegetables	$300,000	Yes	Water, Fencing, Roads
5	25	Yes	Pollinator plants/Honey	TBD	Yes	Fencing, Roads
Open Space/Future Ag/Ranching	140.8	Yes	Open Space/Future Ag/Ranching	TBD	Yes	Water, Fencing, Roads
TOTAL (acres)	610				488.9	

Through the implementation of this Agrivoltaic Program, Mahi Solar will identify and implement solar-compatible farming activities within the project footprint for the life of the solar project. This plan meets the State's intent for integrating solar on LSB Class B and C lands, while also developing important information on agrivoltaic farming, best practices and dual land use policies that can be shared with communities in Hawaiʻi and around the world.

This plan provides further detail about the Mahi solar project and its development team, principles of agrivoltaics and references to several case studies projects, a detailed description of the proposed Agrivoltaic Program and a comparison of current and planned activities, further information on the Mahi Solar project site, and a discussion of greenhouse gasses and carbon sequestration.

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2.0 Mahi Solar Project

2.1 Background

Through legislation and other policies, the state of Hawaiʻi has prioritized actions that contribute to the long-term economic, social, and environmental sustainability of the state, including actions that emphasize the importance of both locally produced agriculture and locally produced clean energy. A summary of related policies is provided below:

- Aloha Plus Challenge, 2014: Identified the goals to at least double local food production, ensure that 20 to 30 percent of food consumed is grown locally by 2030, and reduce reliance on fossil (carbon-based) fuels. These goals have also been identified as priority actions in the Hawaiʻi 2050 Sustainability Plan.
- Act 97, Session Laws of Hawaiʻi (SLH), 2015: The state set a goal of having 100 percent of electricity sales come from renewable sources by the year 2045.
- Act 32 SLH, 2017: Committed our state to combat climate change by systematically reducing greenhouse gas (GHG) emissions and improving Hawaiʻi's resiliency to climate change by aligning with the principles and contributing to the goals set forth by the United Nations' Paris Agreement.
- Act 15 SLH, 2018: Required Hawaiʻi to become net carbon negative "as soon as practicable, but no later than 2045".

Oʻahu in particular has a limited amount of land that is suitable for farming and for solar energy production, both of which perform best on the same type of relatively flat land with abundant sun. Along with the continuing demand for new housing and open space on Oʻahu, there has been increasing competition for land zoned for agriculture. However, unlike residential housing development, renewable energy projects can be integrated with farming and ranching activities, so that the land can be used for both purposes at the same time. In 2014, Hawaiʻi House Bill 2203 approved amendments to Hawaiʻi Revised Statutes (HRS) Chapter 205, Land Use Commission to promote the dual use of agricultural land by requiring solar projects on LSB Class B and C land to provide land for compatible agricultural activities for the entire operational life of the project. Since this amendment to HRS Chapter 205 was enacted in 2014, Oʻahu's two largest solar projects permitted under this statute have actually <u>increased</u> the number of acres of Class B and C land in active agricultural production. The Kawailoa and Waipiʻo solar projects are now home to the island's largest sheep ranch which provides locally raised lamb to local consumers.

Mahi Solar's agricultural plan will bring even more land into agricultural production, not only in ranching, but in farming lettuce, basil and other vegetables, flowering plants for honey production, and nutritious grasses for animal feed. This agricultural plan will develop a comprehensive Agrivoltaic Program, first to research what local crops can be successfully grown along with solar panels and then to expand those agricultural activities at commercial scale across the entire solar project. The project will directly meet the State's policy goals above by co-locating the cultivation of local market crops with a solar facility. Mahi Solar will also work with HARC to collect data on what works – successful crops, methods and best practices – and share the results with the local solar and agriculture industries, to help expand the productive dual use of agricultural land in Hawaii. Implementing this agricultural plan will simultaneously increase both clean energy production and agricultural productivity on the lands used for the project, supporting the state's goals in both areas.

2.2 Project Description

The Mahi Solar project is a 120-megawatt alternating current (MWac) solar and 480-megwatt hour (MWh) energy storage facility located in Kunia, Oʻahu (**Figure 1**). The project is being developed to produce clean energy and support local agriculture in the region. The project area is approximately 620 acres and is comprised of five Tax Map Key (TMK) parcels identified in **Table 2**. The project also includes an electrical substation and switching station to connect to the Oʻahu grid. The project will be able to produce approximately 4 percent of the island's electricity annually, enough to power 37,000 local homes, enabling HECO to burn less fossil fuel and emit less GHGs. The project will save Oʻahu ratepayers $175 million over its lifespan. The project site is located on lands zoned as agricultural, and includes lands rated as LSB Classes B, C, D, and E. Solar is an allowable use on State Agricultural lands rated as LSB Classes B and C with the approval of a Special Use Permit (SUP). The project will also require a City and County of Honolulu CUP (minor) for a Utilities installation, Type B to allow solar uses. The Mahi Solar project is scheduled to start construction in 2022 and be complete by 2023.

Table 2: Tax Map Keys

TMK	Project Area (acres)	Total Parcel Area (acres)
(1) 9-2-001:020	85	1,688.75
(1) 9-2-004:003	15	19.29
(1) 9-2-004:006	180	724.89
(1) 9-2-004: 012	30	93.30
(1) 9-2-004:010	310	425.96
Total Area:	620 acres	2,952.19 acres

The SUP petition prepared for the project discusses potential environmental considerations. The project will be visible along Kunia Road, from the farms in Kunia Loa Ridge Farmlands, and from other distant viewpoints. However, because of the distance of the project from residential areas, most people who reside in the Kunia area will not see it from their homes nor experience adverse impacts related to sound, glare or other environmental impacts. Based on studies to date, the project is not expected to have significant impacts to archaeological resources, cultural practices, or any sensitive flora or fauna. Based on ongoing community outreach, initial indications are that members of the surrounding community would be supportive of the project.

The positive impacts from the project include an increase in locally generated renewable energy, less fossil-fuel burning, less GHGs that contribute to climate change, and lower, more stable electricity prices. The project would also create approximately 200 jobs during construction and another 2-3 long-term positions during operations, as well as supporting local farming and increasing the number of acres of LSB Class B and C land in active agricultural use.

In addition to the project's clean energy impact, the Mahi Solar project will support the state's agricultural goals. The Kunia lands are some of the best agricultural sites in Hawaiʻi with deep soil, excellent sunlight and available water. As such, it is vital that agricultural operations be included as an important part of the solar project providing both energy and food products. Longroad Energy is leasing portions of five adjacent parcels of underutilized land for the project from three landowner-farmers. Leasing areas of property enables the landowners to continue farming, while earning lease revenue from the solar project to support their farming activities. The Mahi Solar project will actually increase the amount of land in active agricultural use. Of the 620 acres of land leased for the project, approximately 314 acres consists of land that is not currently being used , that will be used for farming and ranching after the project is constructed, as outlined in this agricultural plan. This plan will increase agricultural productivity on the land used for the project, increase the acreage used for agriculture in the region, contribute a variety of agricultural uses, contribute to local food production, and improve and increase the use of Important Agricultural Lands (IAL) on the project site, meeting the state's intent for agriculturally zoned lands. Further, no-till practices will be implemented to increase carbon sequestration at the site, further supporting the state's climate change goals (see **Section 6.0**).

Mahi Solar has consulted with HARC, the Hawaiʻi Farm Bureau, Hawaiʻi Agricultural Foundation, Hartung Brothers Inc, Fat Law Farms and several local farmers, beekeepers and ranchers to help develop an informed plan for co-locating solar photovoltaic (PV) energy generation and realistic agricultural activities together at the site through a strategy referred to as "agrivoltaics". In the initial research phase of this agricultural plan, HARC will conduct farming trials of different crops at an existing solar project in Mililani in a collaboration with Clearway Energy. See **Appendix B, HARC Solar White Paper**. HARC's research will happen prior to completion of the Mahi Solar project to determine what crops are economically and viably suited for cultivation at the Mahi Solar project on a large scale. After construction is complete and the solar project is operational, the Agrivoltaic Program will work with local farmers and ranchers to support commercial agricultural activities under and between the PV panels for the duration of the entire operational life of the project. Mahi Solar also plans to engage HARC to collect data from commercial farming and ranching and share results with the local solar and farming industries, so our state can continue expand and improve the dual use of land for energy and agriculture. More information on the concept of agrivoltaics is provided in **Section 3.0**, and the project's Agrivoltaic Program is provided in **Section 4.0**.

2.3 Project Team

The Mahi Solar project is being designed and developed by Longroad Energy, which comprises many of the same people that worked at First Wind to develop seven of the largest clean energy projects now operating on Oʻahu and Maui, including 150 MW of wind and 110 MWac of solar. This development team worked extensively with local residents, businesses and other organizations to develop Kaheawa Wind, Kahuku Wind, Kawailoa Wind, Kawailoa Solar, Mililani Solar and Waipio Solar. In 2015, this team sought the first Special Use Permits to pair local sheep ranching and solar on LSB Class B and C agricultural land. Today those two solar projects are home to Oʻahu's largest sheep ranching operation, which provides 100 percent grass-fed lamb to the local market. The arrangement lowers the cost of operation for the farmer, because the land, water and perimeter fencing are already present at a large solar site.

The same team, now at Longroad Energy, is devoted to working with the agriculture community at Mahi Solar to find new viable solutions and advance best practices for local land use. For the Mahi Solar project, the team is proposing to expand beyond sheep, which may reach its market limitation. The goal of this project is to broaden agricultural opportunities co-located with solar energy generation, and therefore proposes an innovative agricultural plan to expand and support new agricultural activities on the properties like vegetable crops, feed for livestock, and flowering plants to accompany honey production. This agricultural plan proposes to implement an innovative to implement, monitor, and report on new agricultural uses that will enable the dual use of land for both energy and local food production.

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3.0 Principles of Agrivoltaics

The term "agrivoltaics" describes co-developing the same area for both solar photovoltaic energy and agriculture. Since the 1980's, agrivoltaic projects have been designed to share land and sunlight between agriculture and solar panels, and often to study which crops or livestock can co-produce with solar most successfully. Many different types of agrivoltaic projects are being pursued in several countries, which include shade-tolerant crops like lettuce, ginseng, alfalfa, sorghum, lettuce, spinach, beets, carrots, chard, radishes, potatoes, arugula, mint, turnips, kale, parsley, coriander, beans, peas, shallots, mustard. Other agrivoltaic projects pair solar with shrimp production, or with pollen-producing flowering plants and honeybees. Agrivoltaics shows great promise here in Hawaiʻi where land is in short supply, but it is essential to find agrivoltaic crops and combinations of uses that work grow well in Hawaiʻi's unique growing conditions which can support local food production. The following section discusses considerations for successful agrivoltaic projects, including land utilization efficiency, solar PV design factors, types of crops conducive for agrivoltaic projects , and case studies.

3.3.1 Land Utilization Efficiency

The co-location of solar energy production and agriculture assumes that combining both uses on the same land would result in more efficient use of land. This can be particularly important where the availability of land is limited, such as on Oʻahu. Even if solar energy production and agricultural production were each reduced on specific lands to enable their co-location, the net land use efficiency of both energy and farming together could be greater by combining both uses. This is visually presented in **Figure 5** below.

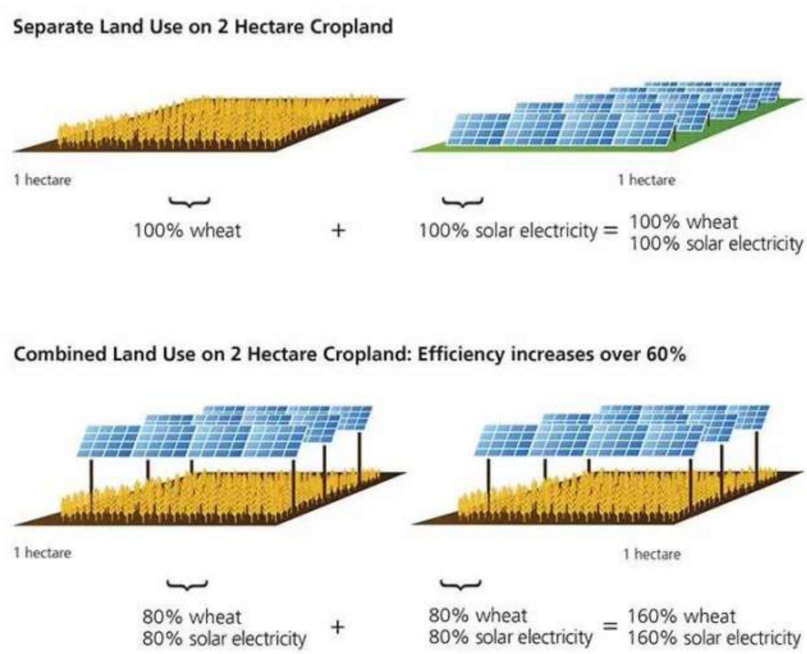

Figure 5
Land Utilization Efficiency Example

A model developed at Michigan Technological University (Dinesh and Pearce, 2016) showed that the value of solar generated electricity coupled to shade-tolerant crop production created an over 30 percent increase in economic value from farms deploying agrivoltaic systems over conventional agriculture only. This ratio of energy production vs agricultural production would vary for a specific application / project depending upon the primary objective - emphasis on solar production, emphasis on agricultural production, or the balance of both.

3.3.2 Microclimate for Crops Under Panels

A canopy of PV panels can also modify the microclimate for crops. Key changes are:

- More shade / less direct sunlight
- Lower temperatures
- Greater moisture retention

Generally, these factors can create growing conditions that require less water, can produce greater yield in hot dry years, and can possibly lengthen the growing season for shade-tolerant crops. Conversely, increased shade can negatively affect production of many crops.

3.3.3 PV Solar Design Factors

3.3.3.1 Panel Mounting System

PV solar panels can be mounted using fixed-tilt systems or single-axis tracking systems. In fixed-tilt systems, the panels are normally arranged in east-west rows and are mounted so they remain stationary at a fixed angle. In single-axis tracking systems, panels are normally arranged in north-south rows and rotate to follow the path of the sun across the sky during the day. The Mahi project will utilize a single-axis tracking system as shown **Figure 6**.

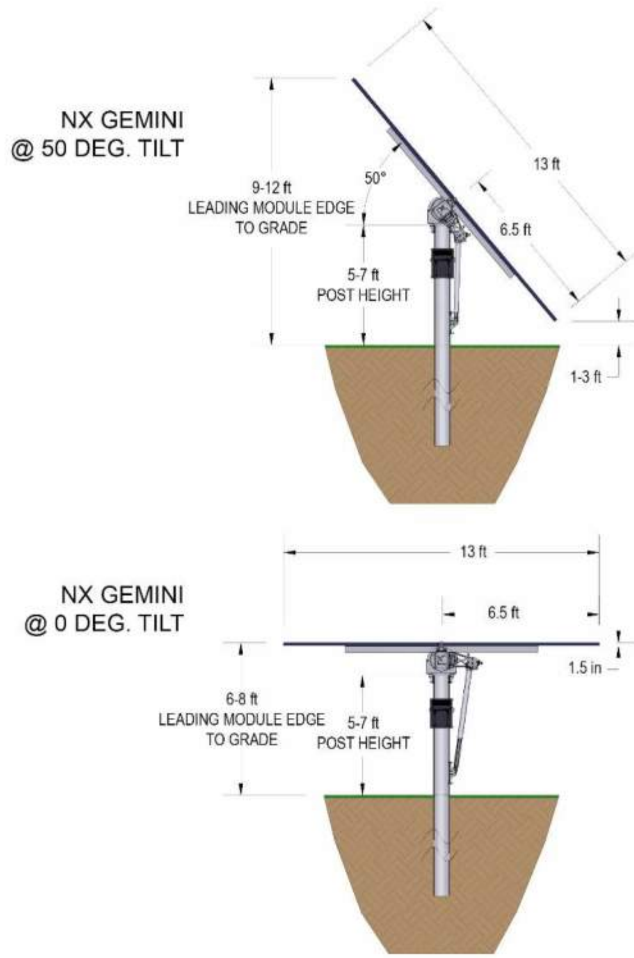

Figure 6
Solar PV Panel Elevation

3.3.3.2 Panel Spacing

PV solar systems are installed in rows with the space between rows designed to maximize the energy generation efficiency of the field. Generally, the rows are spaced so each row would not shade the adjacent rows and also provide enough space for maintenance personnel and equipment. The spacing of rows and panels within rows can affect the amount of light available to the plants below (**Figure 7**).

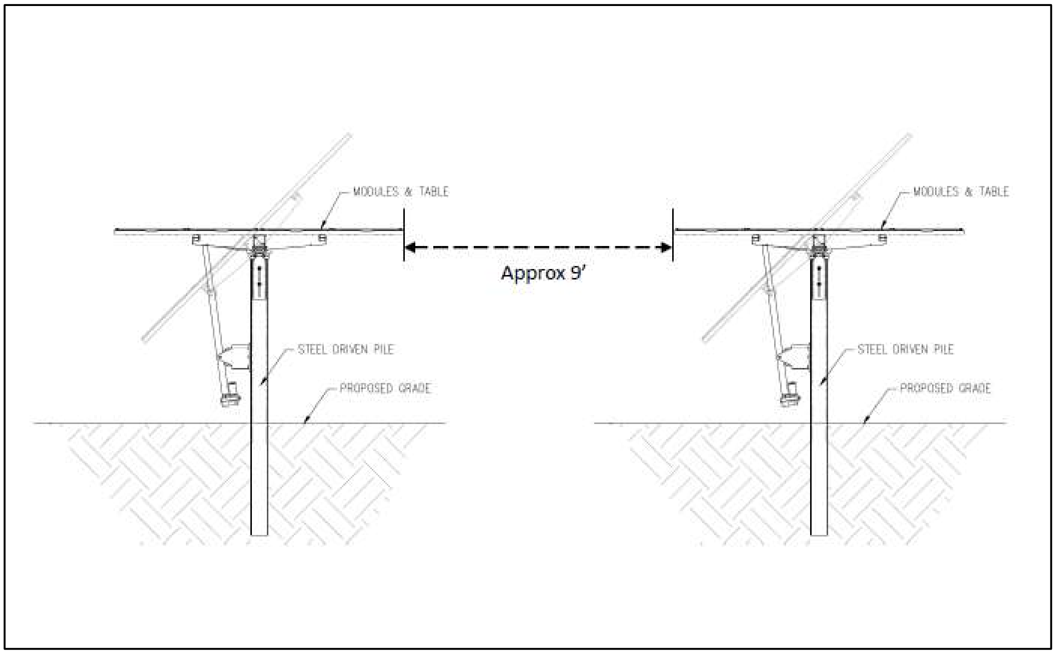

Figure 7
Solar PV Panel Row Spacing

3.3.4 Types of Crops Studied

Many types of crops have the potential the potential to be grown under PV panels. Generally, agrivoltaics work best for plants that are shade tolerant/resistant. These could include vegetables, fruits, pollinator species, pasture/hay, and others.

In a study on tropical agriculture and shade tolerance (Wilkenson and Ellovitch 1998), examples of shade tolerant understory crops were identified. Some were highly shade-loving and some tolerant of light shade only. These crop types included:

- Essential oils: lemon grass, vetiver, patchouli
- Spices: pepper vine, cinnamon, ginger, vanilla, cardamom, wild turmeric
- Fruits: pineapple, annona species, and guava
- Root crops and vegetables: taro, arrowroot, yams, long beans, and velvet bean
- Herbs: oregano, basil, and chili pepper
- Building/fiber materials: rattan, fan palms

- Mushrooms: many culinary and medicinal fungi thrive in the understory
- Other: coffee, tea, cacao, betel vine, kava

An example in Kona was cited where coffee farmers are experimenting with interplanting trees to provide a light canopy for their coffee trees.

3.3.5 Agrivoltaic Case Studies Worldwide

Several agrivoltaic projects have been developed throughout the world during the past several years. Most have been demonstration or research projects designed to evaluate the effectiveness of various design parameters and treatments. These have including testing many different types of crops and various panel spacing configurations to vary the amount of shade / sunlight available to the crops. The following summarizes some of the available results, and **Appendix C** provides a list of agrivoltaic projects referenced in preparation of this plan. Notably, these studies are from around the world, so it is important to conduct research to determine what works best in Hawaiʻi's climate and conditions, which is what is currently being studied by HARC (see **Section 4.3** for further detail).

Generally, agrivoltaics work best for plants that are shade tolerant/resistant. Increased shade providing less light to the plants can reduce production/yields for many crops. Some crops with shade tolerance showing the greatest agrivoltaic potential have included hog peanut, alfalfa, yam, taro, cassava, sweet potato, and lettuce. Specific to lettuce, a research study on the shade tolerance of various crops in Hawaiʻi showed that increased shade up to 30 percent actually increased lettuce production (Wolff, 1988). Studies showed favorable results for vineyards, corn, and additional crops also.

In addition, several studies have suggested that the climate under the solar panels is suitable for growing pollinator species – allowing both local bee / honey production as well as providing improved pollination of adjacent and nearby agricultural lands. Seven states have enacted legislation to promote pollinator-friendly solar development (CESA, 2020).

Most studies showed significant reduction of moisture evaporation under the panels. This reduced the amount of water needed for irrigation and improved production of non-irrigated crops during dry years or seasons. It also allowed the production of crops in some areas that would otherwise be too arid. Also, though not included in this evaluation, several PV solar projects have successfully incorporated the development of pasture grasses under the PV panels with associated grazing.

Obviously, some of the crops studies in other locations are not suitable or applicable in Hawaiʻi. Mahi Solar has consulted with HARC on potential crops that may be successfully integrated into the solar infrastructure in the Kunia area. Based on initial findings, HARC will evaluate additional crops as discussed in Section 4.0 of this plan.

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4.0 Mahi Solar Agrivoltaic Program

Mahi Solar will implement an Agrivoltaic Program to study what type of agrivoltaic farming would be successful in Hawaii and then engage local farmers and ranchers to pursue these activities at commercial scale at the solar project. The purpose of the program is to increase agricultural productivity on the land used for the project, increase the acreage used for agriculture in the region, increase the use of IAL land on the project site, and share the results of what works with both the solar and agriculture industries. Mahi Solar consulted with HARC, Hawaiʻi Farm Bureau, Hawaiʻi Agricultural Foundation, and several local commercial farmers and ranchers to help develop an informed plan for realistic agricultural activities at the site.

Through the Agrivoltaic Program, local farmers and ranchers will have the opportunity to license or sub-lease plots of land at the project site for agricultural activities. The Agrivoltaic Program is designed to be flexible to support different business models. Land and water will be provided to farmers at a nominal cost to assist support these activities at a commercial scale. Mahi Solar will also add or upgrade agricultural infrastructure across the project. This agricultural plan ensures that agricultural productivity is not only retained on the land but is increased.

The following sections compares existing agriculture uses at the site to the planned agricultural activities during the life of the solar project and details the three phases of the Agrivoltaic Program.

(1) **Research** - Prior to completion of the solar project, HARC will study types of solar-compatible farming and best practices work in Hawaiʻi.
(2) **Farming** - Support local farmers with land, water, and start-up funds to grow viable products. Compares existing uses of land to planned uses during the program.
(3) **Sharing Data**: Collect and share data on what works in agrivoltaics with both industries to improve dual use of land between agriculture and clean energy.

A table summarizing agricultural activities proposed for each project area is provided in **Section 1.0**, **Table 1**.

4.1 Phase 1: Research

The Kunia lands are some of the best agricultural sites in Hawaiʻi with deep soil, excellent sunlight and available water. In the initial phase of the Agrivoltaic Program, HARC will evaluate potential viable agricultural uses to learn what practices work best and could be grown at a larger scale by farmers. Beginning trials of potential crops, forage, and hydroponics will advance the understanding what farming products can be productively grown with solar, along with practices that will help farming and solar co-exist successfully. Early research can also gather data about the conditions and microclimates of the solar PV installation to better inform farming efforts, for example the solar irradiance under and between the rows of panels. This information will continue to be implemented as appropriate, throughout the life of the solar project.

In the initial research phase of this agricultural plan, HARC will conduct farming trials of different crops off-site at an existing solar project in Mililani in a collaboration with Clearway Energy. HARC will study what types of solar-compatible farming could be grown successfully at a commercial scale at the Mahi Solar project. The HARC, (formerly the Hawaiian Sugar planters' Association) has extensive knowledge of the Kunia lands and suitable crops for the area. Because of their knowledge and association with current agricultural operations in Kunia, including those growing leafy greens and herbs, HARC is a suitable partner for the initial phase of the Agrivoltaic Program to test, monitor, and report on potential agricultural activities. HARC's off-site demonstrations will likely occur from now through 2023 while the project is in construction. They will likely be involved with the agricultural component of Mahi Solar, in addition to other partners mentioned throughout this plan. The following section outlines HARC's research phase of the plan. A summary is also provided in **Appendix B**.

While studies have been ongoing for over 20 years in agrivoltaic systems, it is important to first determine the microclimates that are conducive for certain crops. Data for temperature, radiation, humidity, and wind speed are being collected over an extended period to determine the microclimate. The 620-acre site of solar panels provides opportunities to include several types of agricultural operations depending on the various slope, soil type, and block sizes for sublease. Within a commercial solar project, there are some limitations relating to crop selection that may be compatible with the height of panels, width of rows between panels, shading under panels, farming practices, and requirement of fire hazard management related to vegetation. Crop recommendations are in part based on the solar array site plan dimensions. The proposed arrays are approximately 13-feet-wide and are aligned north to south in order to track the path of the sun east to west throughout each day (**Figure 7**). There is an approximately 9-foot-wide aisle or "alley" between adjacent arrays of panels when they are in the horizontal position.

In addition to the demonstrations, preliminary observations and expertise in the Kunia region were considered in the selection of agricultural operations to implement. Two general agricultural operations will be implemented, monitored, and reported on, including improved animal forage and production of market crops, concentrating on leafy greens. Planting both grasses and crops beneath and between the panels is proposed for the project area. The animal forage agricultural option will include both grazing of on-site sheep and forage production (e.g., alfalfa).

4.1.1 Animal Forage Including Nitrogen-Fixing Legumes and Nutritious Grasses

In current agrivoltaic practice, sheep are grazed on weeds under some existing solar arrays; however, the grazing of sheep can be improved by establishing mixtures of nitrogen fixing legumes such as alfalfa and perennial peanut and high quality, low growing grasses such as bahiagrass, oats and barley. The panels on the higher steep sloped locations in the project are targeted for this proposed practice. The forages can either be grazed or cut and transported. Alfalfa is well known for attracting bees and will be one of the initial grazing crops evaluated both to support grazing and for establishing an apiary for honey production.

After successful development of improved forage for sheep grazing and determination of locations within the project site that are most appropriate for this activity, free range chickens may also be evaluated as potential co-use.

4.1.2 Market Crops

The project takes advantage of the current expertise in Kunia for growing and marketing crops such as varieties of lettuce, basil, sweet potato and other vegetables. There is a large market in Honolulu for leafy greens and other vegetables that the project could help fulfill. Several local farmers and ranchers have indicated an interest in farming the land at the project site as part of this Agrivoltaic Program. Based on their expertise , they believe several activities can be successful between and under the solar panels. Some of the proposed activities include the following: hydroponic lettuce, which could yield

$20,000 per acre per year; basil, which could yield $7,000 per acre per year; alfalfa, which could yield $4,000 per acre per year; and lamb, which could yield $700 per acre per year, as well as pollinator-friendly plants to support honey production. While the land area (acres) allotted for each activity will not be finalized until after construction, **Table 1** in **Section 1.0** presents the proposed allocation of acreage for different agricultural activities proposed thus far. Additional crops will be included upon verification of the concept.

Lettuce and basil are ideally suited for hydroponic culture and are proposed for the initial trials. Hydroponics is an obvious technology to employ in conjunction with solar panels. It uses significantly less water compared to conventional farming and does not require plowing the soil. There is considerable experience with growing crops under elevated stationary panels: however, less information is available for the rotating panels proposed by Mahi Solar. As such, both hydroponic and conventional soil planted crops are proposed for evaluation. The advantages and disadvantages of each method are described below.

Hydroponic

Based on hydroponic methods already in practice at Kunia Country Farms, plastic lined troughs will be placed on a slight slope end to end and parallel to a table of panels. The troughs are filled with a shallow amount of water to accommodate Styrofoam rafts with holes drilled for net pots which support the crop. An alternative method, called ebb and flow uses an intermittent shallow flow of water which is quickly drained. Both methods will be assessed for yield and water efficiency.

<u>Advantages:</u>

- Existing large market for leafy greens predominantly supplied by imports
- Hydroponic growing of many crops is well established, so multiple crops can be considered
- Panels will supply shade needed by some crops and prevent sunburn (needs to be determined)

Good wind protection by panels <u>Disadvantages</u>

- Requires water tank and monitoring of nutrients and pH
- Requires a recirculating pump and electricity
- Frequent monitoring (can be minimized by technology)
- Minimal slope of the trough beds is critical

Conventional growing of market crops

The space between the panels can also be used for growing rows of crops in the ground using reduced tilling methods. These methods will be compared to hydroponics in the initial trials.

<u>Advantages</u>

- Similar to hydroponics

<u>Disadvantages</u>

- Need to time crop cultivation between panel servicing needs
- Possible soil getting on the panels during the agricultural operations
- Depending on method of irrigation there may be interference with the panel efficiency

4.2 Phase 2: Farming

Of the 620 acres of land leased for the project, approximately 314 acres consists of land that is not currently being used for agricultural activity. Therefore, 306 acres of land within the project area is currently in active agricultural production. Only 98.8 acres are currently in active food production. A portion of Area 4B is currently used to grow basil, while area 4C is used to cultivate other vegetables. Additionally, 207.2 acres encompassing Areas 2B, 2C, 3, and 4A, is being used by the landowner for production of seed corn. See **Figure 8** for a map of existing agricultural uses.

In the second phase, after construction of the Mahi Solar project is complete and in operation in 2023, research from Phase 1 will be applied Phase 2, as full-scale agricultural activities on the site will be implemented with local farmers and ranchers on 610 acres, or approximately 98 percent, of the entire solar project (**Figure 9**). Approximately 2 percent of the project site will be used for the high-voltage equipment in the substation, switchyard, and the BESS facility. These components consist of fenced gravel yards and are not conducive or safe for farming or ranching activities. Plots ranging from 20 to 100 acres will be licensed or subleased to farmers and ranchers, who will conduct agrivoltaic projects that they believe will be successful. Mahi Solar will provide land and water at a nominal cost so that farmers can carry out these activities at commercial scale.

Several stakeholders have expressed the intention to undertake agricultural activities at the site, including HARC, Hartung Brothers (alfalfa forage), and Oʻahu Grazers (livestock grazing) (see **Appendix A**). HARC has also documented interest from Kunia Country Farms (hydroponic lettuce), Alluvion (nursery products), Fat Law Farms (basil), and Island Bee Removals (honey production) (**Appendix B**). While the land area (acres) assigned to each farmer cannot be determined until after construction, **Table 1** of **Section 1.0** and **Figure 9** presents the proposed allocation of area for different agricultural activities proposed thus far.

The program will include local agricultural organizations and agencies to share information and best practices with farmers, including the U.S. Department of Agriculture (USDA), Hawaiʻi Department of Agriculture, Oʻahu Soil and Water Conservation District, HARC, Hawaiʻi Farm Bureau, Agricultural Leadership Foundation, Agriculture Foundation of Hawaiʻi, University of Hawaiʻi College of Tropical Agriculture and Human Resources, as well as individual farms and others in the farming community. The details of implementing the Agrivoltaic Program will be further refined and coordinated with stakeholders.

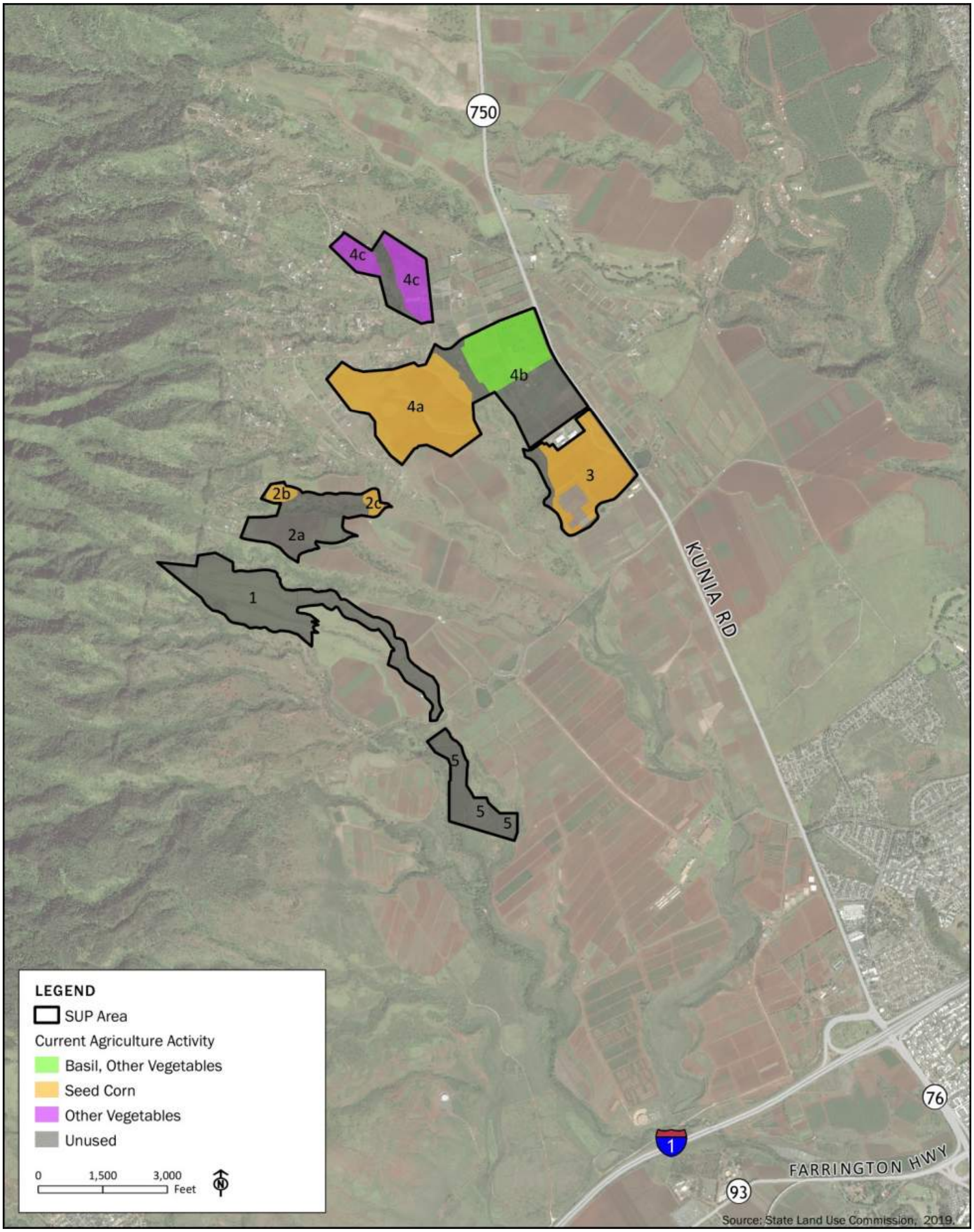

Figure 8
Current Agricultural Activity Map

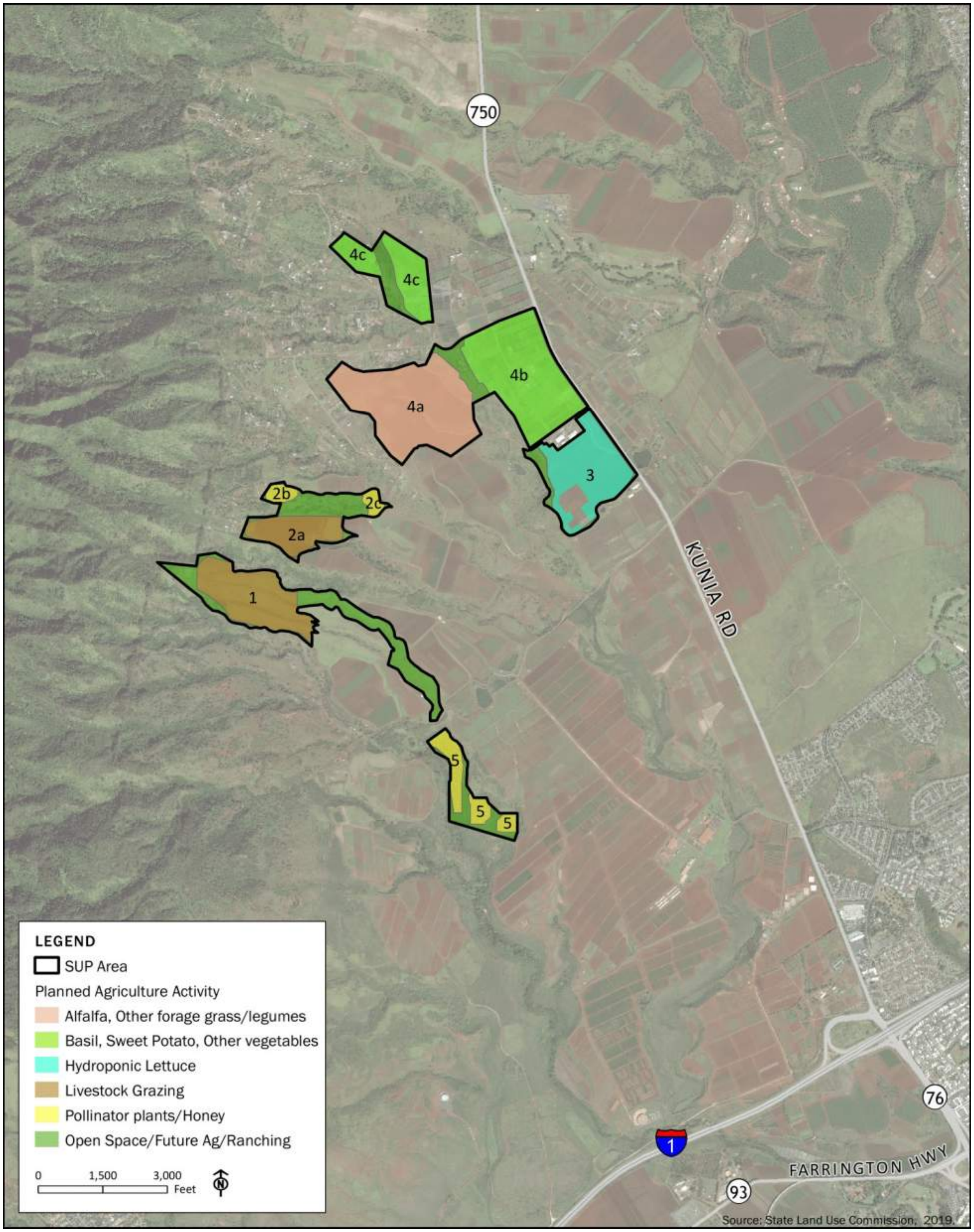

Figure 9
Planned Agricultural Activity Map

Full-scale farming at the site will support the sustained growth of the local agriculture industry and increase food production through long-term viable agricultural uses. **Figure 10** demonstrates the current food production at the project site compared to the planned food production. Currently, only 98.8 acres of the project area are used for food production. With the implementation of this Agrivoltaic Plan, 488.9 acres are planned for food production. Land and water will be provided to farmers and ranchers, at minimal cost, to farmers for them to grow agrivoltaic crops or products that will be commercially successful.

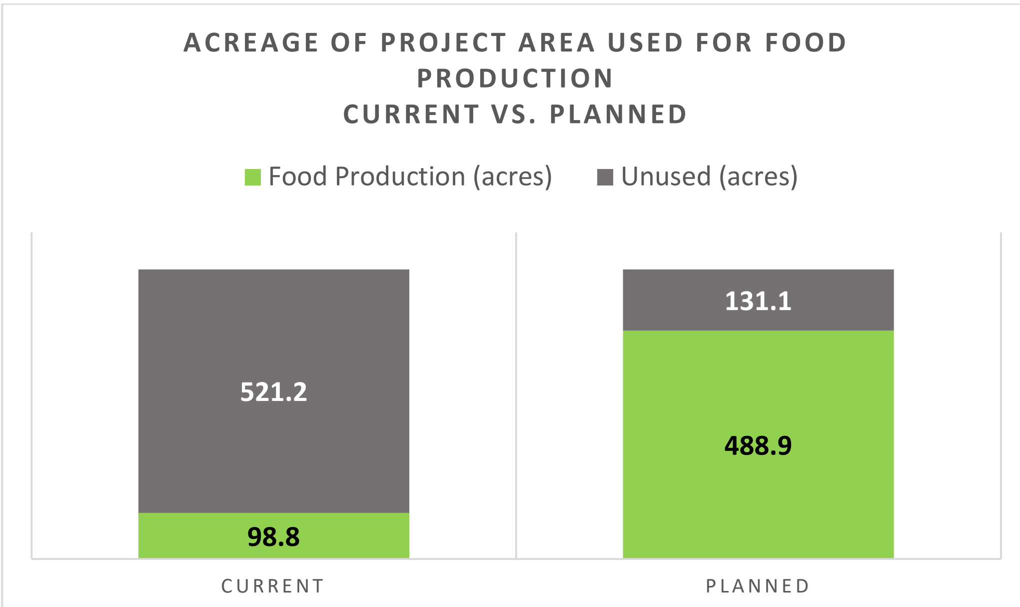

Figure 10
Acreage of Project Area in Food Production, Current vs. Planned

Mahi Solar will invest in adding or upgrading the agricultural infrastructure across the project site. Currently, 262.3 acres of the site that currently has water. Under this Agrivoltaic Program, approximately 444.2 acres of the 620-acre project site will include upgraded infrastructure. **Figure 11** demonstrates the current percentage of the project area with water infrastructure compared to planned conditions. Physical improvements to the project site, including IAL lands, will be limited to the minimum necessary to support these agricultural uses and activities. This effort will maintain the affordability of these lands for farmers, therefore supporting diverse agricultural activities, creating incentives for farmers, and creating opportunities to expand agricultural income and job opportunities.

The program is designed to be flexible to include multiple farmers that can test different products and to continue to iterate and learn about what can be grown successfully. This will establish best practices for compatible solar and agricultural activities throughout the state. Best practices will include no-till practices that will increase carbon sequestration on the site. Soil conservation will also be improved in the project area by no longer clearing the areas of vegetation. With the implementation of this agricultural plan, Mahi Solar is investing resources in farming practices that will help local farmers be successful while also supporting the production of carbon-free energy to the island via the operational solar farm.

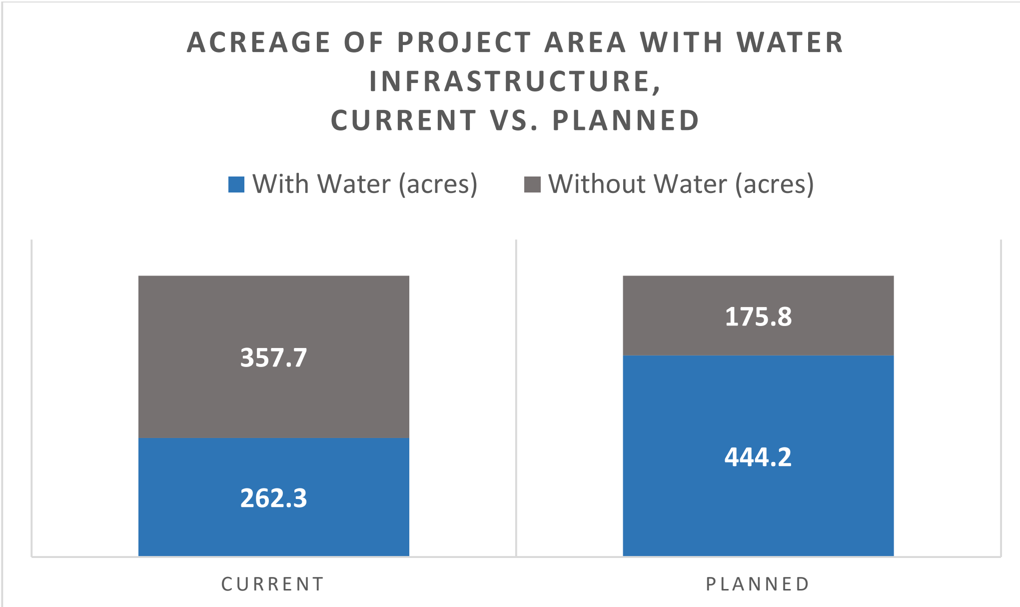

Figure 11
Acreage of Project Area with Water Infrastructure

4.3 Phase 3: Sharing Data

Mahi Solar believes that a key outcome from this Agrivoltaic Program will be sharing the results of the effort to support farming in concert with a solar farm. While agrivoltaics is a practice demonstrated to work around the world, it is important to conduct research to determine what works best in Hawai'i's climate and conditions in order to harness the full potential of agrivoltaics across the state and to help meet food production and renewable energy goals. Mahi Solar is now working with HARC to conduct off-site research and an active examination of trial crops prior to construction of the project. This research will be practically applied to commercial farming activities at the solar farm, which will begin during operation of the solar farm. A goal of the Agrivoltaic Program is to research and grow dozens of different agrivoltaic crops and livestock practices over the next 25 years. As each new use is tested in research trials or grown in the solar fields by farmers, Mahi Solar will gather data and evaluate the results, and farmers and ranchers will continue to learn and modify their methods and crops in an iterative process. Using scientific methods of analysis, this informational research could be published for review and used to increase the knowledge base for other farmers and solar farm operators. By studying what crops and other products are compatible with solar farms, the program will be able to share results with other solar developers, operators, farmers, researchers, and agencies, benefitting not only Hawai'i but potentially communities throughout the world.

Mahi Solar will share this critical information and findings with the broader community, so that farmers and solar developers can find new and more productive ways of using Hawai'i's agricultural land for both farming and renewable energy. The research plan will be developed as more details of the farming practices are determined for the site (i.e., crop types, farm size, farming methods, effect of shading vs unshaded areas, etc.)

5.0 Site Description

5.1 Project Location and Existing Uses

The Mahi Solar project is located on portions of TMKs (1) 9-2-001:020 and (1) 9-2-004: 003, 006, 010, and 012 in Kunia, Oʻahu, Hawaiʻi. The project area encompasses portions of five TMKs totaling approximately 620 acres, identified in **Table 2**. Longroad Energy will lease the lands for the duration of the solar project operations. The project lands are designated as Agricultural by the State Land Use Commission and is zoned as AG-1, Restricted Agricultural District by the City and County of Honolulu's Land Use Ordinance (LUO). The site is planned for "Agriculture and Preservation" uses within both the City and County of Honolulu Central Oʻahu Sustainable Communities Plan (SCP) and ʻEwa Development Plan.

Historically, the project area was part of a larger region of ʻEwa District dedicated to commercial sugarcane agriculture. Today, the project site currently consists of actively farmed areas, undeveloped and fallow agricultural land, overgrown natural vegetation, and structures associated with farming and business operations. Actively farmed areas on the project site are used for the cultivation of crops, including seeds and corn. The use of these farmed areas on the project site will be phased out to focus farming operations to more productive lands on each parcel. Less productive land will be shifted to solar uses and agrivoltaics. Leasing less productive lands for solar and agrivoltaics will enable the landowners to continue farming the more productive portions of their property.

The project area is surrounded by agricultural land to the north, south, east, and west. A portion of the project site is also bound by the Honouliuli Forest Reserve and State-owned vacant preservation land to the west. The National Park Service (NPS) Honouliuli National Historic Site is located adjacent to the southwest of the proposed site. The Royal Kunia residential development is located further southeast. Kunia Loa Ridge Farmlands directly adjacent to the northwest portions of the site.

5.2 Climate and Wind Patterns

The project area is located in Kunia, where the summers are hot, muggy, and dry and the winters are long and comfortable, and it is windy and mostly clear year-round. Over the course of the year, the temperature typically varies from 65°F to 87°F and is rarely below 59°F or above 89°F. The hot season lasts for about 3.5 months, from mid-June to early-October, with an average daily high temperature above 85°F. The cool season is typically from December to March, with an average daily high temperature below 81°F.

Kunia experiences significant seasonal variation in monthly rainfall and wind speeds. The project area experiences an average annual rainfall of approximately 30 inches annually, with the highest precipitation occurring between the months of October through March (**Figure 12**). The average hourly wind speed in Kunia exhibits significant seasonal variation over the course of the year. The windier part of the year lasts for about 4 months, from June to September, with average wind speeds of more than 14.4 miles per hour.

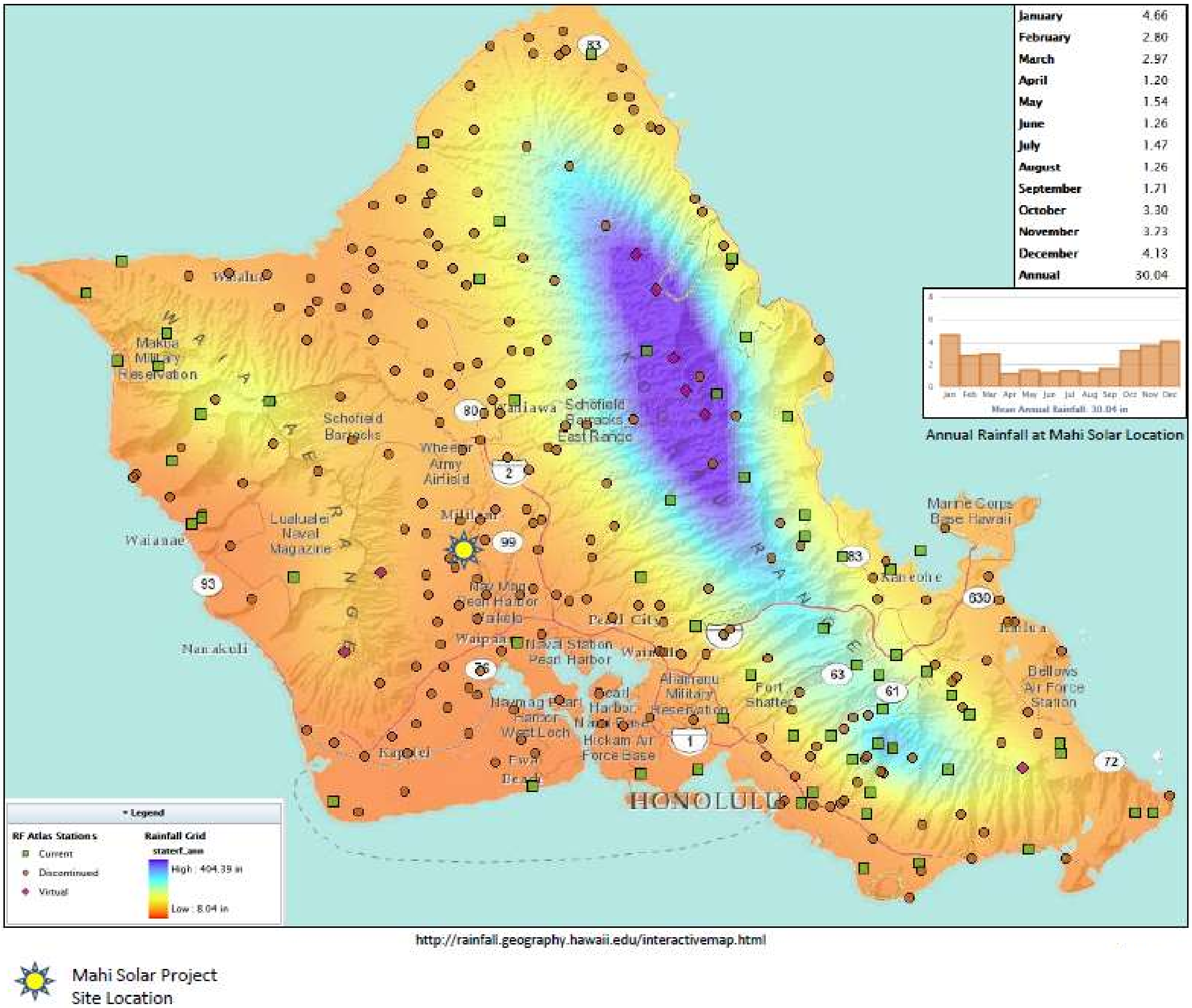

Figure 12
Annual Rainfall, O'ahu, Hawai'i

5.3 Soil Types and Classifications

The project area contains multiple soil classifications and groupings as defined by the U.S. Department of Agriculture (DOA) Natural Resource Conservation Service (NRCS) (**Figure 13**). Each soil type and associated characteristics are described below.

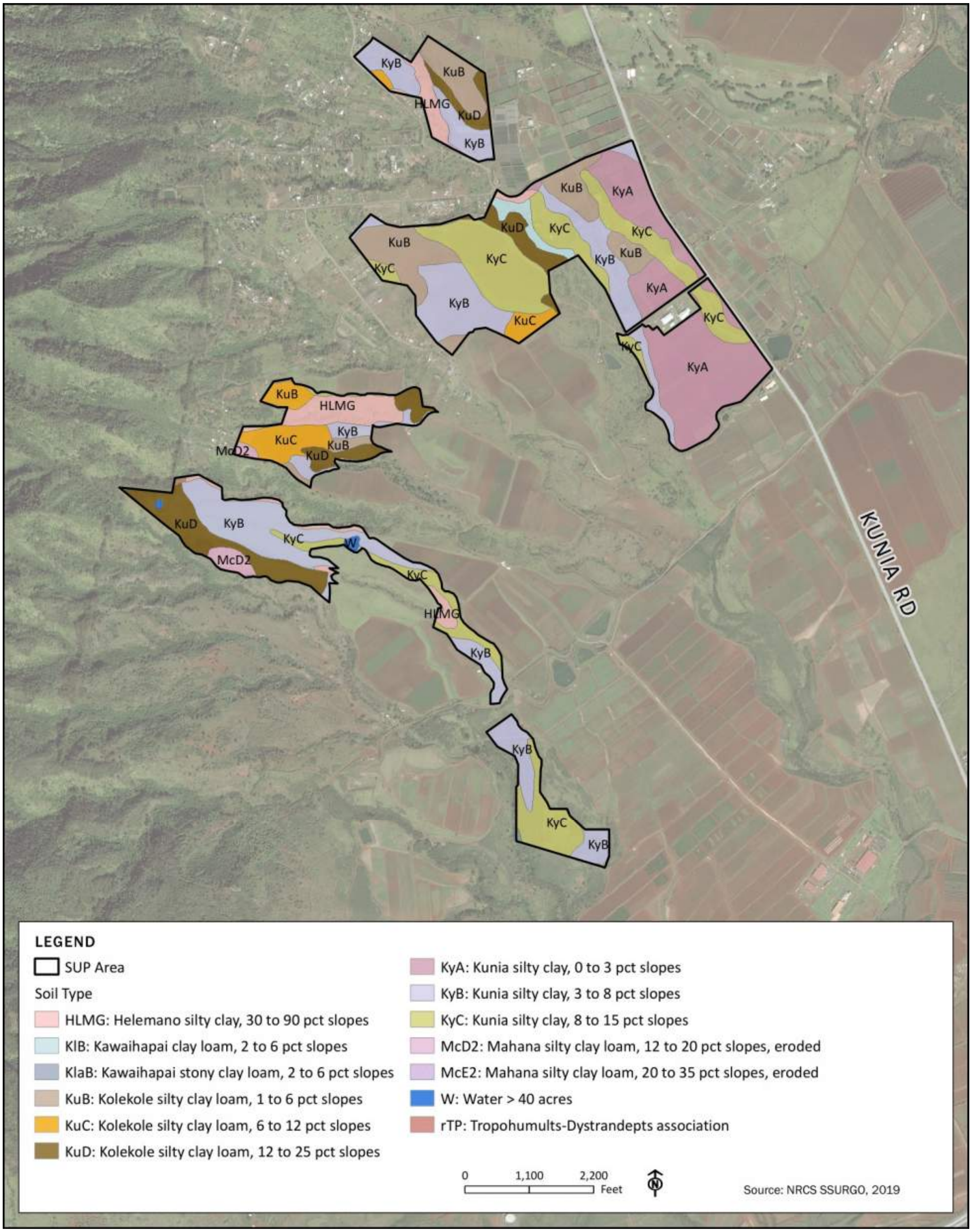

Figure 13
Soils Map

- **Helemano silty clay, 30 to 90 percent slopes (HLMG)** – On this soil, permeability and runoff are rapid, and the erosion hazard ranges from severe to very severe. This soil is used for pasture, woodland and wildlife habitat.
- **Kawaihapai clay loam, 0 to 2 percent slopes (KlA)** – This soil is characterized by moderate permeability, slow runoff, and an erosion hazard that is no more than slight. In some places, this soil is subject to flooding. This soil is used for sugarcane, truck crops, pasture, and orchards.
- **Kawaihapai clay loam, 2 to 6 percent slopes (KlB)** – On this soil, runoff is slow and erosion hazard is slight. This soil is used for sugarcane, truck crops, and pasture.
- **Kawaihapai stony clay loam, 2 to 6 percent slopes (KlaB)** – This soil is similar to KlA except that there are enough stones to hinder, but not prevent, cultivation. Runoff is slow and the erosion hazard is slight. This soil is used for sugarcane, truck crops, and pasture.
- **Kolekole silty clay loam, 1 to 6 percent slopes (KuB)** – This soil occurs on smooth slopes. Permeability is moderately rapid to the panlike layer and moderate in the compact subsoil. Runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.3 inches per foot of soil. This soil is used for sugarcane, pineapple, and pasture.
- **Kolekole silty clay loam, 6 to 12 percent slopes (KuC)** – On this soil, runoff is medium and the erosion hazard is moderate. Workability is slightly difficult because of the slope. This soil is used for sugarcane, pineapple, and pasture.
- **Kolekole silty clay loam, 12 to 25 percent slopes (KuD)** – This soil occurs on narrow side slopes, mainly along drainageways. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Workability is difficult because of the slope. This soil is used for pasture and pineapple.
- **Kunia silty clay, 0 to 3 percent slopes (KyA)** – This soil occurs on broad, smooth slopes. The soil is characterized by moderate permeability, slow runoff, and an erosion hazard that is no more than slight. This soil is used for sugarcane, pineapple, and homesites.
- **Kunia silty clay, 3 to 8 percent slopes (KyB)** – On this soil, runoff is slow and the erosion hazard is slight. This soil is used for sugarcane, pineapple, and homesites.
- **Kunia silty clay, 8 to 15 percent slopes (KyC)** – This soil occurs on narrow side slopes, mainly along drainageways. Runoff is medium, and the erosion hazard is moderate. This soil is used for sugarcane, pineapple, and homesites.
- **Lahaina silty clay, 7 to 15 percent slopes, severely erode (LaC3)** – On this soil, runoff is medium, and the erosion hazard is moderate. This soil is mainly used for sugarcane and pineapple. Small acreages are used for truck crops, pasture, and wildlife habitat.
- **Mahana silty clay loam, 12 to 20 percent slopes, eroded (McD2)** – This soil is characterized by rapid runoff and the erosion hazard is severe. Most of the surface layer has been removed by erosion. This soil is used for sugarcane, pineapple, and pasture.
- **Mahana silty clay loam, 20 to 35 percent slopes, eroded (McE2)** – This soil is characterized by rapid runoff and the erosion hazard is severe. Most of the surface layer has been removed by erosion. This soil is used for pasture, pineapple, and irrigated sugarcane.
- **Tropohumults-Dystrandepts association (rTP)** – Areas mapped as rTP consist of mountainous areas in the Waiʻanae Range on the island of Oʻahu. The areas are dominated by deep, V-shaped drainageways and narrow ridges. The slope ranges from 30 to 90 percent. Elevations range from 1,000 to 4,000 feet. Tropohumults occur on narrow ridgetops at the higher elevations. These are well-drained, strongly acid to extremely acid soils. Dystrandeptsare dark-colored, friable soils on steep side slopes and narrow ridgetops at the lower elevations. In most places the surface layer is silty clay. These soils formed mainly in volcanic ash, but partly in colluvium. They are well drained and medium to strongly acid. Most of the rTP association is very steep and inaccessible. It serves mainly as a watershed. At the lower elevations, the natural vegetation consists of

lantana, molassesgrass, and yellowfoxtail. At the higher elevations, the vegetation is mainly ohia, puakeawae, koa, aalii, and ferns.
- **Wahiawa silty clay, 0 to 3 percent slopes (WaA)** – This soil is found on the smooth, broad interfluves. The surface layer of the soil is dusky red and dusky red silty clay measuring approximately 12 inches thick and is medium acidic. The subsoil is a dark reddish-brown color measuring approximately 48 inches thick and is medium acidic to neutral. The underlying material is weathered igneous rock. On this soil, runoff is slow, and erosion hazard is no more than slight. This soil is used for sugarcane, pineapple, pasture, and homesites.
- **Water > 40 acres (W)** – Denotes areas 40 acres or less where water may exist.

5.4 Land Study Bureau (LSB)

The LSB of the University of Hawaiʻi prepared an inventory and evaluation of the State's land resources during the 1960s and 1970s. The LSB productivity rating system classifies land according to its soil properties, and productive capability. These properties include texture, structure, depth, drainage, parent material, stoniness, topography, climate, and rainfall. The five LSB classes include Class A, B, C, D, or E, with Class A representing the most productive soils and Class E representing the least productive soils.

The project includes soils rated by the LSB as Class B, C, D, and E (**Figure 14**). The project area does not contain soils designated as Class A. As noted in Hawaiʻi Revised Statutes (HRS) Chapter 205-4.5(21), "solar energy facilities" are a permitted use on lands classified by the LSB as Class B and C, with the approval of a SUP. An SUP is not required for development on lands classified as LSB D and E. Pursuant to HRS Chapter 205-4.5(21)(A), the project will include compatible agricultural activities at a lease rate of at least fifty percent below the fair market rent. The project will also meet decommissioning requirements as articulated in HRS Chapter 205-4.5(21)(B) and (C).

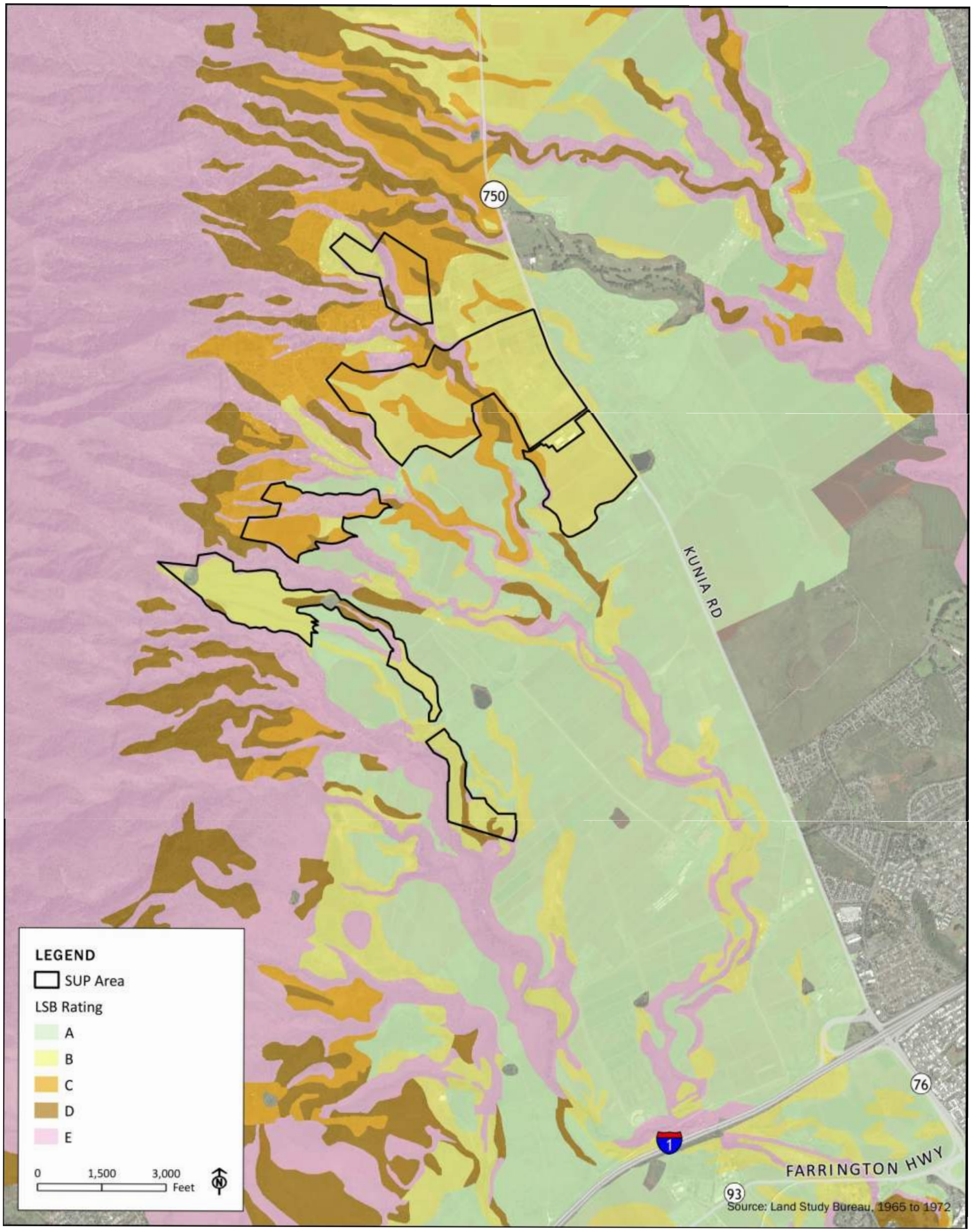

Figure 14
Land Study Bureau (LSB)

5.5 Agricultural Lands of Importance to the State of Hawaiʻi (ALISH)

The Agricultural Lands of Importance to the State of Hawaiʻi (ALISH) Classification System was developed and compiled in 1977 by the State of Hawaiʻi DOA with assistance from the NRCS, U.S. DOA and College of Tropical Agriculture at the University of Hawaiʻi. The ALISH system established the following three classes of agriculturally important lands for the State as part of a national effort to inventory important farmlands:

1) **Prime Agricultural Land**: Lands that are best suited for the production of food, feed, forage, and fiber crops. The land has the soil quality, growing season, and moisture supply needed to produce sustained high yields of crops.
2) **Unique Agricultural Land**: Lands that are typically used for the production of specific high-value food crops, for example coffee, taro, rice, watercress, and non-irrigated pineapple. This land has a special combination of soil quality, growing season, temperature, humidity, sunlight, air drainage, elevation, aspect, moisture supply, or other conditions, such as nearness to market, that favor the production of a specific crop of high quality and/or high yield when the land is treated and managed according to modern farming methods.
3) **Other Important Agricultural Land**: Land other than Prime or Unique Agricultural Land that is also of statewide or local importance for the production of food, feed, fiber and forage crops. The lands in this classification are important to agriculture in Hawaiʻi yet they exhibit properties, such as seasonal wetness, erodibility, limited rooting zone, slope, flooding, or drought, that exclude them from the other two classifications.

The classification of ALISH does not in itself constitute a designation of any area to a specific land use. Rather, the classification is intended to provide decision makers with an awareness of the long-term implications of various land use options for production of food, feed, forage, and fiber crops in the State.

The Mahi Solar project area is comprised of all three types of ALISH lands (Prime, Unique, and Other Important Agricultural Land), and unclassified lands where gulches exist (**Figure 15**).

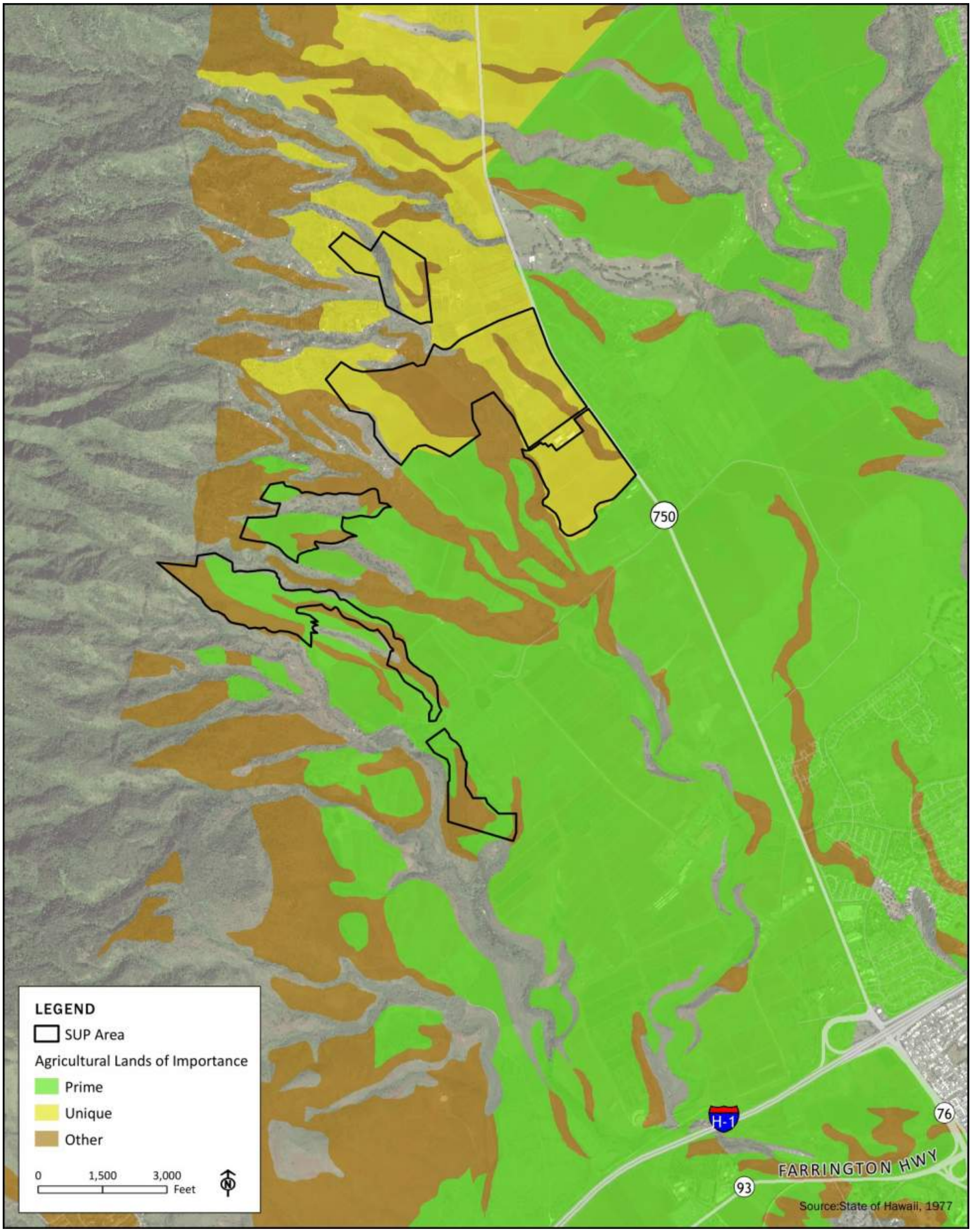

Figure 15
Agricultural Lands of Importance to the State of Hawai'i

5.6 Important Agricultural Lands (IAL)

Important Agricultural Lands (IAL) refers to a State land use designation for a select class of farmland intended to be used in the long-term for active agricultural production. The IAL designation is a supplemental State land use classification for an exclusive sub-set of high-quality farmland within the State Land Use Agricultural District. While only a small part of the project is located on IAL, these acres are critical for the solar project to generate the amount of clean solar energy needed for the state to reach its clean energy and greenhouse gas mandates. Furthermore, the IAL portion is not currently used for agriculture at all. As explained in this agricultural plan, the Mahi solar project will actually increase the agricultural use of these IAL lands and improve the agriculture infrastructure to make them more productive in the future.

Pursuant to HRS Chapter 205-42, IAL refers those lands that: 1) Are capable of producing sustained high agricultural yields when treated and managed according to accepted farming methods and technology; 2) Contribute to the State's economic base and produce agricultural commodities for export or local consumption; and 3) Are needed to promote the expansion of agricultural activities and income for the future, even if currently not in production. Farmers and landowners may petition their land for IAL designation should their land qualify under HRS Chapter 205-44. HRS Chapter 205-47 mandates that each county in the State conduct a mapping process to identify lands within their jurisdiction to be recommended to the LUC to be designated as IAL.

Of the total project area, approximately 69.5 acres is located within lands designated as IAL (**Figure 16**). IAL lands within Area 1 are identified by TMK (1) 9-2-004:006, which is owned by Hartung Brothers. The landowner completed a voluntary IAL designation of this land (LUC Docket DR18-61, June 1, 2018). IAL lands within Area 5 are identified by TMK (1) 9-2-001:020. The landowner, Monsanto Technology, LLC, completed a voluntary IAL designation of the land (LUC Docket No. DR17-59, November 15, 2017). Notably, parcel "020" was identified as parcel "001" in the LUC Decision and Order. None of the 69.5 acres of IAL land is currently in agricultural use.

Pursuant to HRS Chapter 205-47, the City and County of Honolulu DPP completed its IAL mapping project in 2018, titled *Report on the O'ahu Important Agricultural Land Mapping Project* (DPP, 2018). The report maps lands that meet the statutory requirements for consideration as IAL. The island of O'ahu comprises an approximate 386,000 total acres, of which roughly 128,000 acres is designed as State Agricultural District. Approximately 12,300 acres on the island have already been designated as IAL through the landowner-initiated process, accounting for nearly 10% of O'ahu lands in the State Agricultural District. DPP's IAL mapping effort recommends a total of 45,400 acres of land be designated as IAL, including lands that have already been designated through the landowner-initiated process and newly recommended lands. While not formally adopted as IAL, TMK (1) 9-2-004:010, owned by Fat Law's Farm, Inc., has been recommended by the City and County of Honolulu for designation as IAL. Areas 4A, 4B, and 4C are located within this parcel; therefore, 305.6 acres of the project are recommended for IAL designation. The City and County of Honolulu's IAL map has been adopted by the Honolulu City Council (Resolution 18-233, CD1, FD1), and is pending adoption by the LUC (see **Figure 17**).

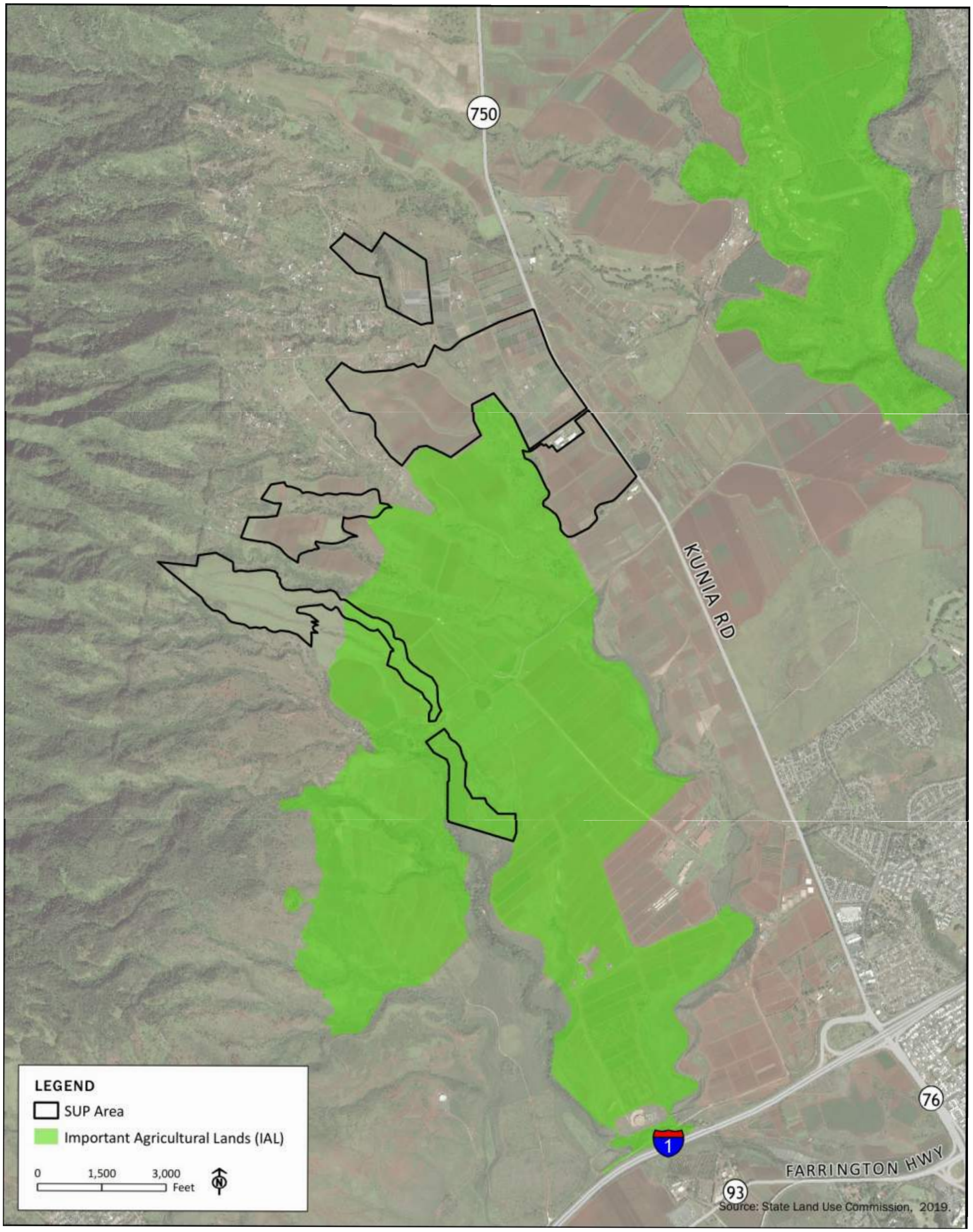

Figure 16
Important Agricultural Lands (IAL)

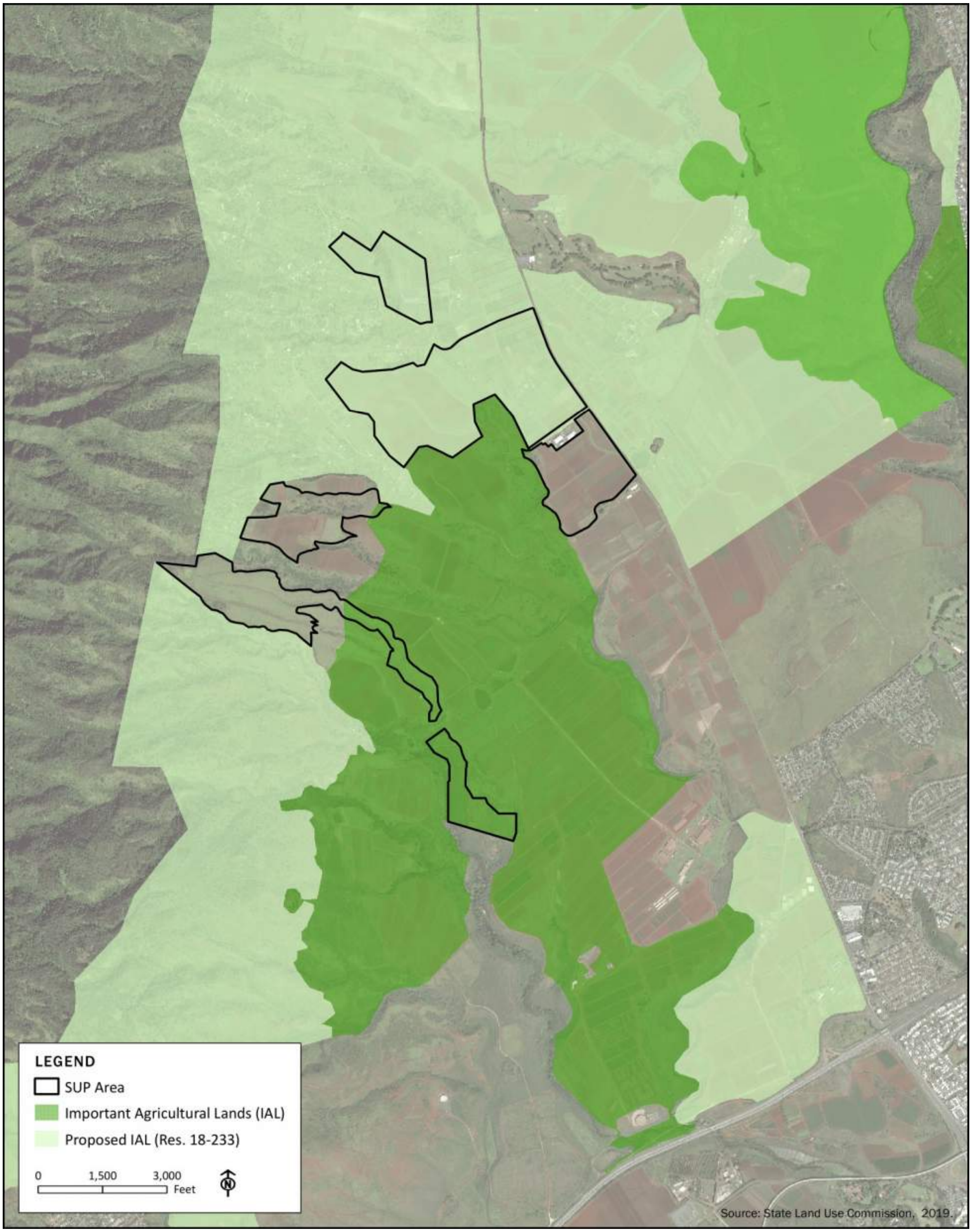

Figure 17
Important Agricultural Lands (IAL) - Proposed

The use of designated and proposed IAL lands within Areas 4A, 4B, 4C, and 5 of the project for solar panels is critical to ensuring the Mahi Solar project meets its commitment to generate enough clean energy to power 37,000 Oʻahu households per year. The use of IAL lands in the project area is also key to Mahi Solar's goal of contributing to local food production through agricultural uses and local, Hawaiʻi-specific research. The co-location of both solar and agricultural uses on IAL helps to state meet its energy and food production goals, resulting in public benefits for all.

The use of IAL lands for the project is consistent with the intent and policies of IAL lands articulated in HRS Chapter 205-43. Designated and proposed IAL lands within Areas 1, 4A, 4B, 4C, and 5 of the project area will be retained in blocks of contiguous, intact, and functional land units large enough to allow flexibility in agricultural production and management. There will be no fragmentation of IAL lands in these areas as only solar panels and agricultural uses beneath the panels are planned. Areas 1 and 5 are not currently used for agricultural activity. The project will implement agricultural uses within these plots, expanding agricultural cultivation and food production on the property and thus meeting the intent of IAL lands. See **Figure 18** illustrating IAL lands currently in agricultural use compared to IAL lands planned for agricultural use, and **Figure 19** showing IAL lands currently in food production and planned for food production. Portions of the area not designated for agricultural uses, including the substation, switch yard, and BESS areas located in Area 3, are not designated as IAL, further meeting the policies of IAL lands to ensure that uses on IAL are indeed agricultural uses.

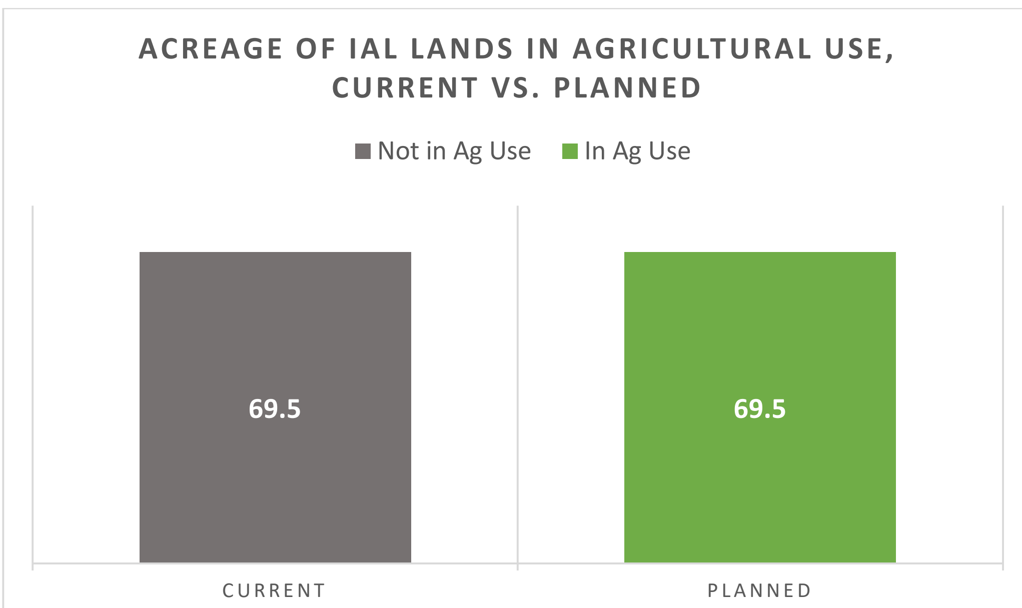

Figure 18
IAL Lands in Agricultural Use

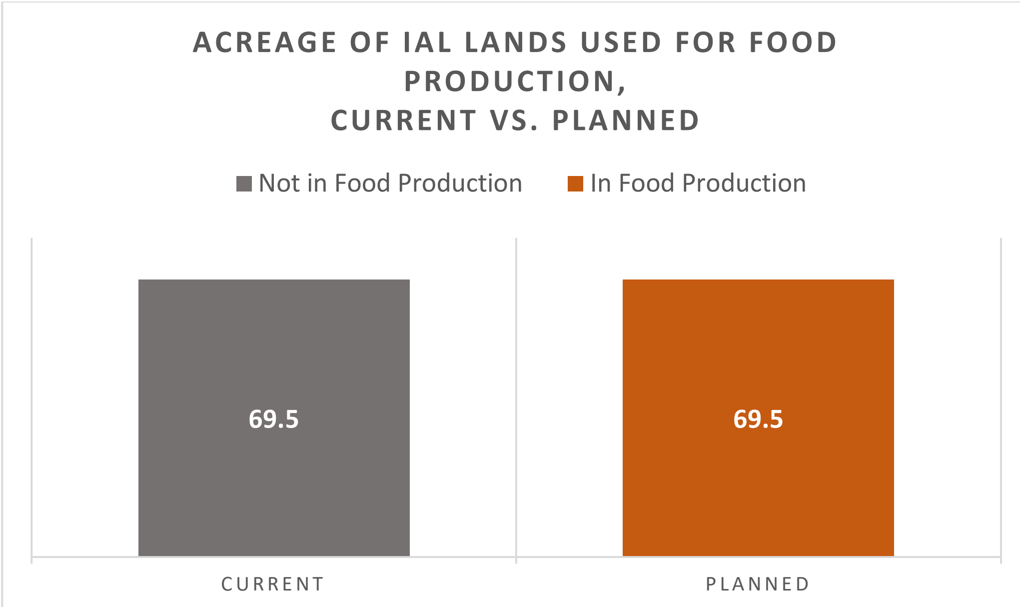

Figure 19
IAL Lands used for Food Production

Through the implementation of this plan, Mahi Solar proposes to continue agricultural uses within the project area by working with HARC to test crops and subsequently license farm plots of approximately 20-100 acres to local farmers at a nominal cost that is well below market pricing to grow viable crops beneath the solar panels. Farmers will be provided start-up resources such as funding and access to existing infrastructure, such as water. Essential agricultural infrastructure systems will be maintained as part of the lease agreements with landowners. Physical improvements on IAL will be limited to the minimum necessary to support these agricultural uses and activities. This effort will maintain the affordability of these lands for farmers, therefore supporting diverse agricultural activities, creating incentives for farmers, and creating opportunities to expand agricultural income and job opportunities. Proposed test crops as discussed in Section 5.0 will produce agricultural commodities for local consumption or export and contribute to the state's economic base.

The agricultural plan therefore dedicates the land to long-term viable agricultural uses, supports the sustained growth of the agriculture industry, and meets the overall objectives of IAL land articulated in HRS Chapter 205-42. Use of the vacant areas for solar will expand the footprint of the land in agricultural use including land which is not in current production as farmers and ranchers explore new uses for land under solar panels.

5.7 Water Supply

Kunia Water Association (KWA) provides water service to the site and surrounding agricultural lands. Onsite water supply for supporting the farming activities will be designed into the solar farm to ensure compatibility with the operation and maintenance activities. The Mahi Solar project will have access to water for agriculture through its lease agreements for the property. Irrigation infrastructure will be installed as needed with soft-material hoses and drip feeder lines strategically located to support crop production.

5.8 Hydrology and Drainage

There is no city storm drainage system in the project vicinity. State storm drainage systems in the vicinity are limited to concrete culverts crossing Kunia Road. There is no subsurface drainage system on the project property.

Elevation on the site varies from approximately 520 feet above mean sea level (amsl) in the southern end of project area to approximately 1,160 feet amsl in the west end. The property is located in Flood Zone D, areas with undetermined flood hazard.

The project site is located in the Honouliuli watershed, which encompasses approximately 23.2 square miles with a maximum elevation of approximately 3,045 feet amsl. Honouliuli Stream and its' larger tributaries have been classified as perennial features, which typically contain water throughout the year during periods of normal rainfall. Other water features outside of the project site include a variety of ditches and reservoirs used for agricultural purposes.

Drainage on site currently exists in the form of surface runoff based on the natural topography, with rainfall and run-off eventually flowing into the various ephemeral tributaries of Honouliuli Stream. All of the channels within the project area are classified as non-jurisdictional under the Clean Water Act.

Grading will be limited, and the project will not significantly alter existing drainage patterns. Rainfall runoff will be addressed through design features that incorporate temporary erosion controls and post-construction Best Management Practices (BMPs) to minimize potential runoff and water quality impacts. BMPs will be identified as part of a Temporary Erosion and Sediment Control Plan (ESCP) and Permanent Post-Construction BMP Plan, in accordance with DPP's Water Quality Rules (2018a). Temporary BMPs include minimization of soil disturbance, erosion prevention and sediment control measures (e.g., silt fencing, sediment traps/basins, etc.), proper stabilization and stockpiling procedures, and establishment of long-term vegetation outside of the farmed areas. Permanent BMPs will include retention, biofiltration, or filtration treatment controls.

6.0 Greenhouse Gas (GHG) Carbon Sequestration

Hawaiʻi's agricultural sector accounts for about 5 percent of the state's GHG carbon emissions (Jones, 2018). Through proper land management, agriculture has the potential to sequester rather than emit carbon through a process called carbon sequestration. According to the Food and Agriculture Organization (FAO) of the United Nations, carbon sequestration refers to improving "agricultural practices [to] help mitigate climate change by reducing emissions from agriculture and other sources and by storing carbon in plant biomass and soils" (FAO, 2017). Agricultural soils hold potential for expanded carbon sequestration and provide a prospective way of mitigating the increasing atmospheric concentration of carbon dioxide.

6.1 Existing Carbon Catalogue

To calculate potential carbon sequestration that would be gained or lost at the project site, project activities that may produce GHG emissions are first identified and catalogued. First, construction activities will require transportation of material to the site and the use of carbon-emitting construction equipment. This would be temporary and only last the duration of construction. Second, activities associated with operation of the project, including periodic lawnmowing and the use of vehicles by farmers and maintenance workers to visit the site, may also increase GHGs. These activities would last only during the project life of 35 years. The third potential source of GHG emissions would be the potential for the proposed solar and agriculture uses at the site to alter existing vegetation.

To measure the impact of these activities, the California Emissions Estimator Model® (CalEEMod) estimator was used to calculate the carbon capturing potential at the property in its existing condition. The vegetated portions of the project site can be classified into five predominant types: cultivated croplands, fallow fields, dry shrubland, dry forest, and dry grassland. Based on the existing land cover and activities at the site, the site has an existing carbon capture potential of 6,058 metric tons of carbon dioxide equivalent per year.

6.2 Mitigation

The project includes enough solar PV to generate clean, renewable energy to power 37,000 homes on Oʻahu. Additionally, approximately 610 acres will be dedicated to agricultural cultivation. The Agrivoltaic Program allows research organizations like HARC and local farmers and ranchers to propose agrivoltaic projects they believe will be successful at the site. Innovative farming practices that, in turn, may contribute to carbon sequestration, may also be implemented. Best practices proposed by the USDA, Natural Resources Conservation Service (NRCS) that could potentially be implemented include tillage management, animal forage planting (including nitrogen-fixing legumes and nutritious grasses), nutrient management, and feed management (NRCS, n.d.). Practices implemented would be at the discretion of the organization or individual farmer, and research may be shared with other solar developers, operators, farmers, researchers, and agencies.

Landscaping will be installed at portions of the site and includes the use of small trees and low visual screening plants. The practice of tree and shrub establishment is also identified by NRCS as a carbon sequestration best practice. Based on the proposed uses and ground cover, the CalEEMod model estimates that the project will reduce the carbon footprint of the island by 123,415 metric tons of carbon dioxide equivalent per year, thereby increasing the carbon capture potential of the site as compared to existing conditions.

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7.0 References

Clean Energy States Alliance (CESA). 2020. State Pollinator-Friendly Solar Initiatives. https://www.cesa.org/wp-content/uploads/State-Pollinator-Friendly-Solar-Initiatives.pdf

Dinesh, Harshavardhan; Pearce, Joshua M. 2016. "The potential of agrivoltaic systems" . Renewable and Sustainable Energy Reviews. 54: 299–308. doi:10.1016/j.rser.2015.10.024

Food and Agriculture Organization (FAO), United Nations. 2017. “What is Soil Carbon Sequestration?”. FAO Soils Portal. http://www.fao.org/soils-portal/soil-management/soil-carbon-sequestration/en/

Jones, T. (2018) Carbon Sequestration: challenges and opportunities for Hawaii’s farmers. Hawaiʻi Agriculture Research Center. Retrieved from: http://files.hawaii.gov/dbedt/op/carbon_farming_task_force/agendas/harc_presentation_status_hawaii_ farmers.pdf

United States Department of Agriculture (USDA), National Agricultural Statistics Service, Hawaiʻi Field Office. 2017. Top 20 Commodities - State of Hawaiʻi for 2017.

USDA, Natural Resources Conservation Service. n.d. “NRCS Practice Standards for Greenhouse Gas Emission Reduction and Carbon Sequestration.” https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/air/quality/?cid=stelprdb1044982

Wilkinson, Kim and Elevitch, Craig. 1998. Overstory #11 - Understory: A Unique Niche for Valuable Crops. AgroForestry. https://www.agroforestry.org/?id=254:overstory-11-understory-a-unique-niche-for-valuable-crops

Wolff, Xenia Yvette. 1988. Productivity of Vegetable Crops Grown Under Shade in Hawaiʻi. University of Hawaiʻi.

Appendices

Appendix A

Letters of Intent

December 15, 2020

Mahi Solar, LLC
Attn: Wren Wescoatt
330 Congress St, 6th Floor
Boston, MA 02210

Dear Mr. Wescoatt:

Hartung Brothers, Inc. is interested using a portion of the land at the Mahi Solar project site to grow alfalfa for livestock feed/forage/grazing. We currently grow alfalfa at our facility on Kauai and believe that it could be grown successfully under solar modules in Kunia. The alfalfa could provide a high-quality feed/forage/grazing for livestock like cattle, sheep, or chickens. It could provide a much better forage for grazing than California grass and weeds that are often found in local pastures.

Hartung Brothers, Incorporated is a family owned and operated agribusiness. Hartung Brothers, Inc.was founded out of a pure passion for agriculture. We have been developing a wide range of solutions for agriculture's producers and processors.

Hartung Brothers acquired the Hawaii operations of Syngenta in 2017 and has been a landowner and farmer in Kunia since then. We are familiar with the growing conditions at the solar farm site, and we are hopeful that alfalfa can be successfully farmed as a secondary crop along with the solar project.

Mahalo,

Joshua Uyehara
Vice President – General Manager, Hawaii Operations
Hartung Brothers Inc.

December 16, 2020

Wren Wescoatt
Mahi Solar Project
Wren.wescoatt@longroadenergy.com
RE: Mahi Solar land

Dear Mr. Wescoatt:

Oahu Grazers is the largest sheep ranching operation on the island of Oahu, with over 500 head of sheep and decades of experience in commercial ranching. Currently, we are in the process of expanding our sheep ranch to supply Oahu restaurants and stores with fresh locally raised, grass fed lamb. We graze sheep at the largest solar projects on the island, as shown below. The sheep can effectively graze the land under and around the panels, which provides the additional service of vegetation management by keeping grass and weeds lower so they don't shade the solar panels.

Our company would like lease a few hundred acres of the Mahi Solar project as additional pasture land so we can continue to grow our sheep ranching business. More pasture locations will enable us to keep several separate herds and selectively breed our stock for better and more consistent lamb production. Oahu Grazers also manages cattle and may be able to use part of the Mahi project area for young cattle, as well. We look forward to working together to utilize the land for both energy and food.

Thanks,

Daniel W Olsen, Daniel W Olsen Date: 12/26/20

Raia Olsen, Raia Olsen Date: 12/16/20

HARC

HAWAII AGRICULTURE RESEARCH CENTER

PO BOX 100, KUNIA, HAWAII 96759

TELEPHONE: (808) 621-1350 FAX: (808) 621-1359

http://www.harc-hspa.com

Mahi Solar, LLC
330 Congress St
6th Floor
Boston, MA 02210

December 17, 2020

Attn: To Whom it May Concern:

Hawaii Agriculture Research Center (HARC) is a 100+ year old agricultural research non-profit organization established to support agriculture in Hawaii. It's former sponsor, the sugar industry, cooperated within its members in research efforts to benefit the industry and the state. We are excited to have been contacted by Mahi Solar to explore the possibility of combining the solar infrastructure with agricultural operations. This is not a new concept and is being studied throughout the world. So far the biggest difference we have seen in what is on-gong else where and Mahi Solar's proposed operation is the solar panel layout. It presents some unique challenges which warrant evaluation which Mahi Solar has indicated that it will support.

HARC has worked with Mahi Solar on its agricultural plan which HARC feels is a work in progress. It has recruited a few successful agricultural operations that it believes can be adapted to this particular solar infrastructure: a lettuce operation; a nursery; and a basil grower. Other potential crops include alfalfa as a more nutritious forage for livestock and ilima, a ground cover, to support bees and honey production. While many different crop operations have been shown to have some success elsewhere, HARC is choosing to start with a few entrepreneurial operations which we feel have a good chance to be successfully integrated into the solar infrastructure in the Kunia area. Based on the initial findings HARC will evaluate additional crops. We feel confident that efficient and economically viable solutions will result.

Sincerely,

Stephanie Whalen
Executive Director

Appendix B

Hawaiʻi Agriculture Research Center (HARC) Solar White Paper

HARC **Hawaii Agriculture Research Center**

P.O. Box 100, Kunia, Hawaii 96759
Ph: 808-621-1350/Fax: 808-621-1359

February 22, 2021

Hawaii Agriculture Research Center (HARC} Agrivoltaic Project

Agrivoltaics is a term increasingly used to describe land use for the purpose of co-producing solar power and agricultural products. This multiple use benefits the public and fulfills Hawaii's goal of becoming both energy and food self-sufficient.

An article published in *Nature* by professors at the University of Arizona pointed out that much cropland offers the greatest potential for solar energy production. Their research and others has shown there are benefits for both operation:

For crop production

Provides shade for crops less tolerant to full sunlight

Reduces crop water demands because of greater soil water retention

Reduces infrastructure costs: land and water

Yields can increase, decrease or stay the same depending on the crop.

For energy production

Increases efficiency for energy production through heat reduction

Reduces degradation of panels

Reduces cost for weed control

Agrivoltaic projects are now being installed primarily in Europe and Asia but increasing in the United States. Massachusetts has a Local Food Action plan and a progressive solar energy program similar to Hawaii and sees agrivoltaics as a way to achieve both of these goals.

The most prominent current agricultural use is the grazing of sheep but work in vegetable and fruit production is increasing. Agricultural use is highly dependent on the type of solar array used, including the spacing and height of the solar panels.

In Hawaii there is interest in both grazing and vegetable production, including hydroponics among the solar arrays. Currently, sheep grazing is the only agricultural use among solar arrays. It provides meat and weed control. Forages can provide habitat for bees and consequently, honey production.

While studies have been ongoing for over 20 years in agrivoltaic systems there remains many questions as environments and panels are different in those studies. However, it is pretty much agreed that there are multiple reasons to pursue this co-use of the land, especially in Hawaii where land is limited and historically energy and agriculture have been pitted against one another. So it is important to determine the micro climates created by the solar arrays being proposed and already in existence here in the state.

HARC's and Mahi Solar's goal is to provide economical land use solutions in Hawaii for the integration of agriculture and photovoltaic operations to achieve the state's goals to have viable agriculture and renewable energy.

Work on this project is starting now in a similar array that ClearWire is providing HARC to initiate demonstrations on. This cooperator uses similar solar array equipment and layout and is in a similar environment to Mahi Solar's proposed new arrays. The initial work on ClearWire's site is to have identified some crops and farmers to be able to go into Mahi Solar's sites as soon as they are available. Microdata for temperature, radiation, humidity, and wind speeed will be collected below, beside and between the arrays over an extended period. HARC will be better able to match up the growth environment to the specific crop most suitable to that environment. Obviously these crops will also be suited for ClearWire's and some other sites. Demonstrations will continue to identify additional crops that are economically suited for these particular arrays and their micro environments. HARC will have field days to provide local farmers and solar operators the ability to learn what crops are suited for these environments. These field days will also provide the opportunity to introduce solar providers and farmers to explore the mutual beneficial arrangements.

From our preliminary observations, discussions and evaluations we are reasonably sure that leafy greens, some nursery crops, mushrooms and some herbs have the potential to be successful. These are the initial crops planned for evaluation on the ClearWire site. Demonstrations of these crop will be available by the time Mahi Solar's arrays are competed.

Interested agricultural producers have been identified: Kunia Country Farms, hydroponic lettuce, Alluvion, nursery products, Fat Law Farms, basil, and Island Bee Removals, honey production, have all expressed their interest in this project to demonstrate the economics for their products under solar conditions.

Upon identifying a cooperating shepherd and solar company with existing sheep and arrays improving existing forage (grasses) will be initiated. Alfalfa is planned to replace the existing volunteer grasses at a site. Alfalfa is an excellent forage and its flowers have good pollen production for bees/honey.

Multiple references follow this document. HARC has and will continue to review the global literature in the area of agriculture and solar operations combined to expedite realistic demonstrations.

Some references for agrovoltaic systems

https://onlinelibrary.wiley.com/doi/10.1002/aenm.202001189

https://ceramics.org/ceramic-tech-today/environment/tinted-semitransparent-solar-panels-for-agrivoltaics

https://link.springer.com/article/10.1007/s13593-019-0581-3 (a review 2019)

https://www.sciencedirect.com/science/article/abs/pii/S1161030112001177?via%3Dihub

https://www.researchgate.net/publication/284130981

https://smallfarms.cornell.edu/2020/07/solar-grazing-livestock-as-landscapers-at-utility-scale-solar-arrays/

https://news.un.org/en/story/2020/05/1063332

https://solargrazing.org/wp-content/uploads/2019/06/Solar-Grazing-Brochure.pdf

https://www.renewableenergyworld.com/solar/japan-next-generation-farmers-cultivate-agriculture-and-solar-energy/

Research by T. Sekiyama and Nagashima showed that an Agrivoltaic system was feasible even for shade intolerant crops

https://www.mdpi.com/2076-3298/6/6/65

Other applications include ornamentals, mushrooms and bee foraging.

https://doi.org/10.1021/acs.est.8b00020

Appendix C

Agrivoltaic Project Examples

CASE STUDY RESEARCH - AGRIVOLTAICS

Project Name	Entity Name	Location	Climate	Project Size (Acres)	Project Size (MW)	Panel Type	Project Configuration	Crop Type(s)	Irrigated (Y/N)	Source	Comments
N/A	Baofeng Group	Binhe New District, China	Desert	26,440 acres	640 MW (plans to expand to 1 GW)	Fixed Tilt	Rows of 72 cell solar panels installed at a height of 2.9m above ground, evenly spaced apart.	Goji berries	Yes, drip irrigation	https://www.pv-magazine.com/2020/09/03/giant-agrivoltaic-project-in-china/	Effectively reduced land moisture evaporation by between 30% and 40%. The vegetation coverage has purportedly increased by 85% while significantly improving the regional climate. This project has allowed farmers to grow crops (goji berries) on the edge of the Gobi Desert, a region where this would normally not be possible.
SJ Solar Tsukuba Power Plant	Shanghai Electric Power Japan Co., Ltd	Tsukuba City, Japan	Temperate	133 acres	35 MW	Fixed Tilt	Few specifics available, but they utilize a higher PV panel density, 50% coverage vs the "traditional" 30% coverage commonly used.	Korean ginseng, ashitaba, coriander and other crops	Yes	https://en.wikipedia.org/wiki/Agrivoltaic	Few project specifics available. In Japan as a whole, as of March 2017, 1296 Japanese farms had registered to install agrivoltaic systems. Their electricity generation capacity ranges from 10–393 kW, but the typical capacity is approximately 50 kW. These farms grow a wide range of crops blackberry, blueberry, broad bean, carrot, chestnut, eggplant, grape, ginger, leek, lettuce, mandarin orange, mushroom, pasture, peanut, persimmon, potato, radish, red bean, rice, spinach, tea, tomato, turnip, and wheat.
N/A	Sun'Agri	Tresserre Occitanie, France	Temperate	18.5 acres	2.1 MWp	Tracking	Few specifics available, this farm utilizes PV panels controlled to track sun or the shade requirement of crops. The panels look to be about 4-5m off the ground and spaced reasonably far apart, leaving room for harvesting equipment to pass underneath and allowing ample light through.	Wine Grapes	Yes	https://www.pv-magazine.com/2020/05/28/france-embraces-solar-with-viticulture-arboriculture-and-market-gardening/	This is the first of seven agrivoltaic projects the French government has selected with a planned total generation capacity of 12 MW in its latest tender for innovative PV technology. The arrays will be installed at no cost to the businesses concerned and financed by the sale of the electricity they generate.
35th Street agrivoltaic solar array	University of Oregon	Corvallis, Oregon	Temperate	6 acres	1435 kW	Fixed Tilt	Rows on 72 cell panels 2 high with no spacing between panels. Set 1.65m above ground and angle at 18 degrees. Rows are spaced 6m apart center-to-center.	Pasture Land	No	https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0203256	Found significant increase in soil water retention throughout the dry summer and solar panels remained closer to their ideal operating temperatures. They have started experimenting with crops similar to the Umass project.
Jack's Solar Garden	Byron Kominek	Boulder, Colorado	Arid	5 acres	1.2 MW	Fixed Tilt	Specific PV setup is not detailed but this farm was developed with help from NREL and University of Arizona. Appears to closely resemble the Biosphere 2 project PV layout.	40 different crop types are planned to be planted under PV panels, including tomatoes, blackberries, herbs and more.	Yes	https://www.5280.com/2020/09/how-jacks-solar-garden-hopes-to-transform-farming-for-good/	Will have the capacity to power 300 homes, generating revenue from selling the power generated. Also a potential 70% increase in food production.
N/A	Slatina secondary school for agricultural engineers/University of Osijek	Virovitica-Podravina, Croatia	Temperate	1.4 acres	500 kW	Fixed, Alternating Tilt	No mention of the height or angle the panels.	Organic vegetable crops, no specific crops listed	Yes	https://www.pveurope.eu/solar-generator/innovative-500-kw-agrophotovoltaic-installation-croatia	The annual capacity of the plant is 565.85 MWh.
N/A	Fraunhofer Institute for Solar Energy Systems	Herdwangen-Schönach, Germany	Temperate	.62 acres	195 kW	Fixed Tilt	5m high steel structures to allow for farm equipment to pass underneath. Few additional specs about system provided. Photos show a fairly conventional arrangement of solar panels	winter wheat, potatoes, celery, grass and clover leys	Yes	https://www.en-former.com/en/agrivoltaics/	Lower yield, which was attributable to shading. Despite the smaller crop, the efficiency of land use is increased by 60 percent, according to calculations by the institute.
Umass Research Farm Trials	University of Mass.	South Deerfield, MA	Temperate	Less than 1 acre	NA	Fixed Tilt	Two Parallel Rows of 72 Solar Panels (three solar panels mounted together to make a 'Panel Cluster'). Panel clusters are installed 7.5 ft off the ground. Spacing between panel clusters is between 2ft and 5 ft apart.	Kale, Swiss Chard, Lettuce, Beans, Broccoli and Peppers	No	https://ag.umass.edu/clean-energy/research-new-initiatives/dual-use-solar-agriculture	2016 was a very hot, dry summer, and shaded plants produced a slightly higher yield compared to the unshaded control group. But in contrast, 2017 was a wet, cool summer and the control group outperformed the shaded crops. Suggests that argivoltaics may increase the drought-resistance of traditionally drought-intolerant crops.

Biosphere 2	University of Arizona	Oracle, Arizona	Semi-arid	Less than 1 acre	NA	Fixed Tilt	PV array—3.3 m off the ground at the lowest end and at a tilt of 32°. 1m spacing is used between panel rows	tomato, jalapeño and chiltepin	No	https://www.nature.com/articles/s41893-019-0364-5 https://www.nrel.gov/news/program/2019/benefits-of-agrivoltaics-across-the-food-energy-water-nexus.html	This project found an 2-3x increase in food production, 65% increase in water savings and 3% increase in power output in hotter months over the control groups.
N/A	Harvard University	Ichihara City, Chiba Prefecture, Japan	Temperate	Less than 1 acre	4.5 kW	Fixed Tilt	72 PV modules (1354 mm x 345 mm) mounted at a height of 2.7 m and tilted at an angle of 30°. In the high-density configuration, there were eight PV module arrays (48 modules) spaced at 0.71 m intervals. In the low-density configuration, there were four PV module arrays (24 modules) spaced at 1.67 m intervals.	Sweetcorn	No	https://dash.harvard.edu/handle/1/42004145	This study showed that it is possible to grow corn, a typical shade-intolerant crop, under the shade of agrivoltaic PV panels. The biomass of corn stover grown under high-density PV module arrays was no less than 96.9% that of control while the biomass of corn stover grown under low-density PV module arrays was even greater than the control by 4.9%. The corn yield per square meter of the low-density configuration was larger than both the high-density configurationand the control configuration. This study also indicated that the annual revenue from PV power generation and the corn harvest in an agrivoltaic farm could be larger than that of a traditional corn field. The total revenue of the high-density configuration was 8.3 times larger than that of the control configuration, whereas that of the low-density configuration was 4.7 times larger.
N/A	Hans Günter Czaloun	South Tyrol, Austria	Subtropical, Oceanic	Less than 1 acre	N/A	double-axis module tracking	PV panels supported by a cable structure five to six meters off of the ground. Cables also provide tracking movement.	N/A	N/A	https://www.pveurope.eu/solar-generator/rope-rack-pv-modules	This innovative system provides many advantages over some traditional support structures. Relatively large areas of panels can be supported by only 4 structures, allowing for better use of space under the panels and providing a higher level of resistance to ground-based hazards, (flooding, farm equipment, grazing animals)

Other Relevant Agrivoltaic Research / Articles

NREL	Summary	https://www.nrel.gov/news/program/2019/benefits-of-agrivoltaics-across-the-food-energy-water-nexus.html
NREL	Summary with map of research projects	https://www.nrel.gov/news/features/2019/beneath-solar-panels-the-seeds-of-opportunity-sprout.html
Anthropocene	Summary article	https://www.anthropocenemagazine.org/2018/09/the-resurgence-of-solar-agriculture/
Department of Energy	Summary information about agrivoltaics	https://www.energy.gov/eere/solar/farmers-guide-going-solar
Center for Pollinators in Energy	Pollinators	https://fresh-energy.org/beeslovesolar/
PV Europe	Croatia	https://www.pveurope.eu/solar-generator/innovative-500-kw-agrophotovoltaic-installation-croatia
Renewable Energy World	Japan	https://www.renewableenergyworld.com/2013/10/10/japan-next-generation-farmers-cultivate-agriculture-and-solar-energy/
PRI	Summary article	https://www.pri.org/stories/2018-06-08/energy-and-food-together-under-solar-panels-crops-thrive
Science Direct	Techno-economic analysis	https://www.sciencedirect.com/science/article/pii/S030626192030249X
Greenomics World	Summary article	https://www.greenomicsworld.com/agrophotovoltaics-or-agrovoltaics-the-future-of-modern-farming/
Springer Link	Summary article	https://link.springer.com/article/10.1007/s13593-019-0581-3
Nature Research Article	Study of land types with high potential for agrivoltaic farming.	https://www.nature.com/articles/s41598-019-47803-3
Clean Energy States Alliance	State pollinator initiatives for solar	https://www.cesa.org/wp-content/uploads/State-Pollinator-Friendly-Solar-Initiatives.pdf

Appendix D

Mahi Solar Project Biological Resources Report, Pueo Survey Addendum, and Gen-tie Desktop Review Addendum Prepared by SWCA Environmental Consultants October 2020, November 2020, and December 2020

Mahi Solar Project
Biological Resources Report

NOVEMBER 2020

PREPARED FOR

Longroad Energy Management, LLC

PREPARED BY

SWCA Environmental Consultants

MAHI SOLAR PROJECT
BIOLOGICAL RESOURCES REPORT
DRAFT

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SWCA Project No. 61736

November 13, 2020

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1 INTRODUCTION

Longroad Energy Management, LLC (Longroad), contracted SWCA Environmental Consultants (SWCA) to provide Biological Resource Assessments for the Mahi Solar Project (formerly Kupehau [Project]). The focus of the 2018 survey was to determine the potential for federally listed and state-listed species (special-status flora and/or fauna) to occur at the project site (study area) as well as to identify critical issues related to natural resources permitting. Based on the findings of the 2018 report, SWCA conducted suitable habitat surveys in 2020 for special-status plants, the O‘ahu ‘elepaio (*Chasiempis ibidis*), and Hawaiian short-eared owl or pueo (*Asio flammeus sandwichensis*) to determine the likelihood of their presence in the study area.

Located in the Ewa Region within the Honouliuli watershed on the Island of O‘ahu, the proposed project would occupy approximately 617 acres of land across several parcels within Tax Map Keys 9-2-001:001, 9-2-004:012, 9-2-004:006, 9-2-004:003, and 9-2-004:010 (Figure 1). At 120 megawatts (MW), the project would produce 4% of the O‘ahu’s electricity annually, enough to power 37,000 local homes, enabling the Hawaiian Electric Company, Inc., to burn less fossil fuel and emit less greenhouse gases. A 480 MW-hour battery system would store solar energy generated during the day to provide power at night, and an electrical substation would connect to the O‘ahu grid.

1.1 Regulatory Environment

This section describes laws and regulations applicable to terrestrial flora and fauna in the context of the project.

1.1.1 *Endangered Species Act*

The federal Endangered Species Act (ESA) of 1973, as amended, is regulated by the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration National Marine Fisheries Service and protects wildlife and plant species that have been listed as threatened or endangered. It is designed to conserve the ecosystem on which species depend. Candidate species, which may be listed in the near future, are not afforded protection under the ESA until they are formally listed as endangered or threatened. Section 9 of the ESA and rules promulgated under Section 4(d) of the ESA prohibit the unauthorized take of any endangered or threatened species of wildlife listed under the ESA. Under the ESA, the term *take* means “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect species listed as endangered or threatened, or to attempt to engage in any such conduct.” As defined in the regulations, the term *harm* means “an act that actually kills or injures wildlife; it may include significant habitat modification or degradation, which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering” (50 Code of Federal Regulations [CFR] 17.3). The rules define *harass* to mean “an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent, as to significantly disrupt normal behavior patterns, which include, but are not limited to, breeding, feeding, or sheltering” (50 CFR 17.3).

The ESA affords maximum legal protections to species listed as threatened or endangered under the law and also provides authorization for incidental take permits for take that occurs incidental to otherwise legal operations. To comply with federal laws, additional measures must be taken to ensure that take of ESA-listed species does not occur as a result of the solar project. Any fatality of a listed species should be reported to the USFWS and the Hawai‘i Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW) as soon as possible, and an incident report should be filed within 24 hours of detection of the fatality.

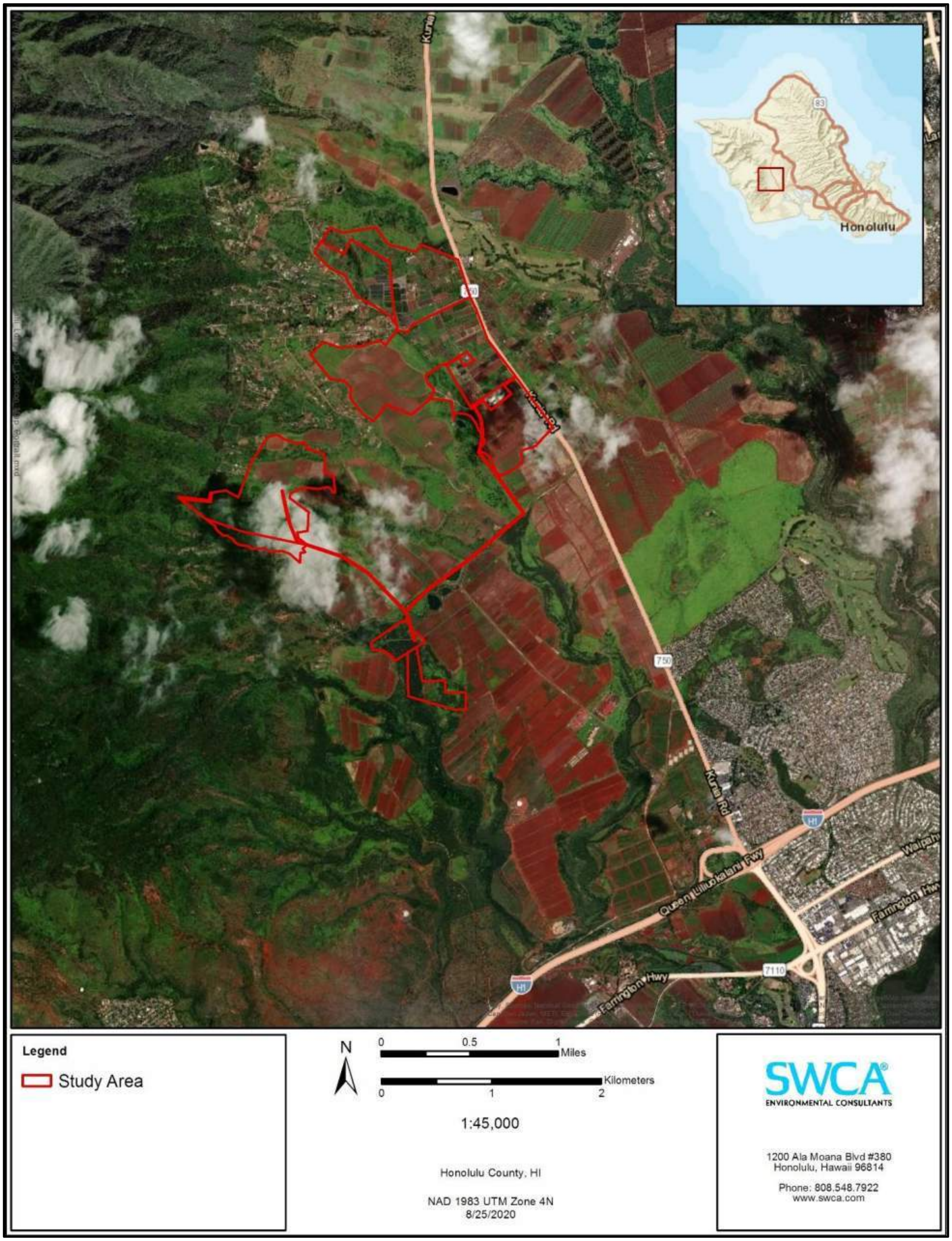

Figure 1. Mahi Solar Project study area.

1.1.2 *Migratory Bird Treaty Act*

The Migratory Bird Treaty Act (MBTA) of 1918, as amended, is regulated by the USFWS and prohibits the take of migratory birds. A list of birds protected under MBTA-implementing regulations is published under 50 CFR 10.13. Unless permitted by regulations, under the MBTA, “it is unlawful to pursue, hunt, take, capture or kill; attempt to take, capture or kill; possess, offer to sell, barter, purchase, deliver or cause to be shipped, exported, imported, transported, carried or received any migratory bird, part, nest, egg or product” (16 United States Code 703–712). The MBTA provides no process for authorizing incidental take of MBTA-protected birds. As a result, birds that are not covered under the ESA that may be adversely affected by the project cannot be covered by take authorizations. Additionally, a 2017 memorandum from the U.S. Department of the Interior (M-37050, December 22, 2017) posited that the MBTA does not prohibit the incidental taking of migratory birds. Regardless, incidental take of individual MBTA-protected species is unlikely to adversely affect the species as a whole; however, any take of MBTA-protected species should be documented and reported in a similar manner to that of any endangered or threatened species of wildlife listed under the ESA.

1.1.3 *Hawai‘i Revised Statutes Chapter 195D*

The purpose of Hawai‘i Revised Statutes (HRS) Chapter 195D is “to insure the continued perpetuation of indigenous aquatic life, wildlife, and land plants, and their habitats for human enjoyment, for scientific purposes, and as members of ecosystems.” Section 195D-4 states that any endangered or threatened species of fish or wildlife recognized by the ESA shall be so deemed by the state statute. Like the ESA, the unauthorized take of such endangered or threatened species is prohibited (HRS Section 195-D-4[e]), but incidental take licenses can be obtained (HRS Section 195D-21). In addition to species protected under the ESA, rules adopted under HRS Section 195D-4 allow for the listing of indigenous species as threatened or endangered due to the following reasons:

- Habitat destruction or alteration (current or predicted)
- Overexploitation
- Disease or predation
- Lack of regulatory mechanisms
- Other factors threatening the species’ continued existence

Determinations are made based on all available sources of data (scientific, commercial, and other) and consultation with appropriate agencies (federal, state, and county) and interested organizations and parties.

1.2 Description of the Study Area

The study area borders Kunia Road in central Maui. It is approximately 1.8 miles north west of Village Park and about 4.2 miles north of Kapolei. The study area consists of approximately 617 acres of land owned by Hartung Brothers, Law Farms, and Bayer. The mean annual rainfall is approximately 31.8 inches (80.7 centimeters); rainfall is typically highest in January and lowest in June (Giambelluca et al. 2013). The study area is currently used by Hartung Brothers, Law Farms, and Bayer for agriculture production. Although the surrounding area is predominantly agricultural, there are residential areas nearby.

The reconnaissance-level Biological Resources Assessment in 2018 covered a smaller study area, while the suitable habitat surveys in 2020 for special-status plants and the Oʻahu ʻelepaio focused on the 2020 study area shown in Figure 1.

2 METHODS

Before the field survey, SWCA conducted a literature review of the study area to determine whether habitat for MBTA, ESA, and HRS Chapter 195-D protected species may be present. The following information was reviewed:

- *Waiawa Energy Ahupuaʻa Proposal for Net-Positive Clean Energy Community and Grant of Easement* (Longroad 2017)
- Aerial imagery
- Study area photographs
- Draft Revised Recovery Plan for Hawaiian Forest Birds
- Hawaiʻi's State Wildlife Action Plan
- The USFWS Information for Planning and Consultation (IPaC) website

2.1 2018 Biological Resources Assessment

During the March 1, 2018, site visit, SWCA conducted a pedestrian field survey to characterize the flora and wildlife present or likely to be present in the study area. This site visit took place from 12:00 p.m. to 2:00 p.m. Species recorded during this survey are indicative of wet conditions and other current environmental factors at the time of the survey. It is possible that additional surveys conducted at a different time of year or time of day may result in minor variations in the number of species and the abundance of flora and fauna observed. SWCA noted any visual and auditory observations and signs, such as scat or prints, indicating animal presence. Field observations were conducted using 10 × 42–millimeter binoculars. All bird, mammal, reptile, amphibian, and invertebrate species seen or heard in or near the study area were noted. In addition, potential habitat for federally listed or state-listed threatened and endangered species and birds protected under the MBTA were noted, if present. Acoustic surveys for the endangered Hawaiian hoary bat or ʻōpeʻapeʻa (*Lasiurus cinereus semotus*) were not conducted; however, areas of suitable bat habitat for foraging and roosting were noted when present.

2.2 2020 Special-Status Flora and Oʻahu ʻElepaio Suitable Habitat Survey

Two SWCA botanists and one wildlife biologist conducted pedestrian and vehicular special-species habitat surveys for listed plants and the Oʻahu ʻelepaio in the study area on July 24 and August 10, 2020. The objective of the surveys was to characterize the vegetation of the area to determine the likelihood of occurrence. Areas in close proximity to Oʻahu ʻelepaio critical habitat and areas more likely to support native plants (e.g., rocky outcrops and forested areas) were more intensively examined.

2.3 2020 Hawaiian Short-Eared Owl Survey

Three SWCA biologists are currently conducting surveys to determine the presence of the Hawaiian short-eared owl in the study area (see Figure 1). These surveys are being conducted using methods from Price and Cotín (2018) and are carried out in the late evening, starting between 60 and 75 minutes before sunset and lasting until 30 minutes after sunset. Observations of both pueo and barn owls are being recorded. Surveys consist of three survey periods spaced at least 3 weeks apart to increase the probability of detecting pueo, as recommended by Price and Cotín (2018). The results of the Hawaiian short-eared owl surveys will be reported in a forthcoming addendum. Owl detections that occur outside of the survey period are also being recorded and included in the results.

3 RESULTS

The following section describes the results of the special-status flora and fauna habitat surveys in the study area.

3.1 Flora

No threatened, endangered, or special status species were seen during surveys. The habitat observed has been transformed by previous land use and is either dominated by non-native invasive species or used for cultivation of crops. The habitat is therefore poor for the majority of special-status species. The vegetated portions of the study area can be classified into five predominant types: cultivated croplands, fallow fields, grassland, koa haole forest, and non-native forest. Cultivated croplands are dominated by corn (*Zea mays*), with sparse weedy vegetation such as koa haole (*Leucaena leucocephala*), golden crown-beard (*Verbesina encelioides*), and Guinea grass (*Urochloa maxima*) (Figure A-1). Fallow fields occur on level land that has recently been used for agriculture, and are dominated by greater than 95% Guinea grass, with occasional weedy vegetation such as koa haole, golden crown-beard, Formosan koa (*Acacia confusa*), and ʻuhaloa (*Waltheria indica*) (Figure A-2). Grasslands are also dominated by Guinea grass and occur on slopes, gulches, and other areas not recently used for agriculture (Figure A-3). Koa haole forest is dominated by thickets of short-statured koa haole trees, with an understory dominated by Guinea grass or buffelgrass (*Cenchrus ciliaris)* (Figure A-4). Non-native forest is made up usually of mixed non-native trees such as monkeypod (*Samanea saman*), Christmas berry (*Schinus terebinthifolius*), Formosan koa, and silk oak (*Grevillea robusta*), with an understory dominated by Guinea grass. Occasional stands of eucalyptus (*Eucalyptus* cf. *citriodora*) occur in several pockets in the study area, where thickets of these trees occur with an understory limited to bare ground or occasional Guinea grass (Figure A-5; see Figure A-3).

Three native species were seen during the surveys. Scattered individuals of ʻiliahialoʻe (*Santalum ellipticum*) occur in one area in the understory of a eucalyptus stand, where it was rare. Scattered individuals of wiliwili (*Erythrina sandwicensis*) occur in the dry lower gulches of the study area. ʻUhaloa was also seen throughout the study area along roadsides. None of these species are considered rare, and none are protected.

Though rare, prickly Russian thistle (*Salsola tragus*), also known as tumbleweed, was seen in the study area. This species has caused impacts to agricultural operations and road safety, inducing road closures on Maui, where it is more thoroughly established (Arakawa 2013; *The Maui News* 2017). Tumbleweed can be controlled using herbicides on managed land, but it has become most problematic on unmanaged land. This species is not yet widespread on Oʻahu.

3.2 Fauna

As listed above, a query was made on the USFWS IPaC website to determine whether undetected MBTA-protected birds may be present in the study area. SWCA used best professional judgement and knowledge of the site to narrow down the results of the query to likely species. The results of this query can be provided if requested. In general, most of the wildlife species expected to occur in the study area include assemblages that are found on O‘ahu between 200 and 365 meters (m) (650 and 1,200 feet) in elevation.

3.2.1 *Avifauna*

The IPaC resource query for this project listed 12 MBTA-protected bird species that could occur in the study area. Based on geographic location, available habitat, and SWCA’s best professional judgement, only two MBTA birds on the IPaC resource list are likely to occur: ‘apapane (*Himatione sanguinea*) and O‘ahu ‘amakihi (*Chlorodrepanis flava*).

In all, 18 bird species were observed during the 2018 site visit, including five MBTA-protected species (Table 1). The avifauna was not resurveyed during the 2020 O‘ahu ‘elepaio habitat assessment because the vegetation and environmental conditions of the study area were unchanged and the same species are expected to occur. Of the species observed, all are non-native permanent residents except for the Pacific golden plover (*Pluvialis fulva*), which is migratory. The study area could provide foraging habitat for all observed bird species. Of the observed MBTA-protected species, the cattle egret (*Bubulcus ibis*), Eurasian skylark (*Alauda arvensis*), house finch (*Haemorhous mexicanus*), and northern cardinal (*Cardinalis cardinalis*) are the only species that could nest in the study area. The Pacific golden plover does not breed in Hawai‘i.

Table 1. Birds Observed by SWCA (2018) in or near the Study Area

Common Name	Scientific Name	Status	MBTA
Black francolin	*Francolinus francolinus*	NN	
Cattle egret	*Bubulcus ibis*	NN	X
Chestnut munia	*Lonchura atricapilla*	NN	
Common myna	*Acridotheres tristis*	NN	
Common waxbill	*Estrilda astrild*	NN	
Domestic chicken	*Gallus gallus domesticus*	NN	
Eurasian skylark	*Alauda arvensis*	NN	X
Grey francolin	*Francolinus pondicerianus*	NN	
Japanese bush warbler	*Horornis diphone*	NN	
Japanese white-eye	*Zosterops japonicus*	NN	
House finch	*Haemorhous mexicanus*	NN	X
Northern cardinal	*Cardinalis cardinalis*	NN	X
Pacific golden plover	*Pluvialis fulva*	M	X
Red-crested cardinal	*Paroaria coronata*	NN	
Red-vented bulbul	*Pycnonotus cafer*	NN	
Rock pigeon	*Columba livia*	NN	
Spotted dove	*Streptopelia chinensis*	NN	

Common Name	Scientific Name	Status	MBTA
Zebra dove	*Geopelia striata*	NN	
Total		**18**	**5**

Notes: Status: M = migrant; NN = non-native permanent resident; MBTA: X = protected under the MBTA.

3.2.2 *Special-Status Species*

No species-specific surveys were conducted to determine whether federally listed or state-listed threatened, endangered, proposed, or candidate species or rare special-status species may occur in the study area; however, the study area could provide suitable habitat for the following special-status species, which are described in further detail below. Other threatened and endangered species were initially considered but were dismissed from further analysis because of a lack of suitable habitat or because the study area is out of their habitat range.

- Hawaiian hoary bat: State-listed and federally listed as endangered
- Oʻahu ʻelepaio: State-listed and federally listed as endangered
- Hawaiian goose or nēnē (*Branta sandvicensis*): State-listed and federally listed as endangered
- Hawaiian short-eared owl or pueo (*Asio flammeus sandwichensis*): State-listed as endangered

Hawaiian waterbirds

- Hawaiian coot or ʻalae keʻokeʻo (*Fulica alai*): State-listed and federally listed as endangered
- Hawaiian gallinule or ʻalae ʻula (*Gallinula galeata sandvicensis*): State-listed and federally listed as endangered
- Hawaiian stilt or aeʻo (*Himantopus mexicanus knudseni*): State-listed and federally listed as endangered

Seabirds

- Band-rumped storm-petrel or akēʻakē (*Oceanodroma castro*): State-listed and federally listed as endangered
- Hawaiian petrel or ʻuaʻu (*Pterodroma sandwichensis*): State-listed and federally listed as endangered
- Newell's shearwater or ʻaʻo (*Puffinus auricularis newelli*): State-listed and federally listed as threatened

3.2.2.1 HAWAIIAN HOARY BAT

Hawaiian hoary bats forage and roost in pasture, cropland, orchards, forests, and developed lands such as golf courses, urban areas, and suburban yards. Hawaiian hoary bats are solitary and roost in exotic and native woody vegetation. They could forage throughout the study area and roost in the extant trees. The birthing and pup-rearing season typically occurs between June 1 and September 15. It is common for adult females to leave flightless young unattended in "nursery" trees and shrubs while foraging.

3.2.2.2 O‘AHU ‘ELEPAIO

The O‘ahu ‘elepaio is an endemic forest bird that is considered to be a habitat generalist and is known to occur in a wide range of native and introduced forest types, ranging from 100 to 550 m (325 to 1,800 feet) in elevation (Conant 1977; DLNR 2015; VanderWerf 1993). Most O‘ahu ‘elepaio occur in areas with a continuous forest canopy and a dense understory, and population densities are roughly twice as high in tall riparian vegetation in valleys than in scrubby vegetation on ridges (USFWS 2006). Habitat for O‘ahu ‘elepaio is variable and dependent on the localized population. Habitat is commonly composed of alahe`e (*Psydrax odorata*), pāpala kēpau (*Pisonia umbellifera*), lama (*Diospyros sandwicensis*), hame (*Antidesma platyphyllum*), māmaki (*Pipturus albidus*), kaulu (*Sapindus oahuensis*), `āla`a (*Pouteria sandwicensis*), strawberry guava (*Psidium cattleianum*), common guava (*Psidium guajava*), kukui (*Aleurites moluccana*), mango (*Mangifera indica*), and Christmas berry (USFWS 2006).

The O‘ahu ‘elepaio’s diet includes a broad range of native and non-native invertebrates (e.g., insects, caterpillars, and spiders). Foraging behavior is diverse and occurs in the air and on the ground, including fallen logs, tree trunks, branches, twigs, and foliage (USFWS 2006). Nesting typically occurs from February to June but has been documented as early as January and as late as July (USFWS 2006; VanderWerf 1998). The O‘ahu ‘elepaio typically builds cup nests in the fork or top branch of a tree. The O‘ahu ‘elepaio could nest and forage in the study area trees.

Suitable nest and forage habitat for O‘ahu ‘elepaio occurs where the study area borders O‘ahu ‘elepaio critical habitat (Figure 2 and A-6). This habitat becomes less suitable as the distance from the critical habitat increases because the vegetation transitions from closed canopy continuous forest into an open canopy fragmented forest mixed with mixed with grassland and shrubland (Figure A-7; see Figure A-6). Although some of the habitat may be less suitable, because O‘ahu ‘elepaio are a forest and foraging generalist, some individuals may use less suitable forest up to 305 m (1,000 feet) from the O‘ahu ‘elepaio critical habitat in the study area for nesting and foraging.

3.2.2.3 HAWAIIAN GOOSE (NĒNĒ)

Nēnē occupy various habitat types ranging from beach strand, shrubland, grassland, and lava rock at elevations ranging from coastal lowlands to alpine areas (Banko 1988; Banko et al. 1999). The geese eat plant material, and the composition of their diet depends largely on the vegetative composition of their surrounding habitats. Most nēnē food items are leaves and seeds of grasses and sedges, leaves and flowers of various herbaceous composites, and various fruits of several species of shrubs (Black et al. 1994). They appear to be opportunistic in their choice of food plants as long as the plants meet their nutritional demands (Woog and Black 2001).

Potential forage and nest habitat are present for nēnē in the cultivated croplands and fallow fields of the study area. Nēnē were first observed on O‘ahu in 2014 where they nested and produced offspring in 2014 at James Campbell National Wildlife Refuge. This small population has been extirpated from O‘ahu (personal communication, Kelly Goodale, USFWS, September 1, 2020). When nēnē occurred on O‘ahu they were known to travel between Mililani (agriculture park and local golf course), James Campbell National Wildlife Refuge, and Turtle Bay Resort on the North Shore of O‘ahu. Because of the known geographic range and non-migratory lifestyle of nēnē, the species is highly unlikely to occur on the study area.

3.2.2.4 HAWAIIAN SHORT-EARED OWL

The Hawaiian short-eared owl is active during the day and occurs in a variety of habitats, including wet and dry forests, grasslands, and shrublands. Its diet consists of small mammals and birds (Holt and Leasure 2006). Little is known about the breeding biology of the Hawaiian short-eared owl, but nesting occurs throughout the year (USFWS 2013). Nests are made on the ground and are lined with grasses and feathers. The results of the 2020 surveys will be reported in a forthcoming addendum to this report.

3.2.2.5 HAWAIIAN WATERBIRDS

Three listed waterbird species—Hawaiian coot, Hawaiian gallinule, and Hawaiian stilt—could visit the study area. These species are found in a variety of wetland habitats, such as freshwater marshes and ponds; coastal estuaries and ponds; artificial reservoirs; kalo or taro (*Colocasia esculenta*) lo‘i, or patches; irrigation ditches; and sewage treatment ponds (USFWS 2011). The Hawaiian coot, Hawaiian gallinule, and Hawaiian stilt could visit and forage in the manmade water sources adjacent to the study area, such as the reservoirs and Wailoi ditch. It is unlikely that the Hawaiian coot, Hawaiian gallinule, and Hawaiian stilt would nest in the study area due to a lack of permanent water resources with aquatic vegetation.

3.2.2.6 SEABIRDS

Three listed seabird species—the endangered band-rumped storm-petrel, the endangered Hawaiian petrel, and the threatened Newell’s shearwater—could fly over the study area at night while traveling to and from their upland nesting sites and foraging areas in the ocean. It is very unlikely they would use the habitat available in the study area for anything other than flying over it.

3.3 Critical Habitat

No critical habitat for special-status species is located in the study area; however, the mauka portion of the site is within 1,300 m of USFWS-designated Lowland Mesic Unit 3 (see Figure 2), which provides protection for a number of federally listed plant species, including *Delissea subcordata*, laukahi kuahiwi (*Plantago princeps*), pōpolo‘aiakeakua (*Solanum sandwicense*), hāhā (*Cyanea grimseana* ssp. *obatae*), *Phyllostegia hirsuta*, ōpuhe (*Urera kaalae*), *Phyllostegia mollis*, *Phyllostegia parviflora*, kāmanomano (*Cenchrus agrimonioides*), and alani (*Melicope saint-johnii*).

Designated critical habitat for O‘ahu ‘elepaio borders the study area’s westernmost border (see Figure 2). Critical habitat for the O‘ahu ‘elepaio was designated in 2002. Although designated O‘ahu ‘elepaio critical habitat borders the study area, not all of the critical habitat is occupied. The closest O‘ahu ‘elepaio occupied designated critical habitat occurs approximately 830 m (2,723 feet) away from the western edge of the study area.

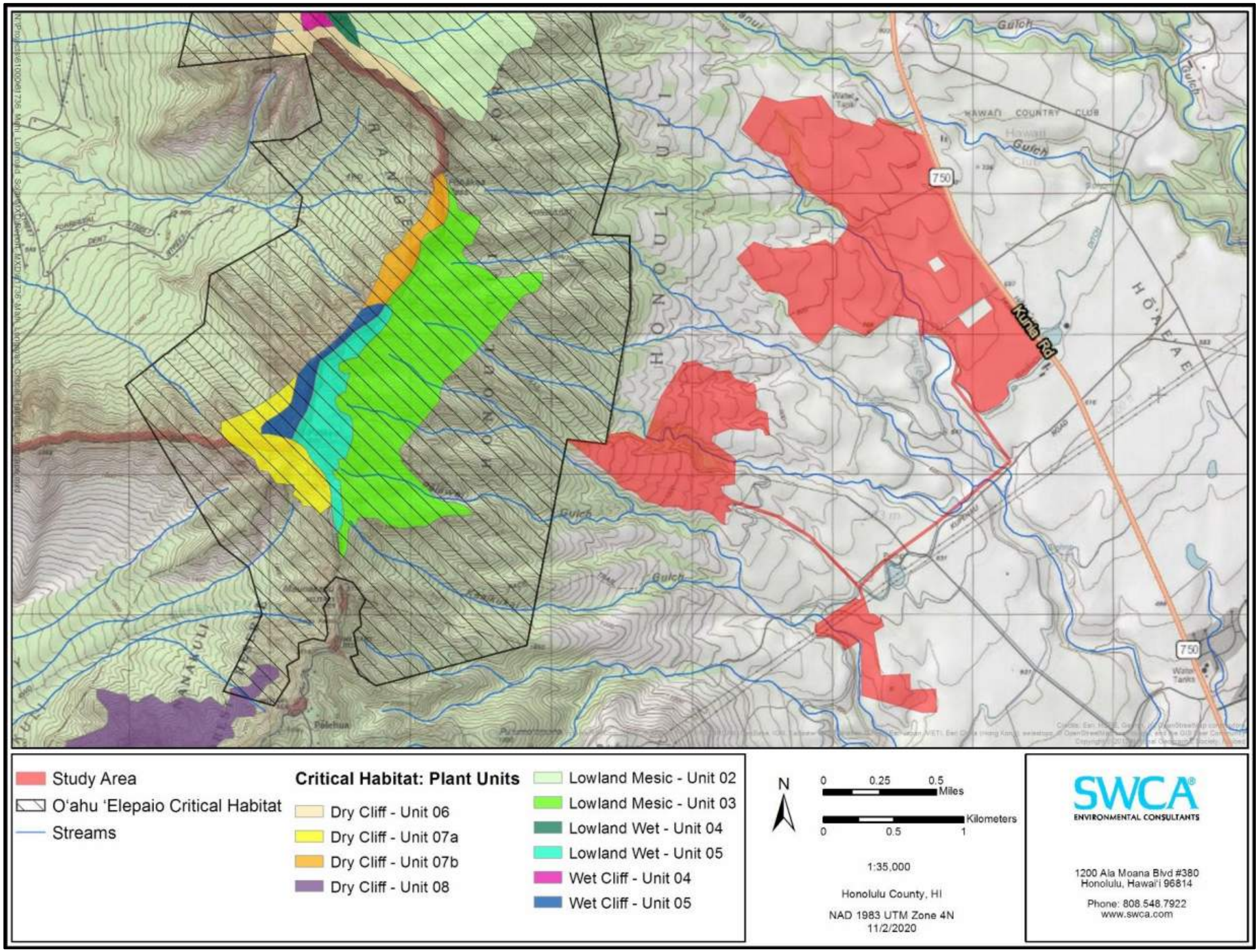

Figure 2. Designated critical habitat ecosystems and O'ahu 'elepaio critical habitat near the study area.

4 POTENTIAL IMPACTS

Potential impacts from the project are described in this section. These impacts could be avoided or reduced by incorporating the recommendations listed below into the project.

4.1 Flora

The vegetation types and habitats observed during the survey are dominated by non-native species. The native species present occur infrequently or in small pockets, and no threatened or endangered plants were found. Therefore, the proposed project would not be expected to have a significant, adverse effect on flora resources.

Weedy non-native plant species are common throughout the study area. Most of these weedy species are widespread on O‘ahu, and their control in the study area is not expected to result in a significant decrease in their number or distribution. However, one invasive species seen at the site, tumbleweed, could spread locally in the study area during construction activities due to soil disturbance. If soil or other potentially infested materials are moved from the study area, there is the potential for spreading this species to other, currently unaffected areas of the island. This species could negatively impact agricultural operations and road safety.

4.2 Fauna

4.2.1 *Avifauna*

Based on a desktop analysis of habitat, range of species, geographic location, and observed species, seven MBTA-protected birds (i.e., ‘apapane, O‘ahu ‘amakihi, Eurasian skylark, cattle egret, house finch, northern cardinal, and Pacific golden plover) could occur in the study area. Short-term impacts associated with project construction could result in temporary displacement of MBTA-protected species from breeding and foraging habitats; however, individuals would be expected to find abundant habitat nearby. The temporary displacement of individuals from the study area as a result of implementation of the project would not be expected to affect the survival of individuals or populations, and impacts would cease after construction is completed. Long-term impacts would be unlikely.

Some solar facilities are known to result in impacts to avian species, as dead birds are occasionally found near solar panels. Mortality may be a result of natural causes, injury sustained off-site, electrocution, or direct interactions with the solar facility (e.g., photovoltaic [PV] panels, overhead powerlines, or other infrastructure) (Erickson et al. 2005; Kosciuch et al. 2020). The cause of mortality often cannot be determined (Kosciuch et al. 2020). Solar flux, or concentrated sunlight, does not occur at facilities that use PV panels (Walston et al. 2015).

Kosciuch et al. (2020) studied avian fatalities at solar facilities in the southwestern United States. It categorized bird fatalities into taxonomic groupings consisting of diurnal raptors, songbirds, water obligates that rely on water for landing and take-off (e.g., loons, grebes, cormorants, coots, and diving ducks), and water associates that rely on aquatic habitats for foraging, reproduction, and/or roosting (e.g., most species of ducks, herons, rails, plovers, sandpipers, and gulls, among others). Water obligates and water associated birds are important to place into separate categories because they have been considered vulnerable to fatality at PV facilities because of the potential to confuse solar panel arrays for bodies of water (Kagan et al. 2014). However, the hypothesis that birds confuse solar panels for water bodies is considered speculative and has not been sufficiently tested (Kosciuch et al. 2020; Walston et al. 2015).

Among the facilities studied by Kosciuch et al. (2020), songbirds and dove mortalities were the most widely represented, with mourning dove (*Zenaida macroura*) being the most widely represented species. Water-obligate mortalities were detected more often than water associates. Kosciuch et al. (2020) also notes that water sources are limited in the southwestern United States, and that the majority of water-obligate and water-associate fatalities were found at facilities located near water sources with high bird use, such as the Salton Sea and Colorado River. The American coot (*Fulica americana*) was the water-obligate fatality most often found in the study. In general, the overall most common species found were generally abundant in the regions where the studies were done, and the species most often found are those that move at or near ground level or are associated with anthropogenic structures. Kosciuch et al. (2020) cautions that these conclusions may not be applicable to other regions.

The Mahi study area is not located near a potential flyway, concentrated fly zone, or heavily used water source, thereby reducing potential for large concentrations of birds passing through the study area. There is the potential for a range of avian species to occur in and/or fly through the study area. The most common species present, those that move along the ground, and those associated with human-built structures likely have the highest potential for fatality at the site. Longroad is committed to implementing its corporate Downed Wildlife Observation Program (DWOP), which consists of training staff to identify and document all found wildlife carcasses. Fatalities of species covered by the MTBA, ESA, and HRS Chapter 195D will be reported to the appropriate agency.

4.2.2 *Special-Status Species*

Based on the site visit, the study area contains habitat for the special-status animal species described above.

Construction at the site may temporarily displace individuals of special-status animal species; however, these individuals would be expected to find abundant foraging and nesting habitat nearby. The temporary displacement of individuals from the study area would not be expected to affect the survival of individuals or populations.

Hawaiian hoary bats may use areas in and near the study area for foraging, socializing, daytime roosting, and raising offspring. If tree removal occurs during the bat breeding season (June 1–September 15), direct impacts could occur to juvenile bats that are too young to fly but too large to be carried by an adult. If Hawaiian hoary bats use the study area trees for roosting, site clearing would result in bats relocating to adjacent forest areas that provide suitable roosting habitat. Foraging bats active at night may continue to use the site during and after construction. Hawaiian hoary bats have been known to become entangled in barbed-wire fences. Barbed-wire fencing should not be included in the construction and project design.

The Oʻahu ʻelepaio may use the study area for foraging and nesting. Direct impacts could occur during the breeding season (January to July) if a tree containing an active nest is removed. If Oʻahu ʻelepaio use the study area trees for nesting, site clearing would result in Oʻahu ʻelepaio relocating to adjacent forest areas that provide suitable nesting habitat.

Nēnē may use the study area for nesting and foraging. Direct impacts could occur during vegetation removal if a nest is damaged or if goslings are separated from adults. The impact of removing foraging and nesting habitat would be minor due to the availability of adjacent foraging and nesting habitat for displaced geese to use. Because nēnē have been extirpated from Oʻahu and were not documented in the study area when they were present, it is highly unlikely that the project could have any impact on this species.

The Hawaiian coot, Hawaiian gallinule, and Hawaiian stilt may visit the study area to forage when moving between permanent water resources. Impacts during construction are unlikely to occur because habitat for these species would not be affected by the project. All potential habitat in the study area vicinity for these species occurs as human-made reservoirs and Wailoi ditch. None of these resources would be affected by the project. The Hawaiian stilt and Hawaiian coot would be attracted to the site only during heavy rain events that would cause ponded water.

The Hawaiian short-eared owl may use the study area for nesting and foraging. Direct impacts could occur during vegetation removal if a nest is damaged or if chicks are separated from adults. The impact of removing foraging and nesting habitat would be minor due to the availability of adjacent foraging and nesting habitat. Hawaiian short-eared owls have been known to become entangled in barbed-wire fences. Barbed-wire fencing should not be included in the construction and project design.

Special-status seabirds (Hawaiian petrel and Newell's shearwater) may transit the area but would not nest or forage there. They are attracted to bright lights, which can cause them to become disoriented and grounded, making them vulnerable to mammalian predators or being struck by vehicles (DLNR 2015).

5 RECOMMENDATIONS

The following section lists avoidance and minimization measures that should be implemented before and during project construction to reduce the potential for impacts to the flora and fauna of the study area. This section also includes avoidance and minimization measures for any water features that may be adjacent to the study area. The section that follows lists recommendations for post-construction mitigation measures.

5.1 Agency Coordination

Informal conversations should take place with the USFWS and DOFAW to gain concurrence on whether the project can be constructed with no effect to listed species. This conversation would begin with a discussion of a list of applicant-committed avoidance and minimization measures that would be incorporated into the project.

5.2 Avoidance and Minimization Measures

5.2.1 *Flora*

Because the solar project would likely involve the movement of materials and construction equipment, SWCA recommends the following invasive species mitigation measures:

- To avoid the unintentional introduction or transport of new terrestrial invasive species to O‘ahu, all construction equipment and vehicles arriving from outside O‘ahu should be washed and inspected prior to entering the site. In addition, construction materials arriving from outside O‘ahu should also be washed and/or visually inspected (as appropriate) for excessive debris, plant materials, and invasive or harmful non-native species (plants, amphibians, reptiles, and insects). When possible, raw materials (gravel, rock, and soil) should be purchased from a local supplier on O‘ahu to avoid introducing non-native species not present on the island. Inspection and cleaning activities should be conducted at a designated location.

- The inspector must be a qualified botanist-entomologist able to identify invasive species and animals of concern relevant to the point of origin of the equipment, vehicle, or material. Invasive species that should be checked for during inspections can be found at the following online locations:
  - U.S. Department of Agriculture Plants (USDA) Database of the Hawai‘i State-listed Noxious Weeds (USDA 2020)
  - O‘ahu Invasive Species Committee’s (OISC’s) Priority Target Species (OISC 2020)
- Due to the presence of tumbleweed on-site, it is recommended that this species be controlled where seen, particularly where construction activities may initiate its local establishment. Also, measures should be taken to limit the spread of this species to other parts of the island. For example, decontamination of equipment and vehicles should be implemented to prevent the movement of soil off-site.

5.2.2 *Fauna*

To minimize potential impacts to special-status fauna, the following measures should be followed:

- Regular on-site staff should be trained to identify special-status species with potential to occur on-site and should know the appropriate measures to be taken if they are present.
- Within 3 days before tree removal, a qualified biologist should conduct a nest search for the MBTA-protected species. If active nests are found, they should be protected in place until the chicks fledge.
- If tree clearing occurs within 305 m (1,000 feet) of O‘ahu ‘elepaio critical habitat from January through July, a qualified biologist should survey the tree clearing area. If a nest is found, the USFWS and DLNR should be contacted.
- If a Hawaiian goose, Hawaiian stilt, Hawaiian coot, Hawaiian short-eared owl, or Hawaiian hoary bat is observed in the area during construction activities, all activities within 30 m (100 feet) of the individual should cease, and work should not continue until the individual leaves the area on its own accord.
- If a Hawaiian goose nest is discovered, all activities within 46 m (150 feet) of the nest should cease, and the USFWS should be contacted. Work should not resume until directed by the USFWS.
- If a Hawaiian short-eared owl nest is discovered, all activities within 46 m (150 feet) of the nest should cease, and the DLNR should be contacted. Work should not resume until directed by the DLNR.
- If tree removal occurs during the bat breeding season, direct impacts could occur to juvenile bats that are too small to fly but too large to be carried by a parent. To minimize this impact, no trees taller than 15 feet (4.6 m) should be trimmed or removed between June 1 and September 15.
- The use of barbless top-strand wire is recommended for all fence construction to avoid entanglement of Hawaiian hoary bats and Hawaiian short-eared owls.

To minimize potential impacts to seabirds, the following measures should be followed:

- Construction activity should be restricted to daylight hours as much as practicable during the seabird peak fallout period (September 15–December 15) to avoid the use of nighttime lighting that could attract seabirds.

- All outdoor lights should be shielded to prevent light from radiating upward. This has been shown to reduce the potential for seabird attraction (Reed et al. 1985; Telfer et al. 1987). A selection of acceptable, seabird-friendly lights can be found online at http://dlnr.hawaii.gov/wildlife/files/2016/03/DOC439 (DLNR 2016).
- Outside lights not needed for security and safety should be turned off from dusk through dawn during the fledgling fallout period (September 15–December 15).

5.3 Post-construction Mitigation

5.3.1 *Avian Electrocution and Collision*

To minimize potential for avian electrocutions, the following measures should be implemented in adherence with the Avian Power Line Interaction Committee (APLIC) guidelines, as is the standard design practice (APLIC 2006, 2012):

- Energized and/or grounded structures should be isolated through adequate spacing, as recommended by APLIC.
- Energized and/or grounded features should be insulated.
- Perch discouragers and ribbons that alert birds to change flight course should be deployed if deemed necessary.
- Bird diverters for visibility of gen-tie lines should be installed as recommended by APLIC.

5.3.2 *Panel Strikes*

Dead birds may occasionally be found near solar panels. Mortality may be a result of natural causes, injury sustained off-site, or direct interactions with the solar facility (Erickson et al. 2005; Kosciuch et al. 2020; Walston et al. 2015). Longroad is committed to implementing their corporate DWOP, which includes staff training and documentation of all animal carcasses found. To document the potential for panel strikes at this site, the following steps should be taken:

- Personnel should be educated about the potential for birds to be attracted and inadvertently harmed.
- Routine monitoring and documentation of species observed should be implemented.
- If monitoring indicates that listed or candidate species are visiting the site, the USFWS and DOFAW should be contacted to provide assistance with avoidance measures to minimize impacts.

5.3.3 *Monitoring and Reporting*

Careful observation and detailed record keeping are the most effective ways to determine whether mortality is a result of natural causes or facility operations. Inspections for deceased wildlife should be incorporated into routine operations and should begin immediately after construction is complete to provide as much information as possible. Specialists should train operations staff in the proper response, documentation, and reporting of any downed wildlife observed. If an animal cannot be identified by solar energy facility personnel, the carcass should be left in place and protected from scavenging until a qualified individual can make a correct determination. Longroad is committed to implementing its corporate DWOP, which includes staff training and documentation of all animal carcasses found.

Any recorded fatalities of state-listed species, federally listed species, or species protected under the MBTA should be reported to the USFWS and DOFAW within 24 hours of detection, and an incident report should be filed according to the most recent agency guidance.

6 LITERATURE CITED

Arakawa, A. 2013. Ask the Mayer: Kihei to Kula Roade: Tumbleweeds; Pools. *Maui Now*. Available at: http://mauinow.com/2013/10/20/ask-the-mayor-kihei-to-kula-road-tumbleweeds-pools/. Accessed March 7, 2018.

Avian Power Line Interaction Committee (APLIC). 2006. *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006*. Washington, D.C., and Sacramento, California: Edison Electric Institute, APLIC, and the California Energy Commission.

———. 2012. *Reducing Avian Collisions with Power Lines: The State of the Art in 2012*. Washington D.C. and Sacramento, California: Edison Electric Institute, APLIC, and the California Energy Commission. Washington D.C. and Sacramento, California.

Banko, P.C. 1988. Breeding biology and conservation of the Nēnē, Hawaiian goose (*Nesochen sandvicensis*). Ph.D. dissertation, University of Washington, Seattle.

Banko, P.C., J.M. Black, and W.E. Banko. 1999. Hawaiian Goose (Nēnē) (*Branta sandvicensis*). In *The Birds of North America, No. 434*, edited by A. Poole and F. Gill. Philadelphia, Pennsylvania: The Birds of North America, Inc.

Black, J.M., J. Prop, J.M. Hunter, F. Woog, A. Marshall, and J. Bowler. 1994. Foraging behaviour and energetics of the Hawaiian goose, *Branta sandvicensis*. *Wildfowl* 45:65–109.

Conant, S. 1977. The breeding biology of the Oʻahu ʻelepaio. *Wilson Bull*. 89(2):193–210.

Erickson, W.P., G.D. Johnson, and D.P. Young. 2005. *A Summary and Comparison of Bird Mortality from Anthropogenic Causes with an Emphasis on Collisions*. USDA Forest Service General Technical Report. PSW-GTR-191.

Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte. 2013: Online Rainfall Atlas of Hawaiʻi. *Bulletin of the American Meteorological Society* 94:313–316.

Hawaiʻi Department of Land and Natural Resources (DNLR). 2015. *Hawaiʻi's State Wildlife Action Plan*. Prepared by H. T. Harvey and Associates, Honolulu, Hawaiʻi. Available at: https://dlnr.hawaii.gov/wildlife/files/2016/12/HI-SWAP-2015.pdf. Accessed August 27, 2020.

———. 2016. *Wildlife Lighting*. Available at: http://dlnr.hawaii.gov/wildlife/files/2016/03/DOC439.pdf. Accessed September 2, 2020.

Holt, D.W., and S.M. Leasure. 2006. Short-eared owl (*Asio flammeus*). In *The Birds of North America*, No. 062. Philadelphia, Pennsylvania: The Birds of North America, Inc.

Kagan, R.A., T.C. Viner, P.W. Trail, and E.O. Espinoza. 2014. *Avian Mortality at Solar Energy Facilities in Southern California: A Preliminary Analysis*. Ashland, Oregon: National Fish and Wildlife Forensics Laboratory.

Kosciuch, K., D. Riser-Espinoza, M. Gerringer, and W. Erickson. 2020. A summary of bird mortality at photovoltaic utility scale solar facilities in the Southwestern U.S. *PLoS ONE* 15(4)e0232034.

Longroad Energy Management, LLC (Longroad). 2017. *Waiawa Energy Ahupua'a Proposal for Net-Positive Clean Energy Community and Grant of Easement*. Boston, Massachusetts: Longroad Energy Management, LLC.

Oahu Invasive Species Committee (OISC). 2020. OISC target pests. Available at: http://www.oahuisc.org/target-pests/. Accessed August 26, 2020.

Price, M., and J. Cotín. 2018. *The Pueo Project Final Report April 2017 – March 2018, Population size, Distribution and Habitat Use of the Hawaiian Short-eared Owl* (Asio flammeus sandwichensis) *on O'ahu.* Honolulu, Hawai'i: College of Tropical Agriculture and Human Resources Department of Natural Resources and Environmental Management.

Reed, J.R., J.L. Sincock, and J.P. Hailman. 1985. Light attraction in endangered procelliariiform birds: reduction by shielding upward radiation. *The Auk* 102:377–383.

The Maui News. 2017. Tumbling tumbleweed is an invasive species. Available at: http://www.mauinews.com/news/local-news/2017/10/tumbling-tumbleweed-is-an-invasive-species/. Accessed March 7, 2018.

Telfer, T.C., J.L. Sincock, G.V. Byrd, and J.R. Reed. 1987. Attraction of Hawaiian seabirds to lights: conservation efforts and effects of moon phase. *Wildlife Society Bulletin* 15:406–413.

U.S. Department of Agriculture (USDA). 2020. Hawai'i State-listed Noxious Weeds. Available at: https://plants.usda.gov/java/noxious?rptType=State&statefips=15. Accessed August 26, 2020.

U.S. Fish and Wildlife Service (USFWS). 2003. *Draft Revised Recovery Plan for Hawaiian Forest Birds, Second Revision*. Portland, Oregon: U.S. Fish and Wildlife Service, Region 1.

———. 2005. *Recovery Plan for Hawaiian Waterbirds*.

———. 2013. Pueo. *Asio flammeus sandwichensis*/Hawaiian Owl. Hawai'i. Hakalau Forest National Wildlife Refuge. Available at: http://www.fws.gov/refuge/ Hakalau_Forest/wildlife_and_habitat/pueo.html. Accessed August 27, 2020.

———. 2020. Information for Planning and Consultation (IPaC). Available at: https://ecos.fws.gov/ipac/. Accessed August 20, 2020.

VanderWerf, E.A. 1993. Scales of habitat selection by foraging 'Elepaio in undisturbed and human-altered forests in Hawaii. *Condor* 95:980–989.

Walston, L.J., Jr., K.E. Rollins, K.P. Smith, K.E. LaGory, K. Sinclair, C. Turchi, T Wendelin, and H. Souder. 2015. *A Review of Avian Monitoring and Mitigation Information at Existing Utility-Scale Solar Facilities*. Prepared for U.S. Department of Energy, SunShot Initiative and Office of Energy Efficiency and Renewable Energy. Report ANL/EVS-15/2.

Woog, F., and J.M. Black. 2001. Foraging behavior and the temporal use of grasslands by nēnē: implications for management. *Studies in Avian Biology* 22:319–328.

APPENDIX A

Photographs

Figure A-1. View of the study area, showing cultivated fields of corn.

Figure A-2. Typical view of fallow fields, showing predominance of Guinea grass.

Figure A-3. View of the study area, showing grassland on the left and non-native forest on the right.

Figure A-4. Typical view of koa haole forest, seen on slopes in the background behind non-native forest in the gulch bottom.

Figure A-5. Typical view from within the stands of eucalyptus, showing minimal growth in the understory, providing poor habitat for understory species.

Figure A-6. O'ahu 'elepaio habitat with closed canopy continuous forest in the study area bordering O'ahu 'elepaio critical habitat.

Figure A-7. O'ahu 'elepaio habitat transitioning from closed canopy continuous forest to open canopy fragmented forest mixed with grassland and shrubland in the study area.

APPENDIX B

Mahi Solar Project O‘ahu ‘Elepaio, Hawaiian Short-Eared Owl and Hawaiian Hoary Bat Habitat Map

INTRODUCTION

This document provides guidance to assist with preconstruction vegetation management for the Mahi Solar Project (project). SWCA Environmental Consultants (SWCA) identified two federal and state endangered species (Hawaiian hoary bat [*Aeorestes semotus*] and Oʻahu ʻelepaio [*Chasiempis sandwichensis*]) and one state endangered species (Hawaiian short-eared owl or pueo [*Asio flammeus sandwichensis*]) (special-status species) that may use the project study area for breeding (Figure B-1). SWCA used aerial imagery to determine where habitat for special-status species is most likely to occur.

HAWAIIAN HOARY BAT

Suitable foraging habitat for the Hawaiian hoary bat occurs throughout the entire study area and bats could roost anywhere there are trees greater than 15 feet tall in the survey area (see Figure A-1). Hawaiian hoary bats typically roost in trees greater than 15 feet with dense canopy foliage, or in the subcanopy when the canopy is sparse and there is open access for launching into flight (Gorresen et al. 2013; U.S. Department of Agriculture 2009; U.S. Fish and Wildlife Service [USFWS] 2020). If trees or shrubs 15 feet or taller are cleared during the pupping season, there is a risk that flightless bats could accidentally be injured or killed because they lack the ability to move away from threats (USFWS 2020). The Hawaiian hoary bat is also known to become entangled in barbed wire.

To determine where Hawaiian hoary bats are most likely to roost, aerial imagery of the study area was used to estimate tree heights and identify suitable bat roost sites. Areas that appeared to have trees greater than 15 feet tall were mapped. Aerial imagery may not capture current conditions and trees greater than 15 feet may occur outside the areas identified on the map. On July 24, 2020, an SWCA wildlife biologist surveyed the area to determine if the aerial imagery accurately reflected the current conditions of the study area and if Hawaiian hoary bat habitat occurred within the study area.

Recommendations

Direct impacts to bats could occur during vegetation removal if a juvenile bat that is too small to fly but too large to be carried by a parent is present in a tree or branch that is cut down. To prevent direct impacts to Hawaiian hoary bat, the following measures are recommended:

- If felling of standing trees occurs during the bat breeding season, direct impacts could occur to juvenile bats that are too small to fly but too large to be carried by a parent. To minimize this impact, no trees taller than 15 feet should be trimmed or removed between June 1 and September 15.
- The use of barbless wire is recommended for all fence construction to avoid entanglement of Hawaiian hoary bat.

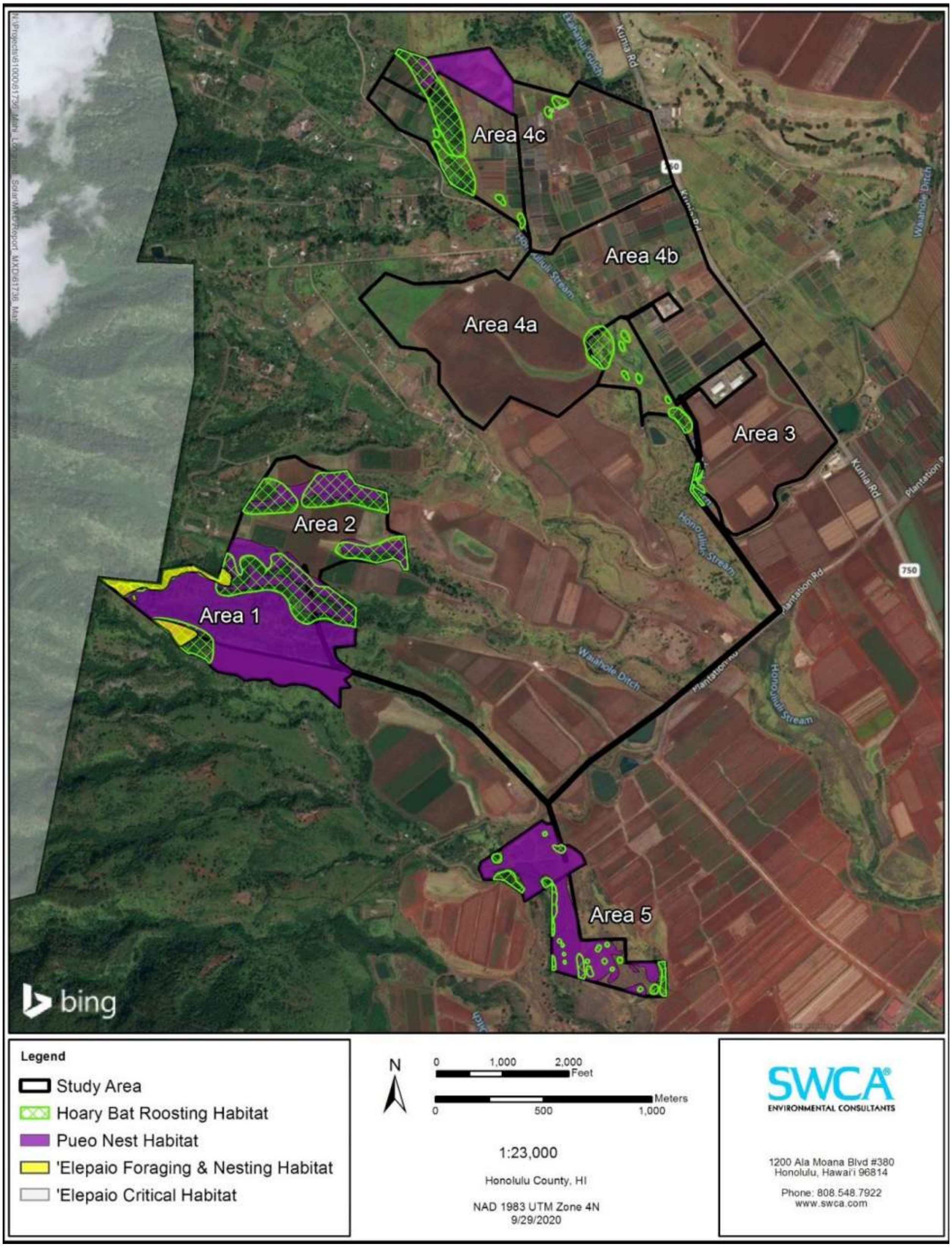

Figure B-1. Mahi Solar Project, special-status species breeding habitat.

O‘AHU ‘ELEPAIO

Suitable nest and forage habitat for O‘ahu ‘elepaio occurs where the study area borders O‘ahu ‘elepaio critical habitat (see Figure B-1). This habitat becomes less suitable as the distance from the critical habitat increases because the vegetation transitions from closed canopy continuous forest into an open canopy fragmented forest mixed with grassland and shrubland. Although some of the habitat may be less suitable, because O‘ahu ‘elepaio is a forest and foraging generalist, some individuals may use less suitable forest up to 1,000 feet from the O‘ahu ‘elepaio critical habitat in the study area for nesting and foraging (see Figure B-1).

To determine where O‘ahu ‘elepaio may occur, a desktop analysis was conducted. The desktop analysis revealed that the study area borders designated O‘ahu ‘elepaio critical habitat. On July 24, 2020, an SWCA wildlife biologist surveyed the area to determine if the aerial imagery accurately reflected the current conditions of the study area and if O‘ahu ‘elepaio suitable habitat occurred within the study area.

Recommendations

Direct impacts to O‘ahu ‘elepaio could occur if activity construction activity and/or noise cause adult-dependent chicks to fledge their nest prematurely or cause nest abandonment by the adults. Direct impacts may also occur if a nest is present in a tree or branch that is cut down. To prevent direct impacts to O‘ahu ‘elepaio, the following measures are recommended:

- If tree trimming occurs from January through July within 1,000 feet of O‘ahu ‘elepaio critical habitat, a qualified biologist should survey trees for active nests 3 days prior to tree clearing activities. Surveys should be repeated within 3 days of project initiation and after any subsequent delay of work of 3 or more days.
- Construction and installation phases should occur during the O‘ahu ‘elepaio non-nesting season.
- If an active nest is found, it should be protected in place until the chicks fledge.
- If a nest is found, the USFWS and Hawai‘i Department of Land and Natural Resources (DLNR) should be contacted.

HAWAIIAN SHORT-EARED OWL

Suitable forage and nest habitat for the Hawaiian short-eared owl occurs in the study area. Hawaiian short-eared owls could forage throughout the entire study area and could nest in the shrublands and grasslands (see Figure B-1). Little is known about the breeding biology of the Hawaiian short-eared owl, but nesting occurs throughout the year (USFWS 2013). Nests are made on the ground and are lined with grasses and feathers. The Hawaiian short-eared owl is also known to become entangled in barbed wire.

To determine where Hawaiian short-eared owl nest habitat may occur, a desktop analysis was conducted. The desktop analysis revealed that the study area contains minimally disturbed shrublands and grasslands in the study area (see Figure B-1). On July 24, 2020, and August 10, 2020, SWCA biologists surveyed the study area and determine that aerial imagery accurately reflected the current conditions of the study area and Hawaiian short-eared owl habitat occurs within the study area.

Recommendations

Direct impacts to Hawaiian short-eared owls could occur if construction activity and/or noise cause adult-dependent chicks to fledge their nest prematurely or cause nest abandonment by the adults. Direct impacts may also occur if construction machinery runs over an active nest. To prevent direct impacts to Hawaiian short-eared owls, the following measures are recommended:

- A biological monitor should be present when clearing vegetation in Hawaiian short-eared owl nesting habitat.
- If a Hawaiian short-eared owl nest is discovered, all activities within 150 feet of the nest should cease, and the Hawai‘i DLNR should be contacted. Work should not resume until directed by the DLNR.
- The use of barbless wire is recommended for all fence construction to avoid entanglement of Hawaiian short-eared owls.

LITERATURE CITED

Gorresen, M.P., F.J. Bonaccorso, C.A. Pinzari, C.M. Todd, K. Montoya-Aiona, and K. Brinck. 2013. *A Five-year Study of Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) Occupancy on the Island of Hawai'i (HSCU-041)*. Hilo, Hawai'i: Hawai'i Cooperative Studies Unit.

U.S. Department of Agriculture. 2009. *Bats of the U.S. Pacific Islands*. Biology Technical Note No. 20. Natural Resources Conservation Service, Pacific Islands Area.

U.S. Fish and Wildlife Service (USFWS). 2013. Pueo. *Asio flammeus sandwichensis*/Hawaiian Owl. Hakalau Forest National Wildlife Refuge – Hawai'i. Available at: http://www.fws.gov/refuge/Hakalau_Forest/wildlife_and_habitat/pueo.html. Accessed August 27, 2020.

———. 2020. Animal Avoidance and Minimization Measures. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office. Available at: https://www.fws.gov/pacificislands//articles.cfm?id=149489720#. Accessed August 2020.

Mahi Solar Project
Pueo Survey Addendum

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Pueo Survey Addendum

Draft

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SWCA Project No. 61736

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Figures

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1 INTRODUCTION

Longroad Management, LLC (Longroad) contracted SWCA Environmental Consultants (SWCA) to conduct a Hawaiian short-eared owl or pueo (*Asio flammeus sandwichensis*) survey for the Mahi Solar project (formerly Kupehau [Project]) because pueo habitat was documented during the 2018 fauna survey. A pueo presence/absence survey is necessary to ensure this state-listed endangered species is not impacted by construction of the project.

The project is located in the Ewa Region within the Honouliuli watershed on the Island of Oʻahu. The proposed project would occupy approximately 617 acres of land across several parcels within Tax Map Keys 9-2-001:001, 9-2-004:012, 9-2-004:006, 9-2-004:003, and 9-2-004:010 (study area) (Figure 1). At 120 megawatts (MW), the project would produce 4% of Oʻahu's electricity annually, enough to power 37,000 local homes, enabling the Hawaiian Electric Company, Inc. to burn less fossil fuel and emit less greenhouse gases. A 480 MW-hour battery system would store solar energy generated during the day to provide power at night, and an electrical substation would connect to the Oʻahu grid.

This addendum describes the pueo survey methods and results; discusses potential impacts from the project; and provides recommendations for avoidance and minimization of the potential impacts.

1.1 Description of the Study Area

The study area borders Kunia Road in central Maui. It is approximately 1.8 miles north west of Village Park and about 4.2 miles north of Kapolei. The study area consists of approximately 617 acres of land owned by Hartung Brothers, Law Farms, and Bayer. The mean annual rainfall is approximately 31.8 inches (80.7 centimeters); rainfall is typically highest in January and lowest in June (Giambelluca et al. 2013). The study area is currently used by Hartung Brothers, Law Farms, and Bayer for agriculture production. Although the surrounding area is predominantly agricultural, there are residential areas nearby.

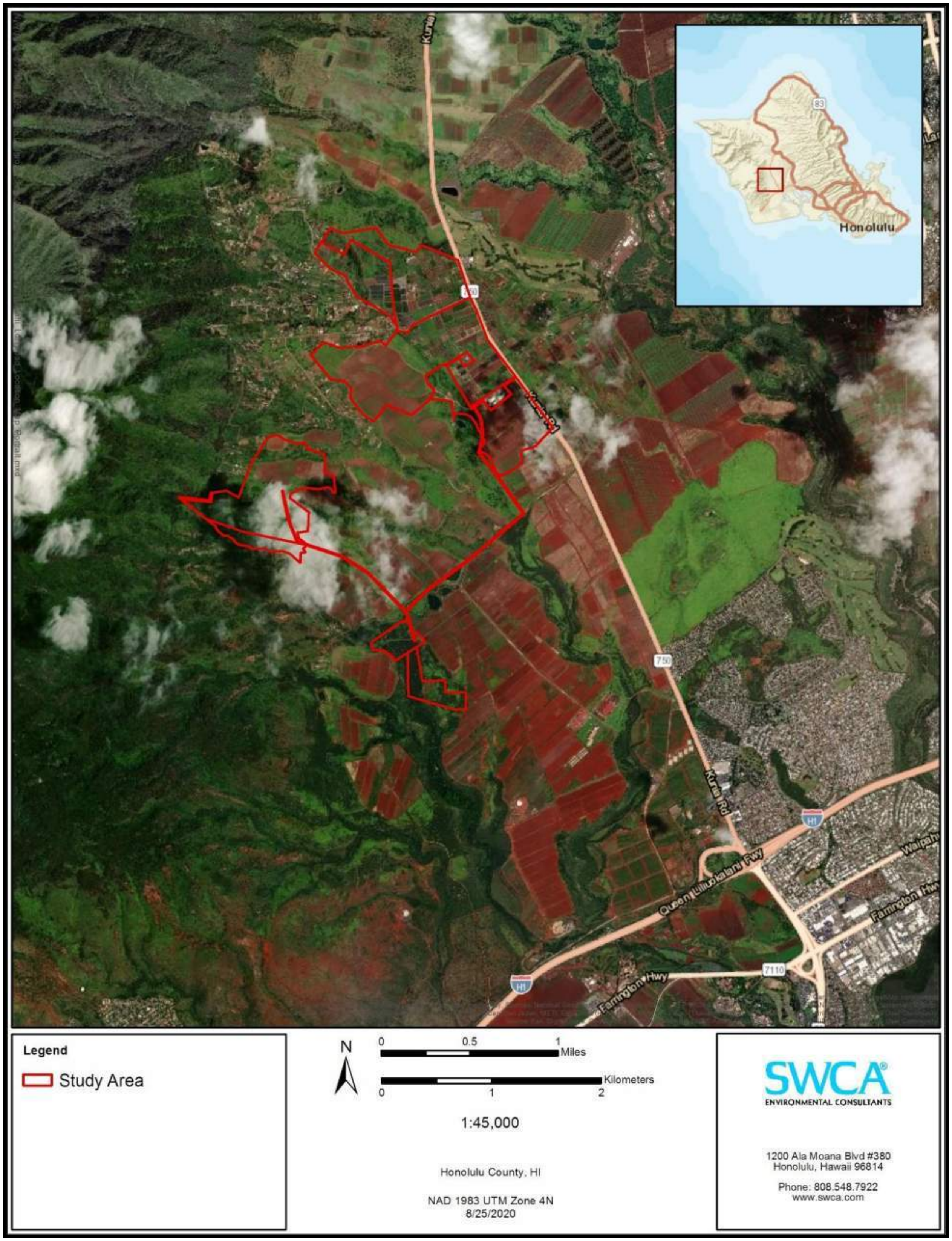

Figure 1. Mahi Solar Project study area.

2 SPECIES DESCRIPTION

Pueo are found throughout the main Hawaiian Islands from sea level to 8,000 feet (Hawaiʻi Department of Land and Natural Resources [DLNR] 2015). This species is not federally listed under the Endangered Species Act, but is listed by the state as endangered on Oʻahu. Based on observed densities from Price and Cotín (2018), the number of pueo occurring on Oʻahu is estimated at between 8 and 2,199 individuals, with a mean population of approximately 807 individuals.

Pueo are active during the day and occupy a variety of habitats, including wet and dry forests, wetlands, grasslands, agriculture land, and shrublands (DLNR 2015; Price and Cotín 2018). Their diet consists of small mammals, birds, and invertebrates (Holt and Leasure 2006; Price and Cotín 2018). Their flight is described as being moth-like, buoyant with slow deliberate wing beats, and hovering when hunting; direct and fast wing-pumping when defending territories; and soaring when avoiding predators or chasing intruders (Holt and Leasure 2006).

3 METHODS

Before conducting the field survey, SWCA reviewed available scientific and technical literature regarding pueo habitat and its potential for occurring in and near the survey area. This literature review encompassed a thorough search of peer-reviewed scientific journals, technical journals, and reports that provide insight into the natural history and ecology of the Hawaiian short-eared owl. Holt and Leasure (2006), Marti et al. (2005), DLNR (2015), USFWS (2013), and Price and Cotín (2018), in particular, provided useful information regarding abundance, distribution, and densities. SWCA also reviewed available geospatial data, aerial photographs, and topographic maps of the survey area.

SWCA wildlife biologist James Breeden led a team of three biologists to conduct visual and auditory pueo surveys with the aid of binoculars. Surveys were conducted using methods from Price and Cotín (2018) and carried out in the late evening, with surveys starting between 60 and 75 minutes before sunset and lasting until 30 minutes after sunset. In all, nine survey points were identified to allow for 100% coverage of the study area (Figure 2). Observations of both pueo and barn owls were recorded during the survey. Owl detections that occurred outside of the survey period were also recorded and included in the results. Surveys consisted of three survey periods spaced at least 3 weeks apart to increase the probability of detecting pueo, as recommended by Price and Cotín (2018). Survey period 1 was from August 10 to August 18, 2020; survey period 2 was from September 8 to September 10, 2020; and survey period 3 was from October 5 to October 8, 2020.

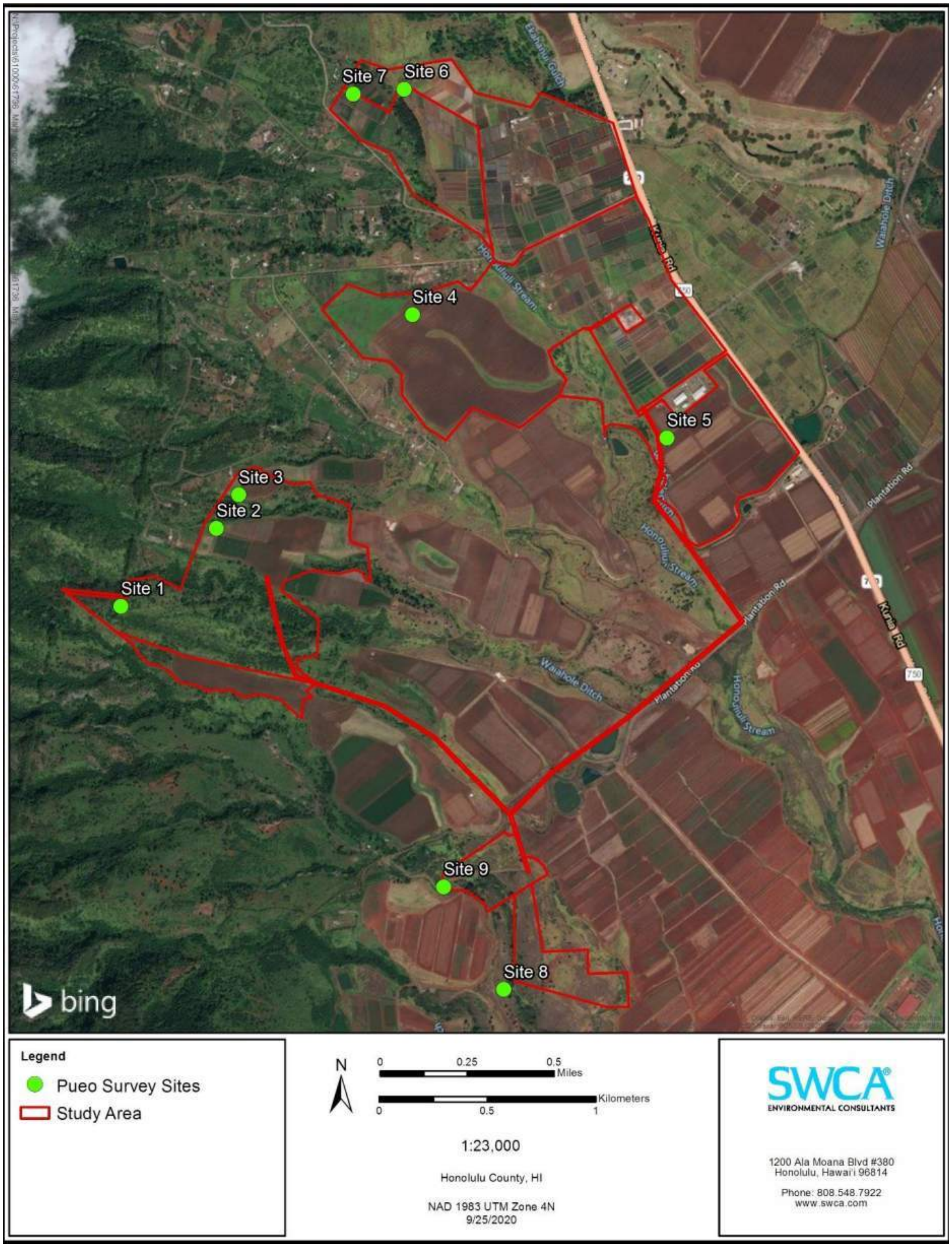

Figure 1. Pueo survey sites.

4 RESULTS

4.1 Habitat

SWCA conducted a habitat assessment, which used a desktop analysis and field surveys to determine where pueo nesting habitat may occur in the study area. The desktop analysis revealed that the study area contains minimally disturbed shrublands and grasslands. On July 24, 2020, and August 10, 2020, SWCA biologists surveyed the study area and determined that aerial imagery accurately reflected the current conditions of the study area and that pueo habitat occurs within the study area.

4.2 Detections

Overall, the survey area was visited on 11 days, totaling approximately 46 survey hours. Pueo activity was confirmed inside the study area. During the surveys, nine owl detections occurred (Table 1, Figure 3). Detections included three total pueo detections, all of them within the study area: one pueo identified by sight, and two pueo identified by sound. One unidentified owl was detected by sight, four barn owls were detected by sight, and one barn owl was detected by sound.

Table 1. Owl Detection Summary

Species	Observation Date/Time	Observer Location	Owl Location	Observed Activity
Pueo 1	September 10, 2020, at 18:46	Survey Point 8	In the study area; originated approximately 20 m outside of study area then flew east into the study area.	First observed flying near a wiliwili tree about 20 m away. The pueo was flying during the entire observation. It appeared as if the observer had startled it, and it was flying away from the observer until it flew out of sight.
Pueo 2	October 8, 2020, at 17:30	Survey Point 8	In the study area; approximately 390 m northeast of survey point 8 inside the study area.	Heard four vocalizations (waowk) from the shrublands lasting for a total of 5 to 6 seconds.
Pueo 3	October 8, 2020, at 17:55	Survey Point 9	In the study area; approximately 122 m east of survey point 9 inside the study area.	Heard 6 short vocalizations (barking) from the eucalyptus forest and grasslands lasting for a total of 10 seconds.
Unidentified owl	August 10, 2020, at 19:49	Survey Point 2	Not in the study area; approximately 1,500 m east of survey point 2.	An owl was seen while the observer was driving out of study area. It is suspected to be a barn owl, but the identification is uncertain.
Barn owl 1	August 10, 2020, at 19:00	Survey Point 1	In the study area; approximately 90 m to the northwest of survey point 1.	Heard a barn owl screech coming from the forest; no movement seen.
Barn owl 2	August 18, 2020, at 19:45	Survey Point 9	Not in the study area; approximately 900 m to the east of survey point 9.	Owl was observed within a few meters of barn owl 3 described below, next to road.
Barn owl 3	August 18, 2020, at 19:45	Survey Point 9	Not in the study area; approximately 900 m to the east of survey point 9.	Owl was observed within a few meters of barn owl 2 described above, next to road. Owl was observed catching prey.
Barn owl 4	October 5, 2020, at 19:58	Survey Point 1	In the study area; approximately 530 m to the northwest of survey point 5.	On the road between area 4a and 4b flying northwest; the barn owl flew over road when the observers were leaving the area and was about 8 m off the ground.
Barn owl 5	October 5, 2020, at 18:45	Survey Point 3	In the study area; approximately 15 m to the south of survey point 3.	The barn owl flew from shrubs on one side of the field to a tree on the other side.

Three pueo detections occurred during the surveys, all within the study area and all in the southern portion of the study area near survey points 8 and 9 (Figure 3). The first pueo detection was visual, with the pueo first seen approximately 20 m northeast of survey point 8, about 20 m outside of the study area. It was flying when first observed, and then continued east, then southeast, into the study area. It continued flying southeast until it was out of view. No vocalizations were heard. The second pueo detection was audial, heard approximately 390 m northeast of survey point 8, within the study area. Four vocalizations (waowk) were heard, lasting approximately 5 to 6 seconds total. The third pueo detection was audial, heard approximately 122 m east of survey point 9, within the study area. Six short vocalizations (barking) lasting approximately 10 seconds were heard. The second and third pueo detections occurred on the same evening, approximately 25 minutes from one another.

One unidentified owl was detected by sight approximately 45 minutes after sunset, when there was not enough light to visually distinguish between pueo and barn owl. Vocalizations were not heard and only a silhouette of an owl could be seen. It was along a road approximately 1,500 m east of survey point 2, just outside the study area. It flew east and was out of sight after flying approximately 10 m due to low light conditions. Although the identification of this owl could not be confirmed, and although it is suspected to be a barn owl, to be conservative, unidentified owl sightings should be regarded as a potential pueo sighting.

Five barn owls were detected during surveys, typically 30 to 45 minutes after sunset, near the end of the day's survey or after the day's survey period when there was not enough light to visually distinguish between pueo and barn owl, unless seen with a vehicle's headlights. Of these, three detections occurred in the study area. The first barn owl was detected within the study area, approximately 90 m northwest of survey point 1. A vocalization (screech) was heard, but the owl was not seen. The second and third barn owls were both about 900 m east of survey point 9, just outside the study area. They were both seen along the road. Barn owl 3 was observed catching prey. The fourth barn owl was visually detected in the study area approximately 530 m northwest of survey point 5. The fifth barn owl was visually detected approximately 15 m south of survey point 3, within the study area.

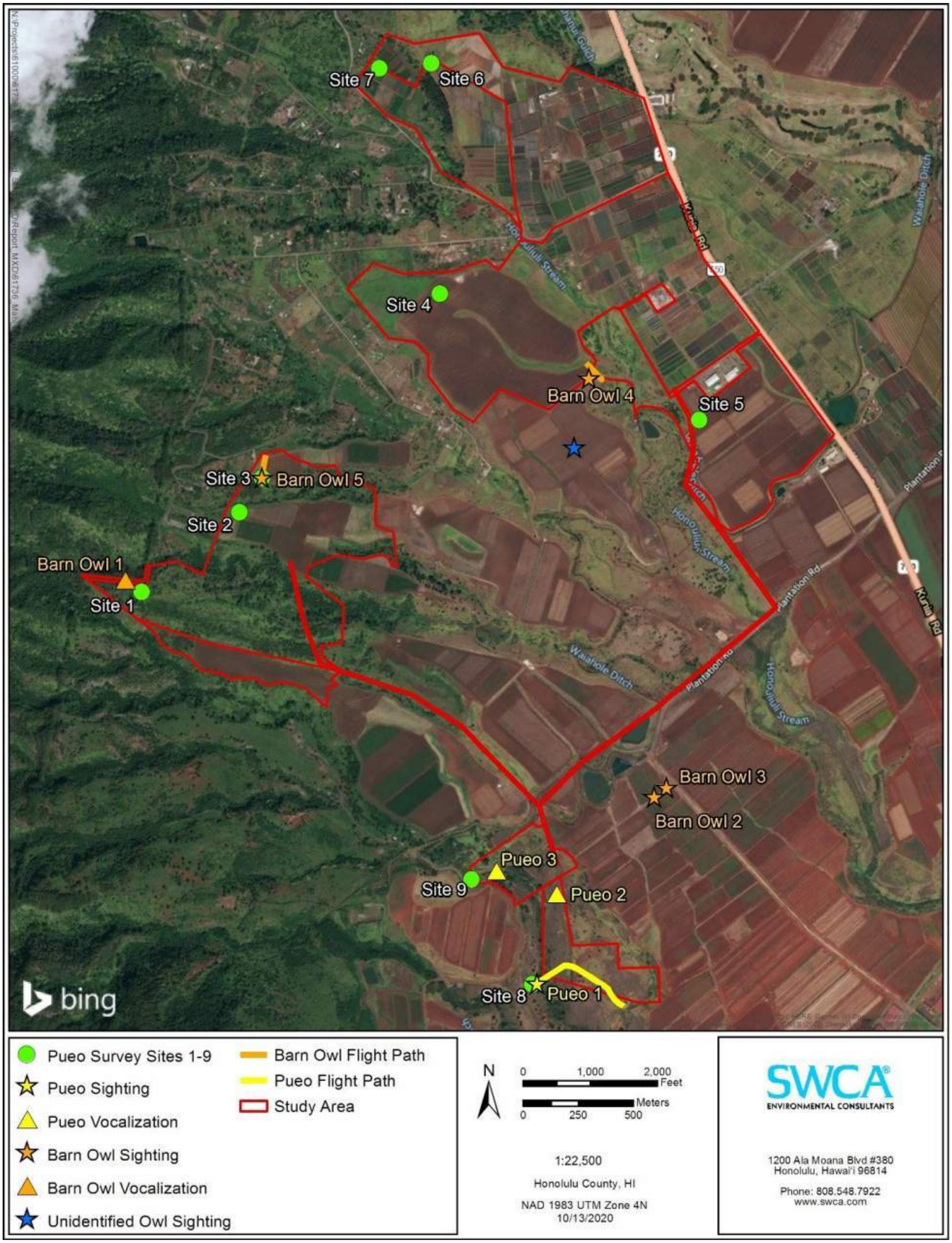

Figure 3. Owl detections in the study area.

5 POTENTIAL IMPACTS

Pueo may use the study area for nesting and foraging. The owls could forage throughout the entire study area and could nest in the shrublands and grasslands. Little is known about the breeding biology of the pueo, but nesting occurs throughout the year (USFWS 2013). Nests are made on the ground and are lined with grasses and feathers. Direct impacts could occur during vegetation removal if a nest is damaged or if chicks are separated from adults. If direct impacts are avoided, the impact of removing foraging and nesting habitat would be minor due to the availability of adjacent foraging and nesting habitat. Pueo have been known to become entangled in barbed-wire fences. Barbed-wire fencing should not be included in the construction and project design.

6 RECOMMENDATIONS

To prevent direct impacts to pueo, the following measures are recommended:

- A biological monitor should be present when clearing vegetation in pueo nesting habitat.
- If a pueo nest is discovered, all activities within 150 feet of the nest should cease, and the Hawaiʻi DLNR should be contacted. Work should not resume until directed by the DLNR.
- The use of barbless wire is recommended for all fence construction to avoid entanglement of pueo.

6.1 Agency Coordination

Informal conversations should take place with the USFWS and Hawaii Department of Land and Natural Resources to gain concurrence on whether the project can be constructed with no effect to pueo. This conversation would begin with a discussion of a list of applicant-committed avoidance and minimization measures that would be incorporated into the project.

7 REFERENCES CITED/LITERATURE CITED

Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte, 2013: Online Rainfall Atlas of Hawai‘i. *Bull. Amer. Meteor. Soc.* 94, 313-316, doi:10.1175/BAMS-D-11-00228.1.

Hawai‘i Department of Land and Natural Resources (DNLR). 2015. Hawai‘i’s State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai‘i. Available at : https://dlnr.hawaii.gov/wildlife/files/2016/12/HI-SWAP-2015.pdf. Accessed on August 27, 2020.

Holt, D.W., and S.M. Leasure. 2006. Short-eared Owl (*Asio flammeus*). In *The Birds of North America*, No. 062, The Birds of North America, Inc., Philadelphia, Pennsylvania.

Marti, C.D., A.F. Poole, and L.R. Bevier. 2005. Barn owl (*Tyto alba*). The Birds of North America online. Available at: bna.birds.cornell.edu/BNA/. Accessed on August 1, 2020.

Price, M. and J. Cotín. 2018. The Pueo Project Final Report April 2017 – March 2018, Population size, distribution and habitat use of the Hawaiian Short-eared Owl (Asio flammeus sandwichensis) on O‘ahu. Honolulu, Hawai‘i: College of Tropical Agriculture and Human Resources Department of Natural Resources and Environmental Management.

U.S. Fish and Wildlife Service. 2013. Pueo. Asio flammeus sandwichensis/Hawaiian Owl. Hawai‘i. Hakalau Forest National Wildlife Refuge. Available at: http://www.fws.gov/refuge/Hakalau_Forest/wildlife_and_habitat/pueo.html. Accessed August 27, 2020.

Draft Mahi Solar Project
Gen-Tie Desktop Review Addendum

DECEMBER 2020

PREPARED FOR

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SWCA Project No. 61736

December 2020

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Figures

1 INTRODUCTION

Longroad Management, LLC (Longroad), contracted SWCA Environmental Consultants (SWCA) to conduct a desktop review of flora and fauna resources in the Gen-Tie project area (project area) of the Mahi Solar project (formerly Kupehau [Project]), with a focus on determining the potential for federally listed and state-listed species (special-status flora and/or fauna) to occur at the project area, as well as to identify critical issues related to natural resources permitting.

The project is located in the Ewa Region within the Honouliuli watershed on the Island of O‘ahu. The proposed project would occupy approximately 60.7 acres of land across several parcels within Tax Map Keys 194003001, 192001001, and 1920040069 (Figure 1).

This addendum describes the survey methods and results and provides recommendations for avoidance and minimization of the potential impacts.

1.1 Description of the Project Area

The project area straddles Kunia Road in central O‘ahu and is located approximately 1.5 miles north of Village Park. It is approximately 3,718 meters (m) long and 639 m wide at its widest point. The mean annual rainfall is approximately 27.4 inches (69.7 centimeters); rainfall is typically highest in January and lowest in June (Giambelluca et al. 2013). The project area is currently used primarily for agriculture.

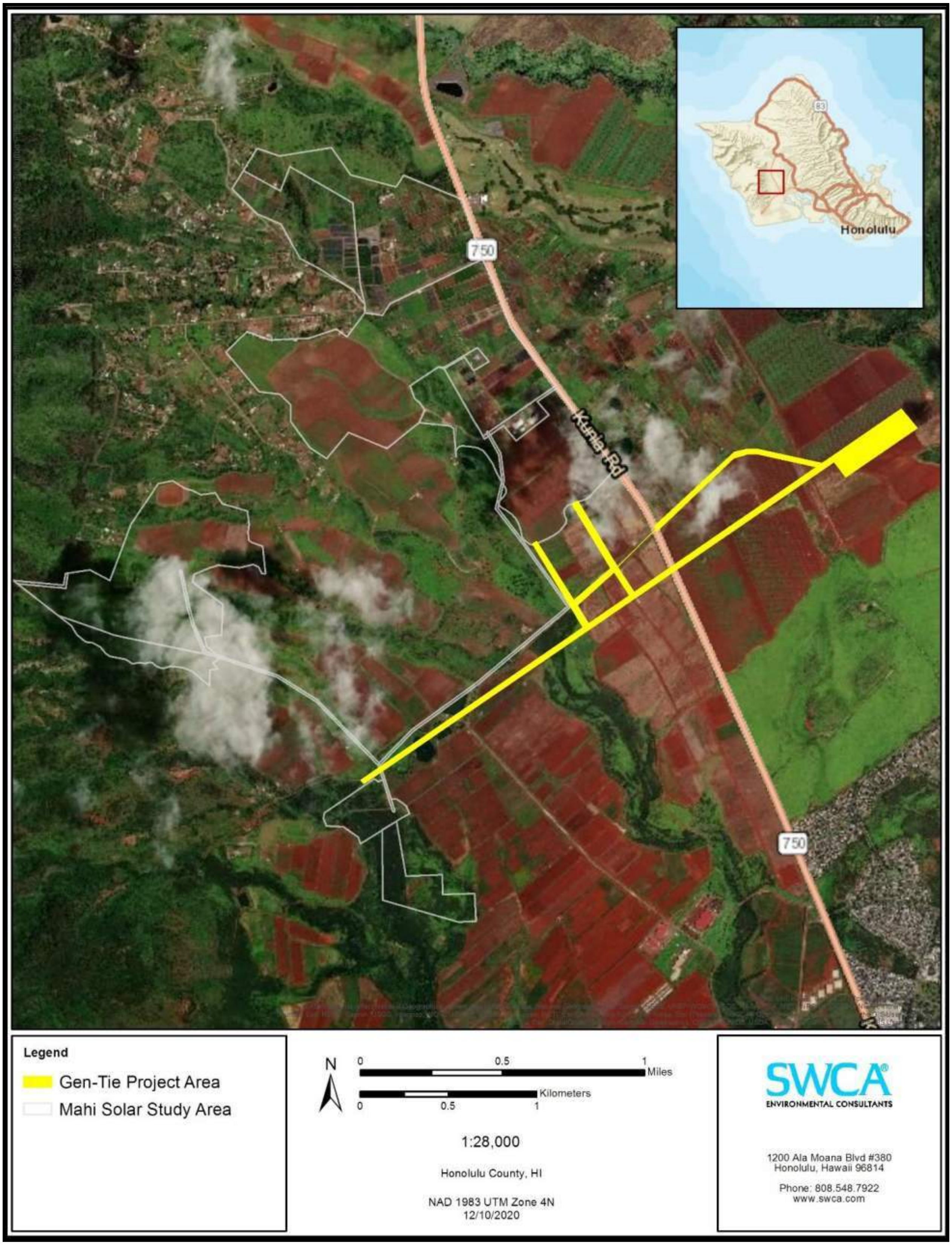

Figure 1. Mahi Gen-Tie project area, with Mahi Solar study area for comparison.

2 METHODS

SWCA reviewed available scientific and technical literature regarding natural resources in and near the project area. A desktop analysis of the project area was conducted to determine if habitat for species protected under the Migratory Bird Treaty Act (MBTA), Endangered Species Act, and Hawai‘i Revised Statutes Chapter 195-D may be present. This analysis consisted of reviewing the following:

- Aerial imagery
- Project area photographs
- Draft Revised Recovery Plan for Hawaiian Forest Birds (U.S. Fish and Wildlife Service [USFWS] 2003)
- Hawaii’s Comprehensive Wildlife Conservation Strategy (Hawai‘i Department of Land and Natural Resources [DLNR] 2005)
- The USFWS Information for Planning and Consultation (IPaC) website (USFWS 2020)

Additionally, SWCA drew on knowledge of the Mahi Solar Project Area, which is adjacent to the project area and consists of similar vegetation and habitat types.

3 RESULTS

3.1 Flora

Because no field surveys were conducted in the project area, all vegetation types and species named are expected to occur based only on desktop research. The vegetation in the project area has been disturbed by previous and current land-use activities, and the vegetation types and species expected to be in the project area are not considered unique on O‘ahu. The vegetated portions of the project area can be classified into two predominant types: cultivated croplands and fallow fields. Cultivated croplands may consist of a mixture of species, likely including corn (*Zea mays*), with sparse weedy vegetation at the edges of fields. Fallow fields consist primarily of grasslands, likely dominated by Guinea grass (*Urochloa maxima*). Other less prominent vegetation types expected include non-native forest consisting of koa haole (*Leucaena leucocephala*) or kiawe (*Prosopis pallida*), and grasslands of Guinea grass formed through disturbances other than cultivation for agriculture. Water bodies such as reservoirs and irrigation ditches exist in the project area; however, these areas do not appear to support any wetland or other vegetation types.

The IPaC resource query for this project did not list any special-status plant species that could occur in the project area. The project area is not expected to contain substantial numbers of special-status plant species. Ground surveys are necessary to confirm that no special-status plants occur in the project area.

3.2 Fauna

The USFWS IPaC website was queried to determine whether special-status and MBTA-protected species may be present in the project area. SWCA used best professional judgement and knowledge of the site to narrow down the results of the query to likely species. The results of this query can be provided if requested. In general, most of the wildlife species expected to occur in the project area include assemblages that are found on O‘ahu between 200 and 365 m (650 and 1,200 feet) in elevation.

3.2.1 *Avifauna*

The IPaC resource query for this project listed three native MBTA-protected bird species that could occur in the project area. Based on geographic location, available habitat, and SWCA's best professional judgement, only two native MBTA-protected birds on the IPaC resource list are likely to occur, both of which are native: ʻapapane (*Himatione sanguinea*) and Oʻahu ʻamakihi (*Chlorodrepanis flava*). Additional non-native bird species could occur in the project area.

3.2.2 *Special-Status Species*

No field surveys were conducted to determine whether federally listed or state-listed threatened, endangered, proposed, or candidate species or rare special-status species may occur in the project area. The IPaC resource did not list any species with potential to occur in the project area. However, based on geographic location, available habitat, and SWCA's best professional judgement, the project area could provide suitable habitat for the following special-status species, which are described in further detail below. Other threatened and endangered species were initially considered but were dismissed from further analysis because of a lack of suitable habitat or because the project area is out of their habitat range.

- Hawaiian hoary bat (*Lasiurus cinereus semotus*): State-listed and federally listed as endangered
- Hawaiian goose or nēnē (*Branta sandvicensis*): State-listed and federally listed as endangered
- Hawaiian short-eared owl or pueo (*Asio flammeus sandwichensis*): State-listed as endangered

Hawaiian waterbirds

- Hawaiian coot or ʻalae keʻokeʻo (*Fulica alai*): State-listed and federally listed as endangered
- Hawaiian gallinule or ʻalae ʻula (*Gallinula galeata sandvicensis*): State-listed and federally listed as endangered
- Hawaiian stilt or aeʻo (*Himantopus mexicanus knudseni*): State-listed and federally listed as endangered

Seabirds

- Band-rumped storm-petrel or akēʻakē (*Oceanodroma castro*): State-listed and federally listed as endangered
- Hawaiian petrel or ʻuaʻu (*Pterodroma sandwichensis*): State-listed and federally listed as endangered
- Newell's shearwater or ʻaʻo (*Puffinus auricularis newelli*): State-listed and federally listed as threatened

3.2.2.1 HAWAIIAN HOARY BAT

Hawaiian hoary bats forage and roost in pasture, cropland, orchards, forests, and developed lands such as golf courses, urban areas, and suburban yards. Hawaiian hoary bats are solitary and roost in exotic and native woody vegetation. They could forage throughout the project area and roost in the extant trees. The birthing and pup-rearing season typically occurs between June 1 and September 15. It is common for adult females to leave flightless young unattended in "nursery" trees and shrubs while foraging.

3.2.2.2 HAWAIIAN GOOSE (NĒNĒ)

Nēnē occupy various habitat types ranging from beach strand, shrubland, grassland, and lava rock at elevations ranging from coastal lowlands to alpine areas (Banko 1988; Banko et al. 1999). The geese eat plant material, and the composition of their diet depends largely on the vegetative composition of their surrounding habitats. Most nēnē food items are leaves and seeds of grasses and sedges, leaves and flowers of various herbaceous composites, and various fruits of several species of shrubs (Black et al. 1994). They appear to be opportunistic in their choice of food plants as long as the plants meet their nutritional demands (Woog and Black 2001).

Potential forage and nest habitats are present for nēnē in the cultivated croplands and fallow fields of the project area. Nēnē were first observed on O‘ahu in 2014 where they nested and produced offspring in 2014 at James Campbell National Wildlife Refuge. This small population has been extirpated from O‘ahu (personal communication, Kelly Goodale, USFWS, September 1, 2020). When nēnē occurred on O‘ahu, they were known to travel between Mililani (agriculture park and local golf course), James Campbell National Wildlife Refuge, and Turtle Bay Resort on the North Shore of O‘ahu. Because of the known geographic range, extirpated O‘ahu population, and non-migratory lifestyle of nēnē, the species is highly unlikely to occur in the project area.

3.2.2.3 HAWAIIAN SHORT-EARED OWL (PUEO)

The Hawaiian short-eared owl is active during the day and occurs in a variety of habitats, including wet and dry forests, grasslands, and shrublands. Its diet consists of small mammals and birds (Holt and Leasure 2006). Little is known about the breeding biology of the Hawaiian short-eared owl, but nesting occurs throughout the year (USFWS 2013). Nests are made on the ground and are lined with grasses and feathers. Hawaiian short-eared owls were documented in the nearby Mahi solar study area, and similar habitat exists in the Gen-Tie project area. The portion of similar habitat is limited to an undeveloped gulch consisting of both grassland and non-native forest in the western portion of the project area. Nests are unlikely to occur in any areas that are currently used for agriculture.

3.2.2.4 HAWAIIAN WATERBIRDS

Three listed waterbird species—Hawaiian coot, Hawaiian gallinule, and Hawaiian stilt—could visit the project area. These species are found in a variety of wetland habitats, such as freshwater marshes and ponds; coastal estuaries and ponds; artificial reservoirs; kalo or taro (*Colocasia esculenta*) lo‘i, or patches; irrigation ditches; and sewage treatment ponds (USFWS 2011). The Hawaiian coot, Hawaiian gallinule, and Hawaiian stilt could visit and forage in the manmade water sources within and adjacent to the project area, such as the reservoirs and Waiāhole ditch. It is unlikely that the Hawaiian coot, Hawaiian gallinule, and Hawaiian stilt would nest in the project area due to a lack of permanent water resources with aquatic vegetation.

3.2.2.5 SEABIRDS

Three listed seabird species—the endangered band-rumped storm-petrel, the endangered Hawaiian petrel, and the threatened Newell’s shearwater—could fly over the project area at night while traveling to and from their upland nesting sites and foraging areas in the ocean. It is very unlikely they would use the habitat available in the project area for anything other than flying over it.

4 AVOIDANCE AND MINIMIZATION MEASURES

4.1 Flora

Because the project would likely involve the movement of materials and construction equipment, SWCA recommends the following invasive species mitigation measures:

- To avoid the unintentional introduction or transport of new terrestrial invasive species to O‘ahu, all construction equipment and vehicles arriving from outside O‘ahu should be washed and inspected prior to entering the site. In addition, construction materials arriving from outside O‘ahu should also be washed and/or visually inspected (as appropriate) for excessive debris, plant materials, and invasive or harmful non-native species (plants, amphibians, reptiles, and insects). When possible, raw materials (gravel, rock, and soil) should be purchased from a local supplier on O‘ahu to avoid introducing non-native species not present on the island. Inspection and cleaning activities should be conducted at a designated location.
- The inspector must be a qualified botanist-entomologist able to identify invasive species and animals of concern relevant to the point of origin of the equipment, vehicle, or material. Invasive species that should be checked for during inspections can be found at the following online locations:
    - U.S. Department of Agriculture (USDA) PLANTS Database of the Hawai‘i State-listed Noxious Weeds (USDA 2020)
    - O‘ahu Invasive Species Committee’s (OISC’s) Priority Target Species (OISC 2020)
- All herbicide use will be applied in a manner consistent with product labels.

4.2 Fauna

The following avoidance and minimization measures will be applied to avoid and minimize impacts to the endangered, threatened, and candidate fauna with potential to occur in the project area (USFWS 2020).

4.2.1 *Hawaiian Hoary Bat*

- If felling of standing trees occurs during the bat breeding season, direct impacts could occur to juvenile bats that are too small to fly but too large to be carried by a parent. To minimize this impact, no trees taller than 15 feet should be trimmed or removed between June 1 and September 15.
- The use of barbless top-strand wire is recommended for all fence construction to avoid entanglement of Hawaiian hoary bat.

4.2.2 *Hawaiian Goose (Nēnē)*

- Hawaiian geese will not be disturbed, approached, and/or fed.
- If Hawaiian geese are observed loafing or foraging within the project area during the breeding season (September–April), a biologist familiar with the nesting behavior of the Hawaiian goose will conduct a nest survey in and around the project area prior to the continuation of any work. Surveys will be repeated after any subsequent delay of work of 3 or more days (during which the birds may attempt to nest).

- If a Hawaiian goose nest is discovered, all work within a 150-foot radius will cease and the USFWS and DLNR will be contacted for further guidance.
- In areas where Hawaiian geese are known to occur, reduced speed limits will be posted and implemented, and project personnel and contractors will be informed about their presence.

4.2.3 *Hawaiian Short-eared Owl (Pueo)*

- A biological monitor should be present when clearing vegetation in pueo nesting habitat.
- If a pueo nest is discovered, all activities within 150 feet of the nest should cease, and the Hawaiʻi DLNR should be contacted. Work should not resume until directed by the DLNR.
- The use of barbless wire is recommended for all fence construction to avoid entanglement of pueo.

4.2.4 *Hawaiian Waterbirds*

- In areas where emergent vegetation or other waterbird nesting habitat would be disturbed, waterbird nest searches will be conducted by a qualified biologist before any work is conducted and after any subsequent delay in work of 3 or more days (during which birds may attempt nesting).
- In areas where waterbirds are known to occur, speed limit signs will be posted and followed.
- Waterbird nests, chicks, or broods found in the project area before or during construction will be reported to the USFWS and DLNR within 24 hours, and a 100-foot buffer will be maintained until the chicks/ducklings have fledged
- If an active nest or brood is found, a biological monitor will be present at the construction site during all construction activities to ensure that Hawaiian waterbirds and nests are not adversely impacted.

4.2.5 *Seabirds*

- Construction activity should be restricted to daylight hours as much as practicable during the seabird peak fallout period (September 15–December 15) to avoid the use of nighttime lighting that could attract seabirds.
- All outdoor lights should be shielded to prevent upward radiation. This has been shown to reduce the potential for seabird attraction (Reed et al. 1985; Telfer et al. 1987). A selection of acceptable, seabird-friendly lights are available online at the State of Hawaiʻi DLNR website (DLNR 2016): http://dlnr.hawaii.gov/wildlife/files/2016/03/DOC439.pdf
- Outside lights not needed for security and safety should be turned off from dusk through dawn during the fledgling fallout period (September 15–December 15).

5 LITERATURE CITED

Banko, P.C. 1988. Breeding biology and conservation of the Nēnē, Hawaiian goose (*Nesochen sandvicensis*). Ph.D. dissertation, University of Washington, Seattle.

Banko, P.C., J.M. Black, and W.E. Banko. 1999. Hawaiian Goose (Nēnē) (*Branta sandvicensis*). In *The Birds of North America, No. 434*, edited by A. Poole and F. Gill. Philadelphia, Pennsylvania: The Birds of North America, Inc.

Black, J.M., J. Prop, J.M. Hunter, F. Woog, A. Marshall, and J. Bowler. 1994. Foraging behaviour and energetics of the Hawaiian goose, *Branta sandvicensis*. *Wildfowl* 45:65–109.

Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte. 2013: Online Rainfall Atlas of Hawai‘i. *Bulletin of the American Meteorological Society* 94:313–316.

Hawai‘i Department of Land and Natural Resources (DNLR). 2005. *Hawai‘i's Comprehensive Wildlife Conservation Strategy*. Available at: https://dlnr.hawaii.gov/wildlife/files/2013/09/CWCS-Full-Document-2005Oct01.pdf. Accessed December 2, 2020.

———. 2016. *Wildlife Lighting*. Available at: http://dlnr.hawaii.gov/wildlife/files/2016/03/DOC439.pdf. Accessed September 2, 2020.

Holt, D.W., and S.M. Leasure. 2006. Short-eared owl (*Asio flammeus*). In *The Birds of North America*, No. 062. Philadelphia, Pennsylvania: The Birds of North America, Inc.

O‘ahu Invasive Species Committee (OISC). 2020. OISC target pests. Available at: http://www.oahuisc.org/target-pests/. Accessed August 26, 2020.

Reed, J.R., J.L. Sincock, and J.P. Hailman. 1985. Light attraction in endangered procellariiform birds: reduction by shielding upward radiation. *The Auk* 102:377–383.

Telfer, T.C., J.L. Sincock, G.V. Byrd, and J.R. Reed. 1987. Attraction of Hawaiian seabirds to lights: conservation efforts and effects of moon phase. *Wildlife Society Bulletin* 15:406–413.

U.S. Department of Agriculture (USDA). 2020. Hawai‘i State-listed Noxious Weeds. Available at: https://plants.usda.gov/java/noxious?rptType=State&statefips=15. Accessed August 26, 2020.

U.S. Fish and Wildlife Service (USFWS). 2003. *Draft Revised Recovery Plan for Hawaiian Forest Birds, Second Revision*. Portland, Oregon: U.S. Fish and Wildlife Service, Region 1.

———. 2011. *Recovery Plan for Hawaiian Waterbirds, Second Revision*. Portland, Oregon: U.S. Fish and Wildlife Service.

———. 2020. Information for Planning and Consultation (IPaC). Available at: https://ecos.fws.gov/ipac/. Accessed December 2, 2020.

Woog, F., and J.M. Black. 2001. Foraging behavior and the temporal use of grasslands by nēnē: implications for management. *Studies in Avian Biology* 22:319–3

Appendix E

A Ka Paʻakai O Ka ʻĀina Analysis for the Longroad Energy Management, LLC Mahi Solar Facility ASM Affiliates December 2020

A *Ka Paʻakai O Ka ʻĀina* Analysis for the Longroad Energy Management, LLC. Mahi Solar Facility

TMK: (1) 9-2-001:020; 9-2-004:003, 006, 010, and 012; 9-4-003:001

Honouliuli Ahupuaʻa
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ASM Project Number 29450.05

A *Ka Pa‘akai O Ka ‘Āina* Analysis for the Longroad Energy Management, LLC. Mahi Solar Facility

TMK: (1) 9-2-001:020, 9-2-004:003, 006, 010, and 012; 9-4-003:001

Honouliuli Ahupua‘a
‘Ewa District
Island of O‘ahu

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1. INTRODUCTION

At the request of Longroad Energy Management, LLC (Applicant), ASM Affiliates (ASM) has prepared this *Ka Pa'akai O Ka 'Āina* Cultural Practices and Resources Analysis associated with the proposed development of the Mahi Solar Facility located within Honouliuli Ahupua'a, 'Ewa District, Island of O'ahu (Figures 1, 2, and 3). The Applicant is proposing to construct a 120-megawatt solar project, a Battery Energy Storage System (BESS), and other associated appurtenances including fencing, roads, and electrical infrastructure on roughly 600 acres of agriculture-zoned land that includes portions of Tax Map Keys (1) 9-2-001:001; 9-2-004:003, 006, 009, 010, 011, 012, and 013; 9-04-003:001 (see Figure 2). The Applicant will be applying for a Special Use Permit with the City and County of Honolulu. This *Ka Pa'akai O Ka 'Āina* Cultural Practices and Resources analysis is intended to aid the State of Hawai'i and its associated agencies with addressing preservation and protection of traditional and customary rights and to aid the Applicant with the planning of the proposed Mahi Solar Facility.

Article XII, Section 7 of the Hawai'i Constitution obligates the State and its agencies, such as the Land Use Commission (LUC), "to protect the reasonable exercise of customarily and traditionally exercised rights of native Hawaiians to the extent feasible when granting a petition for reclassification of district boundaries" (Ka Pa'akai O Ka 'Aina v Land Use Commission, 94 Hawai'i 31, 7 P.3d 1068 [2000]). Under Article XII, Section 7, the State reaffirms and shall protect all rights, customarily and traditionally exercised for subsistence, cultural and religious purposes and possessed by *ahupua'a* tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778, subject to the right of the State to regulate such rights. In the context of land use permitting, these issues are commonly addressed when the LUC is asked to approve a petition for the reclassification of district boundaries or zoning, as such an action most often initiates activities that precede initial intensive development.

On September 11, 2000, the Hawai'i Supreme Court's landmark decision in *Ka Pa'akai O Ka 'Aina v Land Use Commission* established a three-part analytical framework for addressing the preservation and protection of traditional and customary rights specific to Hawaiian communities. To effectuate the State's (and its agencies) constitutional responsibility to protect native Hawaiian customary and traditional practices while reasonably accommodating competing private interest, the framework assesses the following:

1) the identity and scope of "valued cultural, historical, or natural resources" in the petition area, including the extent to which traditional and customary native Hawaiian rights are exercised in the petition area;
2) the extent to which those resources—including traditional and customary native Hawaiian rights—will be affected or impaired by the proposed action; and
3) the feasible action, if any, to be taken by the LUC to reasonably protect native Hawaiian rights if they are found to exist.

Following these requirements, the *Ka Pa'akai o ka 'Āina* analysis provided here consists of four sections. Each section relies on historical archival sources, prior cultural and archaeological studies, and consultation to identify whether any valued cultural, historical or natural resources are present within the proposed project area. These sources, furthermore, aid in identifying the extent to which any traditional and customary native Hawaiian rights are (or have been) exercised in the proposed project area. The first section considers the proposed project area in relation to customary and traditional practices that the broader region of 'Ewa were known for. The second section assesses the extent to which specific customary and traditional practices were practiced in the *ahupua'a* of Honouliuli and the proposed project area. The third section summarizes interviews with community members who have genealogical ties and long-standing residency or relationships to Honouliuli. The last section summarizes these findings and recommends feasible actions and mitigative measures that may be taken by the LUC to reasonably protect native Hawaiian rights if they are found to exist within the proposed project area.

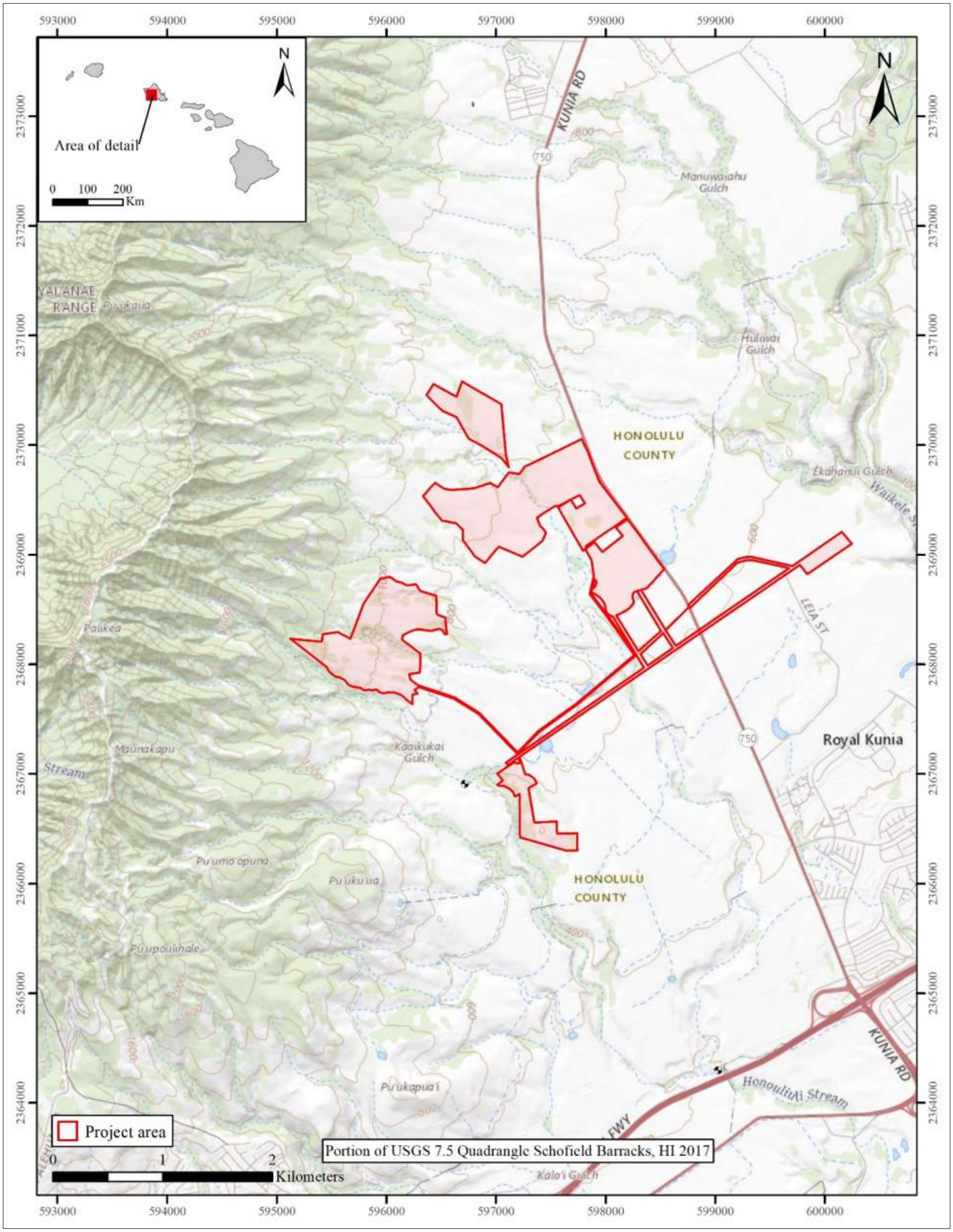

Figure 1. Proposed project area and Tax Map Key parcels shown on a USGS map.

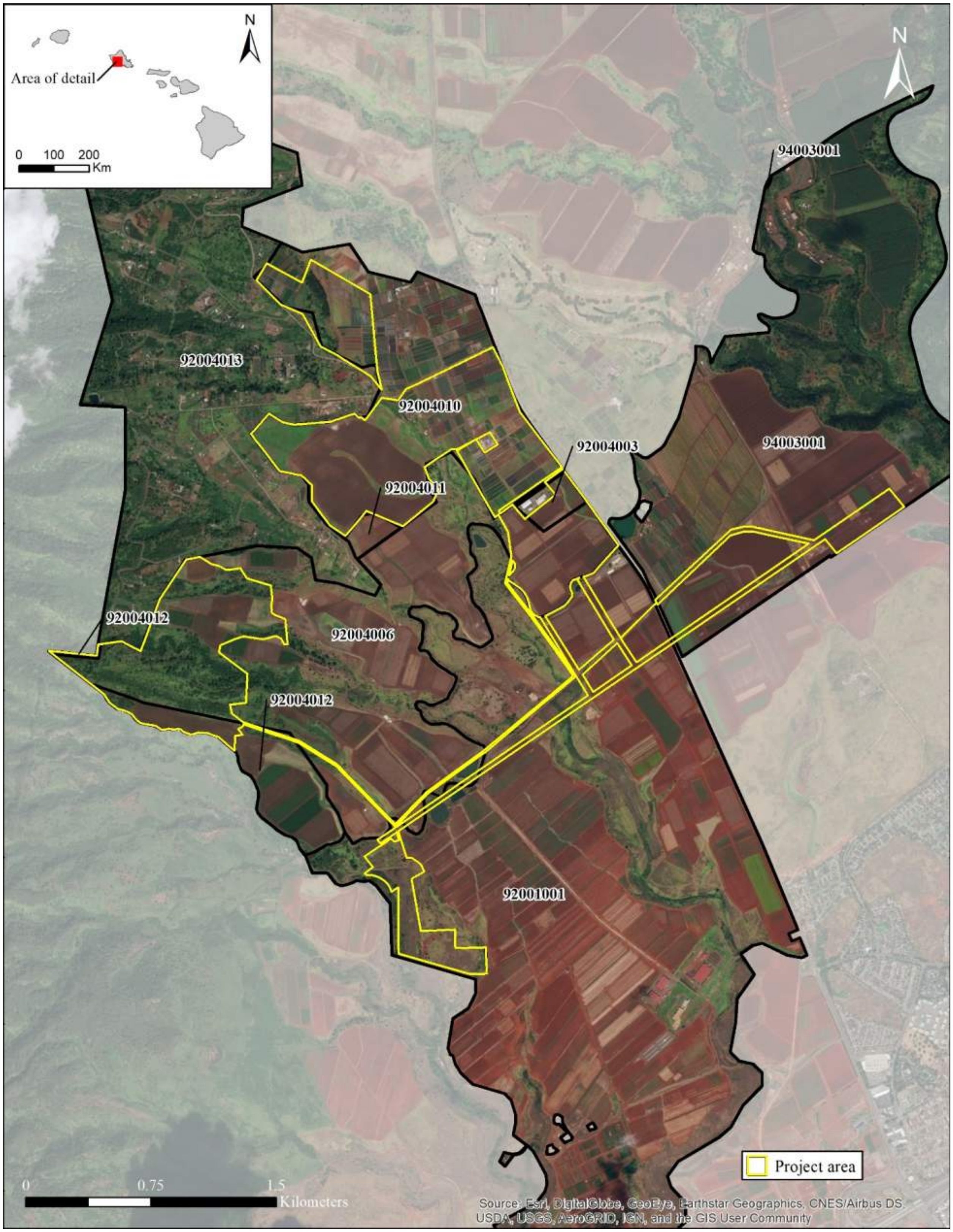

Figure 2. Satellite aerial image showing project area within various Tax Map Key parcels.

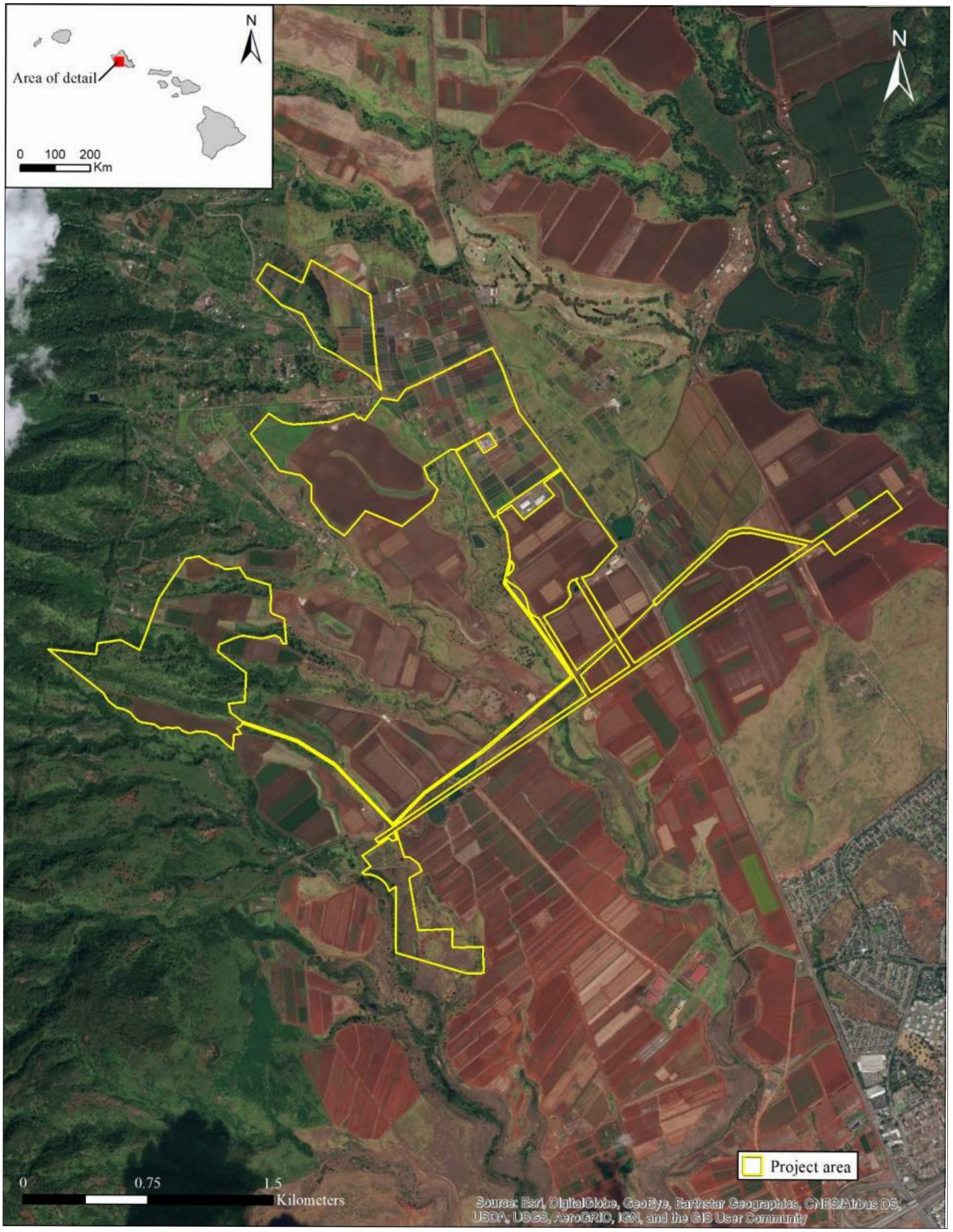

Figure 3. Google Earth™ satellite image showing project area location.

2. IDENTIFICATION OF CUSTOMARY AND TRADITIONAL PRACITCES

In an effort to identify any valued cultural, historical, or natural resources and to assess the extent to which traditional and customary rights are or have been exercised in the project area (the first part of the analytical framework), this section presents a summary of historical-archival information specific to the project area and the greater Honouliuli Ahupua'a.

Select Historical Description of Honouliuli

The proposed project area is located within the *ahupua'a* (traditional land division) of Honouliuli (Figure 4), which has been translated by Pukui et al. (1974:51) as "dark bay" and may refer to the deep waters of Ka-ihu-o-Pala'ai, known today as West Loch of Pearl Harbor (McElroy et al. 2013). Honouliuli is the largest *ahupua'a* of O'ahu and the westernmost *ahupua'a* of the 'Ewa District (see Figure 4). This *ahupua'a* extends from the emerged coral reef known as the 'Ewa Plain that comprises the southwestern extent of O'ahu and runs along the windward side of the southern extent of the Wai'anae Mountain Range (see Figure 4). According to Handy and Handy (1972:469), the traditional *moku* (district) of 'Ewa "consisted of both seaward and high interior plains, the deep valleys of the Ko'olau mountain range, and the coastal region of the Wai'anae range to the northwest." The name 'Ewa translates literally as "crooked" (Pukui et al. 1974:28), and according to Sterling and Summers (1978) the naming of this district is attributed to the male deities, Kāne and Kanaloa while attemping to survey the district boundaries:

> When Kane and Kanaloa were surveying the island they came to Oahu and when they reached Red Hill saw below them the broad plains of what is now Ewa. To mark the boundaries of the land they would throw a stone and where the stone fell would be the boundary line. When they saw the beautiful land lying below them, it was their thought to include as much of the flat level land as possible. They hurled the stone as far as the Waianae range and it landed somewhere in the Waimanalo section. When they went to find it, they could not locate the spot where it fell. So Ewa (strayed) became known by that name. The stone that strayed (Sterling and Summers 1978:1).

In citing the reminder of this story as told to Sterling by Mr. Simeon Nawa'a in 1954:

> Eventually the stone was found at Pili o Kahe. This is a spot where two small hills of the Waianae range come down parallel on the boundary between Honouliuli and Nanakuli (Ewa and Waianae). The ancient Hawaiian said the hill on the Ewa side was the male and the hill on the Waianae side was female. The stone was found on the Waianae side hill and the place is known as Pili o Kahe (Pili = cling to, Kahe = to flow*). The name refers, therefore, to the female or Waianae side hill. And that is where the boundary between the two districts runs. (Sterling and Summers 1978:1)

In providing a geographical description of the district, Handy and Handy state that:

> The salient features of 'Ewa, and perhaps its most notable point of difference, is its specious coastal plain, surrounding the deep bays ("lochs") of Pearl Harbor, which are acutally the drowned seaward valleys of 'Ewa's main streams, Waikele and Waipi'o. The Hawaiian name Pearl Harbor was Ke-awa-lau-o-Puuloa, The-many (*lau*)-harbors (*awa*)-of Pu'uloa. Pu'uloa was the rounded area projecting into the sea at the long narrow entrance of the harbor. Another and more poetic name was Awawa-lei, Garland (*lei*)-of-harbors. The English name "Pearl" was given to it because of the prevalence of pearl oysters (*pipi*) in the deep harbor waters. (Handy and Handy 1972:469)

As a district, 'Ewa contains a diversity of environments. Well-watered lands are found along the central and eastern limits and many of these *ahupua'a* names are associated with *wai* (water) originating from the Ko'olau Mountains including, Waikele, Waipi'o,Waiawa, Waimano, Waiau, and Waimalu (see Figure 4). The western extent of the district, which includes the subject *ahupua'a* of Honouliuli, is situated along the southeastern limits of the Wai'anae Mountain Range and includes the 'Ewa plains which has been characterized in traditional and historic literature as arid. 'Ewa is also known for its red earth and several *'ōlelo no'eau* (poetical expressions) highlight this feature:

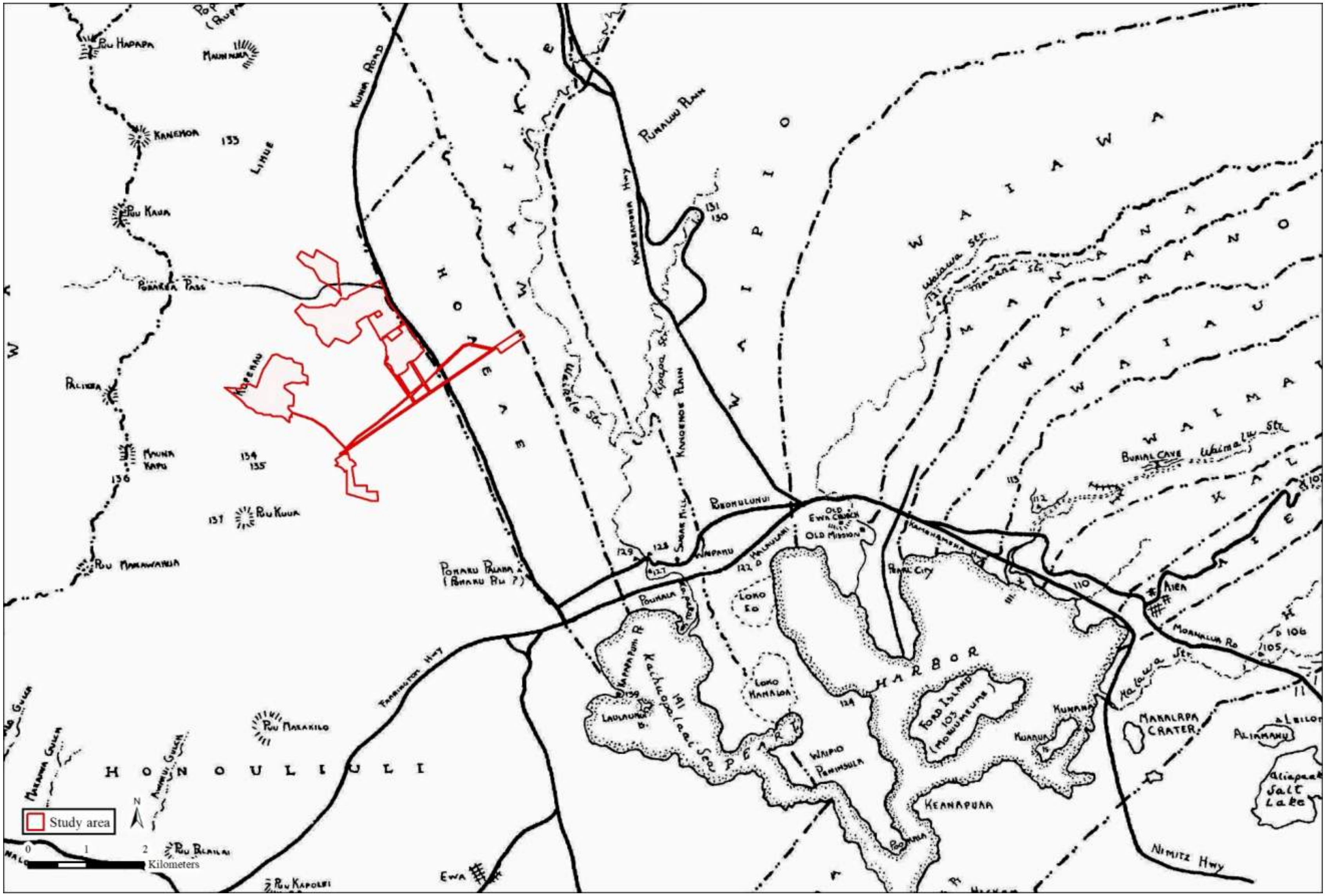

Figure 4. ‘Ewa district with *ahupua‘a* and project area in Honouliuli Ahupua‘a (Sterling and Summers 1978).

ʻĀina koi ʻula i ka lepo.

Land reddened by the rising dust.

Said of ʻEwa, Oʻahu. (Pukui 1983:11)

O ʻEwa, ʻāina kai ʻula i ka lepo.

ʻEwa, land of the sea reddened by earth.

ʻEwa was once noted for being dusty, and its sea was reddened by mud in time of rain. (Pukui 1983:257)

In an article published in the *Honolulu Star-Bulletin* on October 16, 1956, Mr. Simeon Nawaa clarified the extent of the ʻEwa district. That portion of his article which describes the ʻEwa district reads:

> The northern boundary of Ewa begins from the top of Kaala mountain and running towards Koolau mountain range, passing Wahiawa and Halemano; along this mountain range to Moanalua, thence to Keehi lagoon, passing Kapukaki (Red Hill). From the west of Honolulu Airport near Kapuaikaula (Fort Kamehameha), it rund to Barber's Point, thence to Piliokahe; from Piliokahe along Kaala mountain range to the beginning, comprising the following tracts of land: Halawa, Aiea, Kalaauao, Waimalu, Waiau, Waimano, Manana (Pearl City), Waiawa, Waikele, Hoaeae, Honouliuli and including Waikakalaua, Schofield Barracks, Wahiawa and Halemano. (Nawaa in Sterling and Summers 1978:1)

It is within this landscape that a great number of traditional accounts have been recorded. Having an understanding of these accounts helps to understand the layers of cultural meaning and value that have been ascribed to this very landscape.

Traditional *Moʻolelo* of Honouliuli

A great number of *moʻolelo* (story, myth, history, tradition, legend) that feature ʻEwa have been recorded and many of these accounts are centered around the seaward area known as Puʻuloa (see Figure 4), translated as "long hill." The lochs of this area were known traditionally as Ke-awa-lau-o-Puʻuloa (Pukui et al. 1974:201). West Loch, traditionally known as Ka-ihu-o-Palaʻai (see Figure 4), was a culturally significant area of Honouliuli Ahupuaʻa (Pukui et al. 1974). It was on the west end of Ka-ihu-o-Palaʻai along Honouliuli Stream that Honouliuli's prime taro lands, fishponds, and salt production areas were located (see Figure 4).

Concerning traditional *moʻolelo*, it is believed that the first *ʻulu* (breadfruit) planted in the Hawaiian Islands was brought from Upolu, Samoa and planted at Puʻuloa in ʻEwa by Kahaʻi (Fornander 1916-1917), the grandson of the great navigator and *aliʻi nui* Moʻikeha (Emerson 1893). In another story about Puʻuloa, Hawaiian Historian Samuel Kamakau recounts the legend of a *moʻo* (a shape-shifting water lizard) called Kanekuaʻana who came from Kahiki and brought bounties of fish and bivalves with her which she gifted to the people of ʻEwa. According to Kamakau (1964:83), "Kanekuaʻana was the *kiaʻi* [guardian]of ʻEwa, and the *kamaʻaina* from Halawa to Honouliuli relied upon her. Not all of the people of ʻEwa were her descendants, but the blessings that came to her descendants were shared by all..." According to Moses Manu's story of Keaomelemele, the *pipi* was brought to Hawaiʻi from the godly lands of Kuaihelani and Kealohilani by the matriach *moʻo* (water spirit) Moʻoinanea (Manu 2002). Manu goes on to explain how Kanekuaʻana became the caretaker of the *pipi* of ʻEwa:

> Kanekuaana was a royal lizard whose home was the lochs of Ewa. This lizard who was said to have brought the pearl oysters to the sea of Ewa and this was the oyster that was referred to as "the silent 'fish' of Ewa; do not speak lest a wind arise." Many chants have been made with reference to the pearl oyster. In resididng there, this lizard was cared for and worshipped by the people for bringing the pearl oyster...From that time it was much found in Ewa up to recent years, about 1850-1853, the time when this race [Hawaiians] of people were being destroyed by smallpox. The oysters began to vanish from that time to the present. The people of the place believed that the lizard was angry because the konohikis [landlords] imposed kapus [prohibitions], were cross with the women and seized their catch of oysters. So this "fish" was removed to Tahiti and other lands. (Manu 2002:161)

Some of ʻEwa's most famed *moʻolelo* are those associated with the named *manō* (sharks) that protected the people of this land and engaged in epic battles against sharks from the outer island, including the famed chiefess *manō*, Kaʻahupahau, her brother Kahiʻukā, Kamoawa, and many others (Sterling and Summers 1978). Some have reported that Kaʻahupahau resided "in a great cavern on the Honouliuli side of the harbor" (Advertiser 1956a:11), however she was know to frequent other lands in ʻEwa including Waipahu, a spring in Waikele and Waimano (Pukui et al. 1974).

Historian, Joseph Emerson explains that "...they [sharks] became the special object of worship for the people of the districts of Ewa and Waianae, with whom they maintained the pleasantest relations" (Emerson in Pukui and Green 1995:41).Several *ʻōlelo noʻeau* commemorate Kaʻahupahau's role in the history of ʻEwa:

> *Alahula Puʻuloa, he alahele na Kaʻahupāhau.*
>
> Everywhere in Puʻuloa is the trail of Kaʻahupāhau.
>
> Said of a person who goes everywhere, looking, peering, seeing all, or of a person familiar with every nook and corner of a place. Kaʻahupāhau is the shark goddess of Puʻuloa (Pearl Harbor) who guarded the people from being molested by sharks. She moved about, constantly watching. (Pukui 1983:14)
>
> *Hoʻahewa na niuhi ia Kaʻahupāhau.*
>
> The mandating sharks blamed Kaʻahupāhau.
>
> Evil-doers blame the person who safeguards the rights of others. Kaʻahupāhau was the guardian shark goddess of Puʻuloa (Pearl Harbor) who drove out or destroyed all the man-eating sharks. (Pukui 1983: 108)
>
> *Mehemeha wale no o Puʻuloa, i ka hele a Kaʻahupāhau.*
>
> Puʻuloa became lonely when Kaʻahupāhau went away.
>
> The home is lonely when a loved one has gone. Kaʻahupāhau, guardian shark of Puʻuloa (Pearl Harbor), was dearly loved by the people. (Pukui 1983:234)

Among the marine resources treasured by the people of ʻEwa, were the various bivalves found in the waters of Ke-awa-lau-o-Puʻuloa. This included the famed *pipi* or pearl oysters, from which the name Pearl Harbor is derived, as well as *pāpaua*, *ʻowāʻowaka*, *nahawele*, *kupekala*, and the *mahamoe* (Pukui in Sterling and Summers 1978). According to Kamakau (1964:83) the *pipi* were so abundant that it was "...enough for all ʻEwa." Kamakau goes on to add that:

> The *pipi* (pearl oyster)—strung along from Namakaohalawa to the cliffs of Honouliuli, from the *kuapa* fishponds of inland ʻEwa clear out to Kapakule. That the oyster that came in from deep water to the mussel beds near shore, from the channel entrance of Puʻuloa to the rocks along the edges of the fishpnds... (Kamakau 1964:83)

According to Mary Kawena Pukui, the *pipi* was introduced by the *moʻo* Kanekuaʻana (in Sterling and Summers 1978). It is from the *pipi* that several *ʻōlelo noʻeau* specific to ʻEwa are derived:

> *E hāmau o makani mai auaneʻi.*
>
> Hush, lest the wind arise.
>
> Hold your silence or trouble will come to us. When the people went to gather pearl oysters at Puʻuloa, they did so in silence, for they believed that if they spoke, a gust of wind would ripple the water and the oysters would vanish. (Pukui 1983:34)
>
> *Ka iʻa hāmau leo o ʻEwa.*
>
> The fish of ʻEwa that silences the voice.
>
> The pearl oyster, which has to be gathered in silence. (Pukui 1983:145).
>
> *Ka iʻa kuhi lima o ʻEwa.*
>
> The gesturing fish of ʻEwa.
>
> The *pipi*, or pearl oyster. Fishermen did not speak when fishing for them but gestured to each other like deaf-mutes. (Pukui 1983:148)
>
> *Haunāele ʻEwa i ka Moaʻe.*
>
> ʻEwa is disturbed by the Moaʻe wind.
>
> Used about something disturbing, like a violent argument. When the people of ʻEwa went to gather the *pipi* (pearl oyster), they did so in silence, for if they spoke, a Moaʻe breeze would suddenly blow across the water, rippling it, and the oysters would disappear. (Pukui 1983:59)

While the *pipi* is celebrated resources of ‘Ewa, so to are certain fish species including the *nehu* (anchovy; *Stolephorus purpureus*) and *‘o‘opu* (general name for fishes included in the families Eleotridae, Gobiidae, and Blennidae), as shown in the following *‘ōlelo no‘eau*:

> *He kai puhi nehu, puhi lala ke kai o ‘Ewa.*
>
> A sea the blows up *nehu* fish, blows up a quantity of them, is the sea of ‘Ewa. (Pukui 1983:74).
>
> *Ke kai he‘e nehu o ‘Ewa.*
>
> The sea where the *nehu* come in schools to ‘Ewa.
>
> *Nehu* (anchovy) come by the millions into Pearl Harbor. They are used as bait for fishing, or eaten dried or fresh. (Pukui 1983:185)
>
> *Ka i‘a mili i ka poho o ka lima.*
>
> The fish fondled by the palm of the hand.
>
> When it was the season for the *hinana* (*‘o‘opu* spawn), they were so numerous that they could be scooped up in the palm of the hand. (Pukui 1983:149)

While many of the *mo‘olelo* of ‘Ewa are centered around its coastal area, the *mo‘olelo* of Honouliuli often focus on the *ali‘i* and the upland areas including prominent geological features found along the south and southeastern extent of the Wai‘anae Mountain Range, and the *kula* (plain) lands. The following paragraphs are a summary of *mo‘olelo* specific to Honouliuli.

Ka Mo‘olelo O Hi‘iakaikapoliopele

A *mo‘olelo* that features Honouliuli is that of Pelehonuamea’s younger sister, Hi‘iaka-i-ka-poli-o-Pele (Hi‘iaka). Hi‘iaka made an epic journey from Puna on Hawai‘i Island to the island of Kaua‘i to fetch her sister’s lover, Lohi‘auipo. While at least a dozen versions of this *mo‘olelo* have been published historically, the version utilized in this study was published by an author under the pen name of Ho‘oulumāhiehie. Ho‘oulimāhiehie’s account was originally published in the Hawaiian language newspaper *Ka Na‘i Aupuni* between the years 1905-1906 and was compiled, transcribed, translated, and published in a double volume (one in Hawaiian and the other in English) by Hawaiian language scholar, Puakea Nogelmeier. According to Nogelmeier, it is believed that Ho‘oulumāhiehie was the pen name of the famed 19th-century writer/politician Joseph Moku‘ōhai Poepoe who served as the editor of several Hawaiian language newspapers including *Ka Na‘i Aupuni* (Ho‘oulumāhiehie 2006b). Hi‘iaka’s journey through Honouliuli is of particular importance due to the various culturally significant places, some of which are viewable from the project area, endemic plant varieties, and traditional cultural practices that are mentioned.

While on her return trip from Kaua‘i, Hi‘iaka, Lohi‘au, and her companion, Wahine‘ōma‘o, stopped in the Wai‘anae District before heading towards Kou (the ancient name of Honolulu before 1800; Pukui et al. 1974). While Lohi‘au and Wahine‘ōma‘o traveled by canoe from Pōka‘i in Wai‘anae to Kou, Hi‘iaka traveled by foot, entering ‘Ewa from the heights of Pōhākea—a passage northwest of the project area—(see Figure 4) then across the plain of Honouliuli. From Pōhākea, she descended to Keahuamoa—a land area north of the project area—where she encountered several women gathering *ma‘o* (*Gossypium tomentosum*, an endemic yellow-flowered hibiscus) blossoms from which they were making *lei* (garland). To secure a *lei ma‘o* for herself, Hi‘iaka offered the following *oli* (chant) to the women:

E lei ana ke kula o Ke‘ehumoa i ka ma‘o	The plains of Ke‘ehumoa are garlanded with ma‘o
‘Ohu‘ohu wale nā wāhine kui lei o ka nahele	The lei-stringing women of the forest are festively adorned
Ua like nō a like ma nā lehua o Hōpoe	Just like the lehua blossoms of Hōpoe
Me he pua koili lehua ala i ka lā	Like lehua blossoms ensconced in the sun
Ka ‘ohi pua koai‘a i ka pali	Gathering koai‘a flowers on the cliffs
I nā kaupaku hale o ‘Āpuku	Those roof tops of ‘Āpuku
Ke kū nō ‘o ke alo o ka pali o Pu‘uku‘ua	The cliff face of Pu‘uku‘ua rises up
He ali‘i nō na‘e ka ‘āina	Yet the land is the chief
Ha kauā nō na‘e ke kanaka	Man is but a servant
I kauā nō na‘e au i ke aloha	As I am a servant to love

Na ke aloha nō i kono e haele nō māua	It was love that invited the two of us to go
E hele nō wau ē.	I must, indeed, go on.
(Hoʻoulumāhiehie 2006b:287)	(Hoʻoulumāhiehie 2006a:268)

Captivated by Hiʻiaka's chant, the women called out and welcomed Hiʻiaka by placing the *lei maʻo* around her neck and inviting her to their *kauhale* (village) for a feast. Hiʻiaka politely declined their request and bid the women farewell before proceeding to the coast of Honouliuli to Puʻuloa (Hoʻoulumāhiehie 2006b). As Hiʻiaka traversed the plain, she saw two women stringing *lei* of the *ʻilima* (*Sida fallax*) blossom beside the *ala loa* (trail). The two women recognized Hiʻiaka and feared she would kill them. To escape potential death, the two women transformed into their *moʻo* forms and hid in a depression of a stone located along the *ala loa* which continued on to Waiʻanae. In detailing the name of the place where the two *moʻo* hid, Hoʻoulumāhiehie (Hoʻoulumāhiehie 2006b) states:

> *A ua kapa ʻia nō ia wahi pōhaku e kū nei, ke ʻole naʻe e pau i ka wāwahi ʻia e ka poʻe hana alanu o kēia au hou nei, ma ka inoa o Peʻekāua, ʻo ia hoʻi, ka upeʻe ʻana o ua mau wahi moʻo nei ma loko o nā poli ʻālualua o ua pōhaku lā.* (Hoʻoulumāhiehie 2006b:288)
>
> That stone, which still stands there, if it has not been crushed by the road builders of these modern times, is called "Peʻekāua," or "let us hide," a reference to those two moʻo hiding in the holes of that stone. (Hoʻoulumāhiehie 2006a:269)

From the plain of Honouliuli, Hiʻiaka turned her gaze to Puʻu Kapolei and Nāwahineokamaʻomaʻo, both of whom were relaxing at the top of hill shaded by *ʻōhai* shrubs (Hoʻoulumāhiehie 2006a:270). Puʻu Kapolei is also the name of a *wahi pana* locate southwest of the current project area (see Figure 3). Careful not to offend Puʻu Kapolei and Nāwahineokamaʻomaʻo, Hiʻiaka acknowledged the women by offering the following chant:

Aloha ʻolua, e Puʻukapolei mā	Greetings to you, O Puʻuokapolei
E Nāwahineokamaʻomaʻo	O Nāwāhineokamaʻomaʻo
E nonoho maila i noho wale lā	Sitting there, there you dwell
I ka malu o ka ʻōhai	In the shade of the ʻōhai
I ke kui lei pua kukui i ka lā	Stringing kukui blossom garlands in the sun
Lei aku i ka pua o ka maʻomaʻo	Wearing lei of the maʻomaʻo flower
Lei kaunoʻa ʻula i ke kaha o Koʻolina lā	Lei of bright kaunoʻa upon the strand of Koʻolina
He ʻolina hele ē	Such a festive way, all about.
(Hoʻoulumāhiehie 2006b:289)	(Hoʻoulumāhiehie 2006a:270)

After hearing the chant, Puʻukapolei responded to Hiʻiaka thusly:

> *Aloha! Aloha ʻoe, e Hiʻiaka!! E hele nō ʻoe, a mai kipa mai ʻoe iā māua nei; ʻaʻohe a māua ʻai o neʻi nei e ola ai lāʻi ka maka pōniuniu pōloli e kipa mai.*
>
> *ʻOia auaneʻi ke kipa ʻana mai iā māua nei a he mau ʻelemākule kāne māua, loaʻa ka mahiʻai aku i kēia kula panoa e waiho mai nei, a hiki hoʻi ke kanu aku kahi lau ʻuala a kupu aʻe hoʻi.*
>
> *E laʻa nei hiki ʻana mai nei ou, he imu ka mea hoʻā aku, a ola nei lā pōloli. ʻAʻohe a māua ʻai, ʻaʻohe a māua iʻa, ʻaʻohe kapa. Hoʻokahi nō o māua kapa, ʻo ka mauʻu pilipili ʻula.*
>
> *Hele aku māua a uhuki mauʻu a kū ka pūʻā, hoʻi mai a ulana iho i mau wahi ʻāleuleu kapa pua mauʻu no māua. A i ka wā e maloʻo mai ai ka mauʻu, noho ʻōlohelohe ihola nō māua.*
>
> *Pā maila ke anu a ke Kēhau a me ka Waikōloa, ʻaʻohe anu a koe. Aia nō ko māua mehana a ulu hou mai ka mauʻu o ka ʻāina.* (Hoʻoulumāhiehie 2006b:289)
>
> Aloha! Welcome to you, Hiʻiaka!! You should, however, travel on, and not stay with us here; we have no food to stave off the dizzy eyes of hunger if you visit.
>
> It would be all right to call on us here if only we were old men, for then we could do some tilling of this arid plain, and plant ʻuala leaves that would sprout and grow.
>
> Your arrival is inopportune, for an oven should be set to cooking to appease hunger. Yet we have no vegetables or meat, no kapa for clothing or covers. Our only kapa is the red pilipili grass.
>
> We go and pull up grass and bundle it, to bring back and weave into rough cloth of grass sheaves for ourselves. When the grass all dries up, we abide in our nakedness.

The chill comes with the Kēhau and Waikōloa winds, which are so very cold. We are only warmed again when the grasses of the land grew anew. (Hoʻoulumāhiehie 2006a:270)

After hearing the woeful cries of Puʻukapolei, Hiʻiaka descended towards the sea at Puʻuloa and noticed a *maʻo* blossom stunted by the stifling sun. Upon seeing this, Hiʻiaka raised her voice in chant:

Liua Kona i ka lā loa o Makaliʻi	Kona is dazed by the powerful Makaliʻi-season sun
Māewa ka wiliwili, hele i ka laʻi	The wiliwili trees sway, moving in the calm
Kūlōlia ka mauʻu o Kānehili	Longsuffering are the grasses of Kānehili
Welawela ka lā o Puʻuokapōlei	The sun is oppressively hot at Puʻuokapolei
ʻUkiki ka maʻo, kū lā i kai	The maʻo is stunted, standing at the shore
Me he kapa halakea lā ka pua o ke nohu	The blossom of the nohu is like a yellow halakea kapa
Ka ʻoaka, ka puaʻula i ke kaha o Kaupeʻa lā	Flashing, blooming bright in the strands of Kaupeʻa
A he hoa	As a companion
E hoʻohoa aku ana i ka makani he Nāulu	Befriending the wind, a gusting Nāulu
A he hoa ē.	A companion indeed.
(Hoʻoulumāhiehie 2006b:290)	(Hoʻoulumāhiehie 2006a:271)

Hiʻiaka continued *makai* down the trail until she reached Kualakaʻi on the coast of Honouliuli to the south of the project area (see Figure 4), where she found a freshwater spring called Hoakalei, which was flanked by two beautiful *ʻōhiʻa lehua* (*Metrosideros polymporpha*) trees from which she took blossoms to string into more *lei*. Hoakalei is located to the north of Kualakaʻi, near Kalaeloa (Barber's Point), and from there she walked on to Puʻuloa. With respect to Hiʻiaka's journey through ʻEwa, Pukui (1983:16) recorded the following *ʻōlelo noʻeau* in which Hiʻiaka uttered to Wahineʻōmaʻo as a caution not to speak to Lohiʻau while they were passing along ʻEwa in their canoe, "Anu o ʻEwa i ka iʻa hāmau leo e. E hāmau! *ʻEwa is made cold by the fish that silences the voice. Hush!"* Pukui (1983:16) interpreted this saying thusly, "A warning to keep still. First uttered by Hiʻiaka to her friend Wahineʻomaʻo to warn her not to speak to Lohiʻau while they were in a canoe near ʻEwa."

He Kaʻao no Kahalaopuna

The route at Pohakea (see Figure 4) taken by Hiʻiaka as she passed from Waiʻanae into ʻEwa is also mentioned in the account of Kahalaopuna, the young maiden of Mānoa. As recounted by Fornander (1918-1919), Kahalaopuna was betrothed by her parents to Kauhi, a man from Alele, Koʻolauloa. Kauhi with the hopes of securing her as a wife sent her many gifts. After one *anahulu* (ten-day period) had lapsed, rumors about Kahalaopuna being unfaithful had reached Kauhi and he sought to kill the young girl. Having arrived at her home in Mānoa, Kauhi asked Kahalaopuna to go with him to Pohakea to which she agreed. Kauhi subsequently bound her hands and he led her from Mānoa to Pohakea on trails that were not frequented by people. At Pohakea, Kauhi took her under a large *lehua* (*Metrosideros polymorpha*) tree, where he broke off a branch and in a jealous rage, beat Kahalaopuna. To save her life, she chanted to Kauhi but he persisted with his cruel acts until Kahalaopuna died. Kauhi concealed her body by covering it with leaves and ferns and returned to his home.

Kahalaopuna's spirit flew into the trees and upon seeing a company of travelers, she chanted informing them of her death. After her second attempt to get the attention of the travelers, they heard the calls of Kahalaopuna and returned to Mānoa to inform her parents. Her father and mother (Kauakuahina and Kahoiamano) retrieved their daughter's body from Pohakea and returned it to their home where they proceeded to restore her to life. News of the girl's restoration had spread to Koʻolauloa. Hearing the news, Kauhi returned to Mānoa to see for himself and to beg Kahalaopuna to take him back to which she staunchly refused (Fornander 1918-1919).

He Kaʻao no Palila

Several land areas in Honouliuli are briefly mentioned in the legend of Palila, a supernatural warrior from Kamoʻoloa, Kauaʻi. As told by Fornander (1918-1919), Palila was born as a piece cord to his parents Kaluaopalena and Mahinui, both of whom left the cord in a rubbish pile. The piece of cord was then taken by Palila's grandmother Hina, who, through a series of rituals and ceremonies, restored the cord to its human form and raised Palila on a diet consisting purely of bananas. Palila was taken by his grandmother to Alanapo where he was trained by spirits in the art of warfare. As such, Palila was able to assume a human or spirit form, a skill that provided him with further advantages over his enemies.

In one portion of the story, Palila traveled to ʻEwa to rid the area of a supernatural farmer named Kamaikaahui who could change his form into a bunch of bananas, a rat, a shark, and a human. When in his human form, it was the custom of Kamaikaahui to always wear a piece of *kapa* to conceal the shark mouth that located on his back. Wherever he went, Kamaikaahui terrorized the people and when he came to ʻEwa he followed his same practice. He had done these terrible acts so often that the people of ʻEwa began to fear him and he began to rule over them. Having heard of Kamaikaahui, Palila sought to put an end to his terror and restore peace to the land. With his magical club Huliamahi, Palila flew from Kauaʻi and landed at Kaʻena Point at Waiʻanae, then after leaving Kaʻena he flew:

> ...on to Pohakea, then to Maunauna, then to Kanehoa, then to the plain of Keahuamoa and looking toward ʻEwa. At this place he stood and looked at the dust as it ascended into the sky caused by the people who had gathered there; he then pushed his war club toward Honouliuli. (Fornander 1918-1919:142)

After landing at Honouliuli, Palila went on to Waikele (see Figure 4) where a great crowd had gathered to witness the athletic games of Ahuapau, the king of Oʻahu. Palila stood near the king and observed the spectacle before him. Palila proceeded to hurl insults to Kamaikaahui and at the sight of Palila, Kamaikaahui attempted to flee into the sea not before being caught by Palila. Palila lifted the *kapa* of Kamaikaahui and exposed the mouth on his back to the crowd before delivering his final blow and killing the supernatural farmer.

Kaʻao no Namakaokapaoo

In the story of the mysterious Namakaokapaoo, as told by Fornander (Fornander 1918-1919), the lands of Honouliuli and the plains of Keahumoa are noted. Namakaokapaoo's parents were Kauluakahai, a chief from Kahiki and his mother was Pokai. After conception, the father, Kauluakahai returned to his home in Kahiki and left his pregnant wife in a state of destitute. Pokai met a man named Pualii who was from the uplands of Līhuʻe, north of the project area (see Figure 4), and the two became lovers. Pokai and her young son resided with Pualii at Kula-o-Keahumoa and there Pualii made two large potato patches, which he named Namakaokapaoo.

One day, Pualii went to the coast of Honouliuli to fish at which time, the young Namakaokapaoo told a group of boys to dig up the potatoes belonging to Pualii. The boys proceeded to dig up the potatoes but left behind the vines. Not having completed the requested task, Namakaokapaoo took it upon himself to pull up all of the vines, piled them in stacks, and set them on fire. When Pualii returned home from fishing, he went to his potato patch and saw that his patch had been stipped of potatoes. Angered, Pualii asked his wife about the situation to which she declined having any knowledge of. Pualii declared his anger and threatened to kill the boy with his ax. Namakaokapaoo raised his voice and uttered a death prayer to Pualii. In a fury, Pualii raised his ax at Namakaopaoo at which time, the ax turned back on Pualii severing his head. Namakaokapaoo proceeded to "...pick up Pualii's head and threw it towards Waipouli, a cave situated on the beach at Honouliuli..." (Fornander 1918-1919:276)

Accounts Associated with Puʻukapolei

Puʻu Kapolei is located far south of the project area (Puuokapolei; see Figure 4) and is a *puʻu* (hill) that is mentioned frequently in *moʻolelo.* One example comes from the story of how Kamapuaʻa, the powerful pig-god and chief, took his grandmother to live there. Pertaining to the origins of Kamapuaʻa, Beckwith (1970) states that "[t]radition relates the immigration to the group of the Kamapuaʻa family during the colonizing period. His genealogy also appears in the fifth epoch of the cosmogonic chant, Kumulipo (Beckwith 1951). As a shape-shifter Kamapuaʻa was known to take on other forms including the *humuhumunukunukuapuaʻa* fish, and plants such as the *kukaepuaʻa, kukui*, *ʻuhaloa*, and *ʻamaʻu* fern (Beckwith 1970). In addition to these plants being *kinolau* (body form) of Kamapuaʻa they were also valued for their medicinal and utilitarian properties with *kukui* perhaps having the most uses that included dye and *kapa* made from the bark, oil from the nut used for the skin, traditional lamps, and fishing, *lei* from the flowers and leaves, pigment from the burnt shell, and the wood from which various item could be made (Abbott 1992). The escapades of Kamapuaʻa, a *kupua* (demigod), was one of mischief and passion and often involved the epic love-hate affair between his lover and foe, Pele. This account includes details about the conditions of a residence formerly located there. That portion of the story referring Puʻuokapolei reads thusly:

> Kamapuaa subsequently conquered most of the island of Oahu, and, installing his grandmother as queen, took her to Puuokapolei, the lesser of two hillocks forming the southeastern spur of the Waianae mountain range, and made her establish her court there. This was to compel people who were to pay tribute to bring all the necessities of life from a distance, to show his absolute power over all.

> Puuokapolei. . . is as desolate a spot as could be picked out on the whole island. It is almost equally distant from the sea, from which came the fish supplies; from the taro and potato patches of Ewa, and from the mountain ravines containing the banana and sugar plantations.
>
> A very short time ago the foundations of Kamaunuaniho's house could still be seen at Puuokapolei; also the remains of the stone wall surrounding her home. It has even been said that her grave could then be identified, but since the extension of cane and sisal planting to the base of Puuokapolei, it is possible the stones may have been removed for wall-making. (Nakuina 1904:50-51)

Kame'eleihiwa (1996) noted that Pu'u O Kapolei was the hill where the body and spirit of Kamapua'a's brother Kekelei'akū was deposited after he had committed suicide in an act of grief over the death of their younger brother. Kame'eleihiwa (1996) recounted the following story of Kamapua'a journey through Honouliuli. The story opens with a description of eight canoes that were filled with foods and gifts intended for the kings of O'ahu 'Iouli and 'Iomea who had replaced 'Olopana as king after his death. The king's attendants had docked the well-stocked canoes near Kamapua'a's cave, Keanapua'a located on Moku'ume'ume (Fort Island) in Hālawa Ahupua'a to wait for the rising tide the following dawn. That night after the attendants drifted to sleep Kamapua'a snuck up and devoured six canoes worth of food then proceeded to filled the empty calabashes with his excrement and water grouds with urine. The following morning, the chiefs attendants rose and discovered the foul gifts left by the pig.

The attendants made preparations to depart 'Ewa with the two canoes that were left untouched by Kamapua'a. As the canoes were leaving 'Ewa, Kamapua'a appeared on the shore and the attendants returned to shore to fetch the pig as cargo. While the canoe approched Kepo'okalā on the Waipi'o Peninsula, Kamapua'a leaped out of the canoe and "began to climb upland of Honouliuli until he arrived at Honouliuli Pond" (Kame'eleihiwa 1996:202). A footnote in the story suggest that Honouliuli Pond may actually be Kalo'i, an old taro patch and freshwater spring that has been lost (Kame'eleihiwa 1996:202). Upon reaching Honouliuli Pond, Kamapua'a observed his grandmother Kamaunuaniho gathering *'ohā* (taro offshoots) floating on the water of a taro patch. Kamapua'a inquired as to why she was gathering the *'ohā*, to which she replied "I am gathering a few *'ohā* floating on the water, so that I may live. "This is a time of famine for the land" (Kame'eleihiwa 1996:202). Kamapua'a then turned and pointed to another taro patch located on an open plain that contained mature taro and asked his grandmother "[y]ou should leave this place for another taro patch that is mature" (Kame'eleihiwa 1996:203). She replied, "[t]hat mature taro patch belongs to the king" and "[i]t's not for the people like us" lest the king kill us (Kame'elihiwa 1996:203). Despite the warnings from his grandmother, Kamapua'a headed to the king's taro patch and with great strength pulled up all the taro, bundled them, and loaded it onto his grandmother's back. To lesson the weight of the burden, Kamapua'a chanted to his grandfathers to aid with carrying the load. They returned to Pu'u O Kapolei where they lit an *imu* (underground oven) and cooked some of the taro.

In a description of Pu'ukapolei published on January 13, 1900, in the Hawaiian language newspaper *Ka Loea Kalaiaina* (in Sterling and Summers 1978:33-34), it states that:

> If a traveler should go by the government road to Waianae, after leaving the village of gold, Honouliuli, he will first come to the plan of Puuainako and when that is passed, Ke-one-ae. Then there is a straight climb up to Puu-o-Kapolei. It is this hill that hides Ewa from view. When you go to that [Nānākuli] side of Waimanalo, you see no more of the sight back here.
>
> Let us go on to Puu-o-Kapolei. This was one of the most famous hills in the olden days. The chant composed for games in the olden days began with the name of this hill and went on (with the place names) all around the island. This chant was used for those who swung with ropes, played on wooden ukeke instruments, or those who juggled with stones, noni fruit or kukui nuts.

The place-name chant described in the passage above appears in the January 13, 1900 article and that portion of the chant specific to Pu'uokapolei and Honouliuli has been reproduced below and a translation provided:

E Kawelo e, e Kawelo—e	Kawelo, oh Kawelo
E Kawelo Mainui o Puuokapolei	Kawelo Mainui of Pu'uokapolei
O Puuokapolei—	Pu'uokapolei
Uliuli ka Poi a kaua e	The *poi* we consume is darkened
Ai nei—o Honouliuli...	Oh Honouliuli...
(Ka Loea Kalaiaina 1900:1)	(in house translation by L. Brandt and H. Kapuni-Reynolds)

In addition to the accounts detailed above, Kamakau tells of how Pu'uokapolei was used to track the changing seasons on the Island of O'ahu. Kamakau states:

> In the same way, the people of Oʻahu reckoned from the time when the sun set over Puʻuokapolei until it set in the hollow of Mahinaona and called this period Kau, and when it moved south again from Puʻuokapolei and it grew cold and the time came when young sprouts started, the season was called from their germination (oilo) the season of Hoʻoilo. There were therefore two seasons, the season of Makaliʻi and the season of Hoʻoilo. (Kamakau in Sterling and Summers 1978:34)

Ka Hana Paʻakai (Salt Production)

Other traditional land use in Honouliuli Ahupuaʻa includes a renowned *wahi hana paʻakai* (salt-making area) that was formerly located along the leeward shores of the West Loch (see Figure 4) and continued to provide *paʻakai* (salt) well into the 20th century. In *The Archaeology of Oʻahu*, McAllister (1933:109) provided the following description of the salt production area near Puʻuloa:

> Site 146. Ewa coral plains, througout which are remains of many sites. The great extent of old stone walls, particularly near Puuloa Salt Works, belongs to the ranching period of about 75 years ago.

According to Maly's interview with Thelma Genevieve Parish, a resident of Honouliuli Ahupuaʻa and descendant of James Dowsett, some of the salt was bought by Alaskan fishing fleets and to salt the salmon catch (Maly n.d.:23). Additionally, she recalled that during her childhood many types of *limu*, as well as lobsters, and fish were plentiful in the coastal waters of Honouliuli, prior to the residential development of ʻEwa Beach, the marina, and military facilities (Maly n.d.).

Precontact Battles in Honouliuli

The bounty of land and marine resources made ʻEwa a place sought after by *aliʻi*. As a result, several accounts describe battles taking place in Honouliuli during the time of the *aliʻi* Kūaliʻi, who reigned sometime between 1720-1740, and Māʻilikūkahi and Kaʻihikapu-a-Manuia, whose reign predated that of Kūaliʻi (Cordy 2002). From the time of Māʻilikūkahi until the era of Kākuhihewa (A.D. 1640-1660), Oʻahu remained an independent chiefdom. However, over the next three generations, the island ruler gradually lost power to the district chiefs (Fornander 1880). When Kūaliʻi came to power, he defeated the island's district chiefs and acquired influence over windward Kauaʻi and initiated war on the windward parts of Molokaʻi and Hawaiʻi Island, thus marking the expansion of Oʻahu's independent chiefdom (Cordy 2002). As political expansion continued, kinship links were forged with outer island polities as intermarriage among Hawaiian nobility of different island chiefdoms occurred frequently (Cordy 2002). The shift from intra-island to inter-island warfare continued throughout the 18th century and persisted until the time of European contact in 1778.

Honouliuli and a few of its *wahi pana* are mentioned in a *mele* published as part of *Moʻolelo o Kūaliʻi* (History of Kūaliʻi) printed in *Collection of Hawaiian Antiquities and Folk-lore Volume IV* by Fornander (1916-1917:364-433). Kūaliʻi was a celebrated chief of Oʻahu. The following *mele* was composed by two brothers, Kapaahulani and Kamakaaulani (Fornander 1916-1917). These brothers devised a plan in which Kamakaaulani would give the chant's name to Kūaliʻi while Kapaahulani would urge his rival "to make war upon Kualii" and upon reaching the battlefield, Kapaahulani would chant their prayer, thus ending the battle before it began. Everything went according to plan and Kapaahulani chanted the *mele* of Kūaliʻi on the plains of Keahumoa, north of the project area in Honouliuli on the eve of Kāne (moon phase). After he finished, "the two armies came together and the battle was declared off" (Fornander 1916-1917: 400). As a result, "the king of Koolauloa then gave over, or ceded, the districts of Koolauloa, Koolaupoko, Waialua and Waianae" (Fornander 1916-1917). The following excerpt is from the *mele* for Kūaliʻi which makes specific referece to Honouliuli and other places in the ʻEwa District:

O Kawelo-e, e Kawelo-e	O Kawelo! Say, Kawelo!
O Kaweloiki puu oioi,	Kaweloiki, the sharp-pointed hill,
Puu o Kapolei e—	Hill of Kapolei.
Uliui ka poi e piha nei—o Honouliuli	Blue is the poi which appeases [the hunger] of Honouliuli
Aeae ka paakai o Kahuaiki—Hoaeae	Fine the salt of Kahuike—Hoaeae;
Pikele ka ia e Waikele—o Waikele	Slippery is the fish of Waikele—Waikele;
(Fornander 1916-1917:401)	(Fornander 1916-1917:400)

Kamakau (1991) tells of a battle between Māʻilikūkahi and chiefs of the islands of Hawaiʻi and Maui. Born at Kūkaniloko and later selected by the council of chiefs, Māʻilikūkahi took the role as *aliʻi* of Oʻahu at the age of twenty-nine. Among his many deeds, Māʻilikūkahi is perhaps most celebrated for reordering the land division system which brought about peace and prosperity over the land and people. According to Kamakau:

> When the kingdom passed to Māʻilikūkahi, the land divisions were in a state of confusion; the *ahupuaʻa* , the *kū* [*ʻili kūpono*], the *ʻili ʻāina*, the *moʻo ʻāina*, the *paukū ʻāina* , and the *kīhāpai* were not clearly defined. Therefore Māʻili-kūkahi ordered the chiefs, *aliʻi*, the lesser chiefs, *kaukau aliʻi*, the warrior chiefs, *pūʻali aliʻi*, and the overseers, *luna* to divide all of Oʻahu into *moku* and *ahupuaʻa*, *ʻili kūpono*, *ʻili ʻāina*, and *moʻo ʻāina*. There were six districts, *moku*, and six district chiefs, *aliʻi nui ʻai moku*. Chiefs were assigned to the *ahupuaʻa*—if it was a large *ahupuaʻa*, a high chief, and *aliʻi nui*, was assigned to it. Lesser chiefs, *kaukau aliʻi*, were placed over the *kūpono* lands, and warrior chiefs over *ʻili ʻāina*. Lands were given to the *makaʻāinana* al over Oʻahu. (Kamakau 1991:54-55)

After reordering the land division system, Māʻilikūkahi encouraged prosperity over the land. According to Kamakau (1991:55) "...the land was full of people. From the brow, *lae*, of Kulihemo to the brow of Maunauna in ʻEwa, from the brow of Maunauna to the brow of Puʻukua [Puʻu Kuʻua] the land was full of chiefs and people." The high state of prosperity of his kingdom had reached the chiefs of Hawaiʻi and Maui and in an attempt to seize Māʻilikūkahi's chiefdom, the outer island chiefs attempted to invade Oʻahu. In remarking on the battle, Kamakau writes:

> Hilo, the son of Hilo-kapuhi, Hilo-a-Luʻukapu, and Punaluʻu, chiefs of Hawaiʻi, and Luakoʻa, a chief of Maui, decided to go and make war on Māʻili-kūkahi. They sailed and landed in Waikīkī, then went to Kapuaʻikāula in ʻEwa with their canoes full of men. *Mauka* of Wai-kakala-ua gulch the battle was to begin. While they were going inland, they were cut off in the rear by the foster children of Māʻilikūkahi. Of the chiefs of Hawaiʻi and Maui, Punaluʻu was killed on the plain now called Punaluʻu. Corpses that "paved" a gulch gave the name Kīpapa to that place. Some of the invaders reached as far as the sea at ʻEwa and Waimano—the gulches were filled with their corpses. The heads of Hilo *ma* were cut off and taken to Honouliuli to a place now called Poʻo-hilo [located near the coast of West Loch]. (Kamakau 1991:56)

Kamakau mentions Honouliuli during the reign of Kaʻihikapu-a-Manuia, who ruled sometime after Māʻilikūkahi. Having deposed his elder brother Kū-a-Manuia, Kaʻihikapu-a-Manuia managed to have a rather peaceful reign. During his reign, Kū-a-Manuia made circuits around the island and on one such occasion:

> ...he came to Waikele in ʻEwa where his younger brother Haʻo was living. Cultivating and raising animals were the main occupations of Haʻo's people, and from Honouliuli as far as Wai-piʻo, the land was full of his men. Kaʻihikapu-a-Manuia noted the many men that swarmed about the land. He was afraid he might lose the chiefdom to Haʻo and became very anxious about it. (Kamakau 1991:64)

Early Historic Descriptions of Honouliuli

Historical accounts penned by visitors, missionaries, and residents are another means to reconstruct life in Honouliuli and the greater ʻEwa during the Precontact and early Historic periods. In 1793, just five years after Captain James Cook arrived in Hawaiian water, Captain George Vancouver, while anchored off the entrance of West Loch described the ʻEwa landscape:

> The part of the island opposite to us was low, or rather only moderately elevated, forming a level country between the mountains that compose the east [Koʻolau] and west [Waiʻanae] ends of the island. This tract of land was of some extent, but did not seem to be populous, nor to possess any great degree to natural fertility; although we were told that, at a little distance from the sea, the soil is rich, and all the necessaries of life are abundantly produced. (Vancouver 1801:361)
>
> Mr. Widbey observed, that the soil in the neighbourhood [*sic*] of the harbour [*sic*] appeared of a loose sandy nature; the country low for some distance, and, from the number of houses within the harbour, it should seem to be very populous: but the very few inhabitants who made their appearance was an indication of the contrary (Vancouver 1801:363)

In addition to the observations penned by Vancouver, cartographer, Lieutenant C. R. Malden, on this same trip, drafted a map of Oʻahu's south coast which included portions of Honouliuli in the vicinity of West Loch (Figure 5). Malden's map which was later published in 1825 depicts a cluster of houses, fish traps, and palm trees on the west end of West Loch. A trail network is also shown on Malden's map leading out in a westerly direction from what is presumed to be the main settlement area in Honouliuli. Of particular interest is the trail that branches *mauka* from the Waiʻanae route (see Figure 5). Malden's map is one of the earliest known cartographic records for this region and thus provides a glimpse into the early Historic settlement of this area.

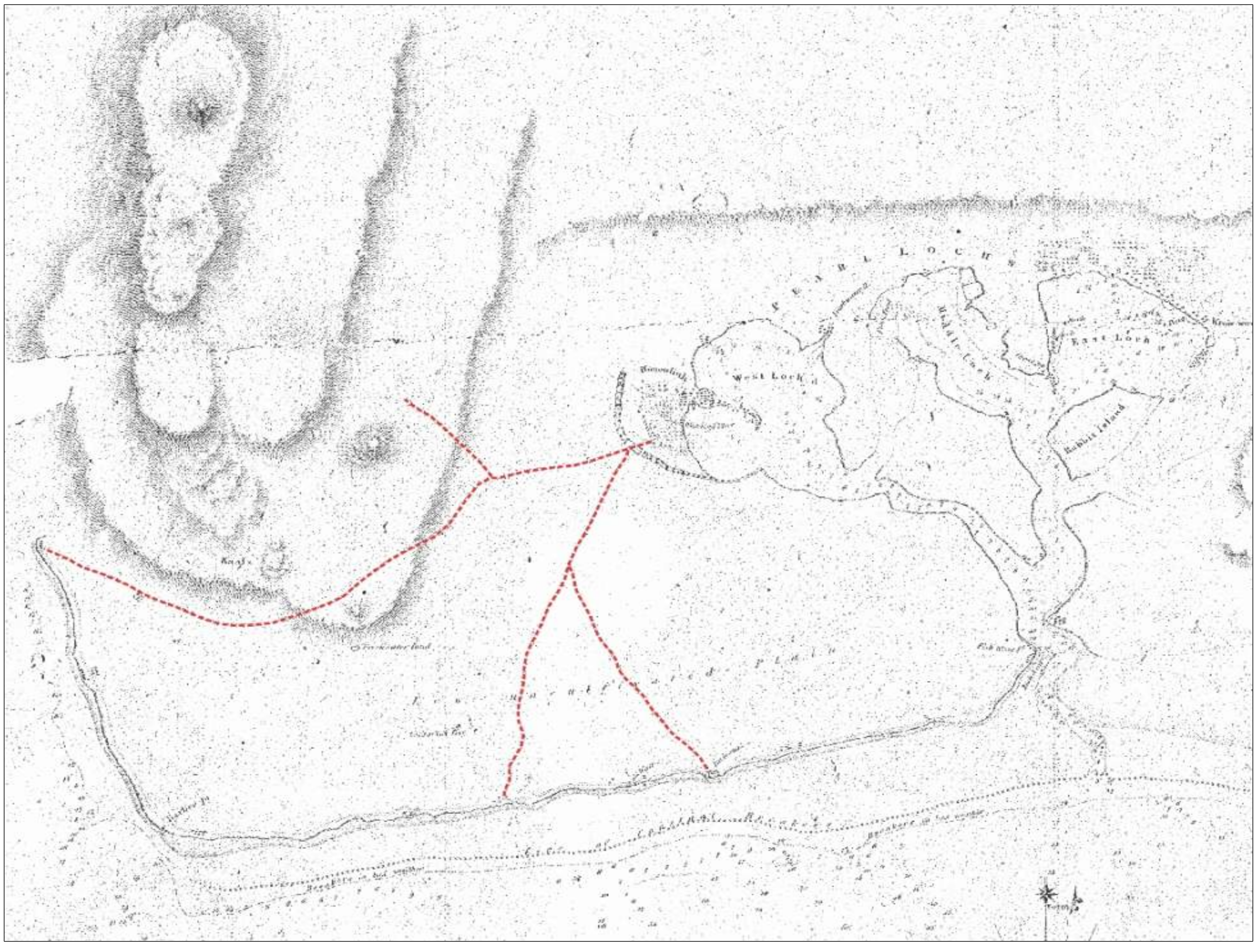

Figure 5. Hawai'i Registered Map 640 by Lt. Malden shows trails in the Honouliuli vicinity ca. 1793, project area not shown.

Samuel Kamakau (1992) provided the following narrative of the ship *Arthur* under the command of Captain Henry Barber which ran aground at Kalaeloa. It was from this incident that the name Barber's Point is derived. Kamakau describes the account thusly:

> In October of 1796, a ship [*Arthur*, under Henry Barber] went aground at Kalaeloa, Oahu. This ship had visited the island on several occasions during the rule of Ka-lani-ku-pule. This was the first time a foreign ship had grounded on these shored. Kamahemaha was on Hawaii, but Young had remained on Oahu. All the men on the ship came ashore at night in their boats. At daylight when the ship was seen ashore Ku-i-helani placed a band on the property of the ship and took care of the foreigners. Hawaiian divers recovered the valuables, and they were given over to the care of Ku-i-helani, but part were given by Captain Barber to the men who had recovered them. (Kamakau 1992:174)

In 1809, Scottsman Archibald Campbell, wrote the following description of the Pearl Habor area. Before Campbell arrived at O'ahu, he had been shipwrecked off the northwest coast of North America. Both of his feet were badly frostbitten and were subsequently amputated. With the aid of his guides, Campbell traveled through the 'Ewa District on the back of his guides, before settling on some land in Waimano Ahupua'a that was provided to him by King Kamehameha.

> In the month of November, the king was pleased to grant me about sixty acres of land, situated upon the Wymummee [Waimomi], or Pearl-water, an inlet at the sea about twelve miles to the west of Hanaroora [Honolulu]. I immediately removed thither; and it being Macaheite [*makahiki*] time, during which canoes are tabooed, I was carried on the men's shoulders. We passed by foot-paths, winding through an extensive and fertile plain, the whole of which is in the highest state of cultivation. Every stream was carefully embanked, to supply water for the taro beds. Where there was no water, the land was under crops of yams and sweet potatoes. The roads and numerous houses

> are shaded by cocoa-nut trees, and the sides of the mountains covered with wood to a great height. We halted two or three times, and were treated by the natives with the utmost hospitality. 160 (Campbell 1817:160)

Concerning his observations of the "Pearl River" area, Campbell noted:

> Wymumme, or Pearl River, lies about seven miles farther to the westward. This inlet extends ten or twelve miles up the country. The entrance is not more than a quarter of a mile wide, and is only navigable for small craft; the depth of water on the bar, at the highest tides, not exceeding seven feet; farther up it is nearly two miles across. There is an isle in it, belonging to Manina, the king's interpreter, in which he keeps a numerous flock of sheep and goats. The flat land along shore is highly cultivated; taro root, yams, and sweet potatoes, are the most common crops; but taro forms the chief object of their husbandry, being the principal article of food amongst every class of inhabitants. (Campbell 1967:114-115)

In his memoir Hawaiian historian Ioane (John) Kaneiakama Papa ʻĪʻī, who was born in 1800 in Waipiʻo, ʻEwa mentions a network of trails that extended across Honouliuli to neighboring lands. A portion of this trail network appears to correspond with the current alignment identified today as Farrington Highway and Kunia Road as shown in the map produced by Paul Rockwood (Figure 6). It is important to note that Rockwood's map is an artisitc rendering based on ʻĪʻī's recollection which not did not utilize formal land surveying techniques to ensure accuracy. In Rockwood's map, the northern trail alignment (Kunia Road) is shown extending just beyond the eastern boundary of the project area and a secondary trail alignment (Pohakea Pass) is shown extending west through the northern portion of the project area where it ascends to Pohakea in the Waiʻanae Mountains (see Figure 6). In addition to plotting the location of the region's trail, Rockwood's map also shows several place names in the Honouliuli area that were mentioned in traditional accounts including Keahuamoa, Pohakea, Maunauna, and Puʻu o Kapolei (see Figure 6). In relating information about the trails in the project area and the fishing practices, ʻĪʻī state:

> The trail went down to the stream and up again, then went above the taro patches of Waiau, up to a *maika* field, to Waimano, to Manana, and to Waiawa; then to the stream of Kukehi and up to two other *maika* fields, Pueohulunui and Haupuu. At Pueohulunui was the place where a trail branched off to go to Waialua and down to Honouliuli and on to Waianae. As mentioned before, there were three trails to Waianae, one by way of Puu o Kapolei, another by way of Pohakea, and the third by way of Kolekole.
>
> From Kunia the trail went to the plain of Keahuamoa, on to Maunauna, and along Paupauwela, which met with the trails from Wahiawa and Waialua. The trail continued to the west of Mahu, to Malamanui, and up to Kolekole, from where one can look down to Pokai and Waianaeuka... (Ii 1993:97)
>
> There [Kapuna, Waikele], patches of taro were grown, draw nets made, and houses built. The fishing was done in the sea of Honouliuli. Because the people of the place did not like Waikele's farm overseer, and for other reasons too, perhaps, they would say, "We are of Honouliuli." If the farm overseer went to Honouliuli, they would say, "We belong to Waikele." It was true that their homes were in Waikele, but all of their fishing was done in Honouliuli. It was laziness and dislike of the overseer that made them point one way and then another. (Ii 1993:32)

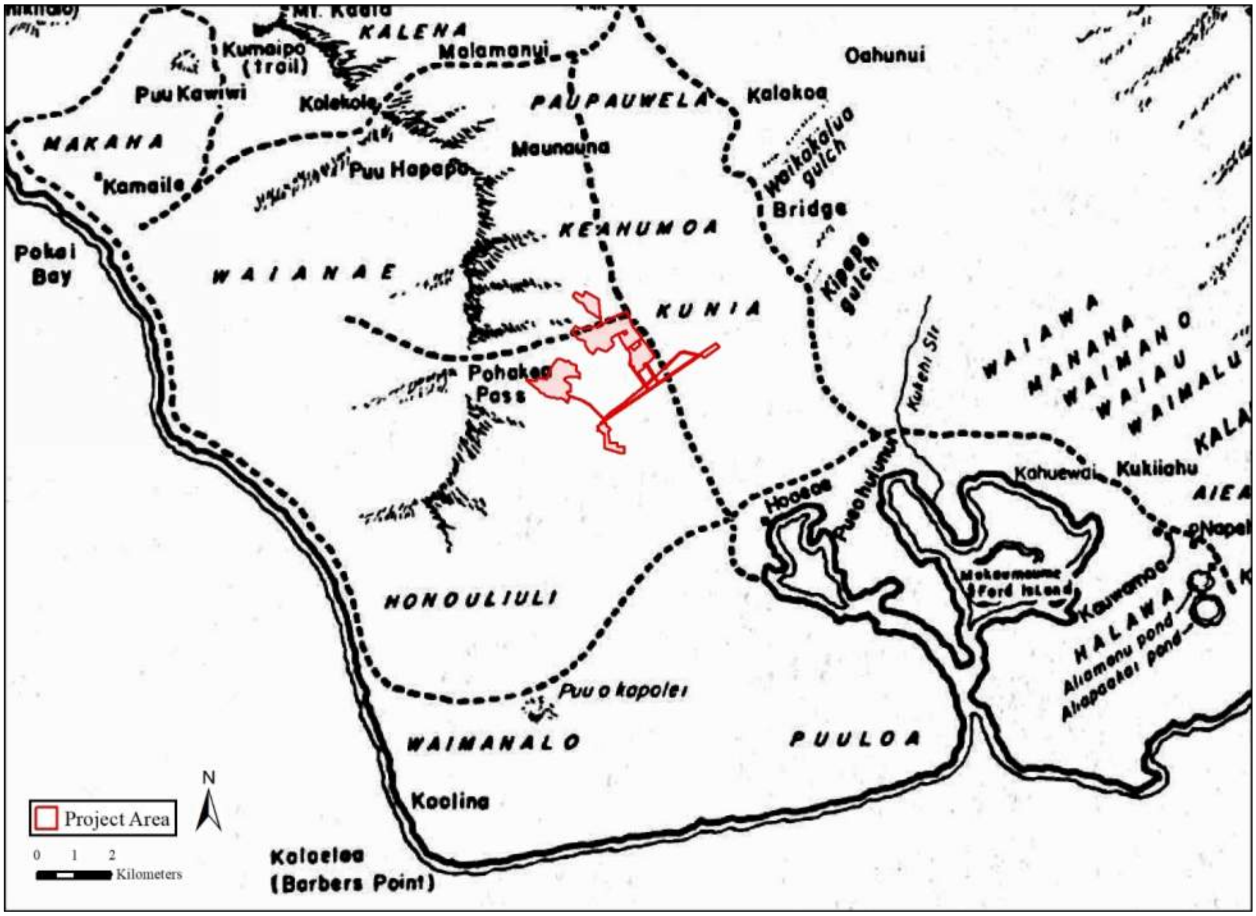

Figure 6. "Trails of leeward Oahu as described by Ii. Map by Paul Rockwood" (Ii 1993:96).

In 1820, American Missionary Hiram Bingham described the view from atop Punchbowl looking towards Barber's Point in ʻEwa as follows:

> . . . Below us, on the south and west, spread the plain of Honolulu, having its fish-ponds and salt making pools along the sea-shore. . . From Diamond Hill [Diamondhead], on the east, to Barber's Point and the mountains of Waianae, on the west, lay the sea-board plain, some twenty-five miles in length, which embraces the volcanic hills of Moanalua, two or three hundred feet high, and among them. . . . the lagoon of Ewa [Pearl Harbor/ Puʻuloa], and numerous little plantations and hamlets, scattered trees, and cocoanut [*sic*] groves. . . (Bingham 1848:93)

Early missionary, William Ellis described the ʻEwa area during his visit in 1823-1824. His comments read thusly:

> The plain of Eva is nearly twenty miles in length, from the Pearl River to Waiarua, and in some parts nine or ten miles across. The soil is fertile, and watered by a number of rivulets, which wind their way along the deep watercourses that intersect its surface, and empty themselves into the sea. Though capable of a high state of improvement, a very small portion of it is enclosed or under any kind of culture, and in travelling across it, scarce a habitation is to be seen. (Ellis 1963:7)

James Macrae, a Scottish botanist aboard the *HMS Blonde* which called into Honolulu in 1825 provided the following remarks about the Puʻuloa vicinity:

> Pearl River is about seven miles west of Hanarura [Honolulu], and is improperly called a river, being rather inlets from the sea, branching off in different directions. There are three chief branches, named by the surveyors, the East, Middle and West Lochs. The entrance to Pearl River is very narrow and shallow, and in its present state it is fit for very small vessels to enter, but over the bar there is deep water, and in the channel leading to the lochs there are from 7 to 20 fathoms. The lochs themselves are rather shallow.

> The coast from Hanarura to the west of Pearl River possesses no variety of plants beyond two or three species, such as Argemones, Portulacas, and a few other little annuals, intermixed
>
> The oysters that are found in Pearl River are small and insipid and of no value or consequence. (Macrae 1922:29-30)
>
> The neighborhood of the Pearl River is very extensive, rising backwards with a gentle slope towards the woods, but is without cultivation, except round the outskirts to about half a mile from the water. The county is divided into separate farms or allotments belonging to the chiefs, and enclosed with walls from four to six feet high, made of a mixture of mud and stone. The poorer natives live on these farms, also a few ragged foreigners who have a hut with a small spot of ground given to them, for which they must work for the chiefs a certain number of days besides paying an annual rent in dogs, hogs, goats, poultry and tapa cloths, which they have to carry to whatever spot their master is then living on the island. (Macrae 1922:31)

In his 1831 visit, botanist Franz Meyen commented on the high state of cultivation along the waters of Puʻuloa. He states:

> At the mouth of the Pearl River the ground has such a slight elevation, that at high tide the ocean encroaches far into the river, helping to form small lakes which are so deep, that the long boats from the ocean can penetrate far upstream. All around these water basins the land is extraordinarily low but also exceedingly fertile and nowhere else on the whole island of Oahu are such large and continuous stretches of land cultivated. The taro fields, the banana plantations, the plantations of sugar cane are immeasurable. (Meyen 1981:63)

Between 1840 and 1841, Commander Charles Wilkes (1845) of the U.S. Exploring Expedition made a tour of the Hawaiian Islands. In July of 1840, Wilkes and several other members in his party made of tour of the ʻEwa District and commented on the landscape and life of the people. After an uneventful trip to Mount Kaʻala, the party made their way towards Honolulu and:

> ...across the plain between the two ranges of mountains. This plain, in the rainy season, affords abundance of food for cattle in three or four kinds of grasses, and is, as I have before remarked, susceptible of extensive cultivation by irrigation from the several streams that traverse it. The largest of the streams is the Ewa. Scraggy bushes of sandalwood and other shrubs are now scattered over a soil fit for the cultivation of sugar-cane and indigo.
>
> At Ewa they were kindly received by the Reverend Mr. Bishop and lady, who have charge of the station. The district of Ewa commences about seven miles to the west of Honolulu, and extends twenty miles along the south shore, or from the hill in the vicinity of salt lake to beyond Laeloa or Barberʻs Point. There are no chiefs or any persons of distinction residing in the district; the people are labourers or Kanakas, and the landholders reside near the king at Lahaina, or at Honolulu. The taxes and occasional levies without any outlay have hitherto kept them poor.
>
> In this district is a large inlet of the sea, into the river Ewa empties; at the entrance of this inlet is the village of Laeloa: the whole is known by the name of Pearl River or harbour, from the circumfrance that the pearl oyster is found here; and it is the only place in these islands where it occurs.
>
> Pearl-River Harbour affords an abundant of fine fish. Two species of clams are procured here, called by the natives okupe and olepe. Mr. Drayton, who went to Pearl River for the purpose of examining its shores, and obtaining shells, reported that he found a large bed of fossil oyster-shells, extending into the bank in a bed from one to four feet wide, and half a mile in length: they were found cemented together with soft limestone and a reddish sand, and were so numerous that there was scarcely enough of the cement between to hold them together. The dredging was unsuccessful, a small spotted venus being the only shell that was obtained, although it was the general belief, among both the foreign and native inhabitants, that it would have produced an abundant reward for the trouble. (Wilkes 1845:78-79)

Wilkes goes on to describe the abundance of waters, soil, missionary presence, and changes to the native culture:

> The district, unlike otheres of the island, is watered by copious and excellent springs, that gush out at the foot of the mountains. From these run streams sufficient for working sugar-mills. In consequence of this supply, the district never suffers from drought, and the taro-patches are well supplied with water by the same means.

> The soil on the sides of the hills is a hard red clay, deemed useless except for pasturage. Here and there in the valleys passing through these hills and in the low grounds, is found soil capable of producing all the varieties of tropical vegetation.
>
> At Ewa, Mr. Bishop has a large congregation. The village comprises about fifty houses, and the country road is dotted with them. The village presents an appearance of health and cleanliness, clearly indicating the influence. Mr. Bishop has exerted over his flock, in managing which he is much aided by his lady.
>
> The church is a large adobe building, situated on the top of a small hill, and will accomodate a great number of persons. Mr. Bishop sometimes preaches to two thousand persons.
>
> The native have made some advance in the arts of civilized life; there is a small sugar-mill which, in the season, makes two hundred pounds of sugar a day. They have been taught, and many of them area now able to make their own clothes, after the European pattern. There is a native blacksmith and several native carpenters and masons, who are able to work well.
>
> In 1840, the church contained nine hundred members, seven hundred and sixty of whom belong to Ewa, the remainder to Waianae; but the Catholics have now established themselves at both these places, and it is understood are drawing off many from their attendance on Mr. Bishop's church. Schools are established, of which there are now three for children under teaches from Lahainaluna. Mr. Bishop informed me that there was great difficulty in procuring suitable teachers, and a still greater difficulty in raising funds for their support. The teachers complain much of their inability to secure a regular attendance from their scholars, which is thought to result from a want of parental authority at home, and their leaving it optional with the children to attend school or not.
>
> This district contained in 1840 two thousand seven hundred and ninety-two inhabitants, and there is no satisfactory evidence of a decrease, although many speak of it a being great; but the latter opinion is formed from the census of 1836, which was on many accounts inaccurate, and ought not to be taken as authority on which to found such a statement.
>
> This is the best part of the island for raising cattle and sheep, which are seen here in great numbers than elsewhere. (Wilkes 1845:80-81)

During the early 19th century, the interior landscape of Honouliuli and the central ‘Ewa plains was altered from the over-harvesting of *‘iliahi* (sandalwood; *Santalum ellipticum*). The sandalwood trade, established by Euro-Americans in 1790, became a viable commercial enterprise by 1805 and was flourishing by 1810 (Oliver 1961). Prized in China for its unique fragrance and used to manufacture items such as incense, perfume, and medicine, Kamehameha I, before his death in 1819, seized control of the industry and ordered his lesser chiefs and the people to the mountains to harvest the prized wood (St. John 1947). Kamakau (1992:294) noted that sometime around 1829, "Manuia was cutting sandalwood at Pu‘ukuo [Pu‘u Ku‘ua; southwest of the project area, see Figure 4] in Honouliuli when Boki asked him to join them" in preparing for their trip to New Hebrides. Although the industry proved to be lucrative for the chiefs in control, it created a burden on the people and had a lasting impact on the environment. Farmers and fishermen were ordered to spend most of their time logging, resulting in food shortages and famine that led to a population decline. Kamakau (1992:204) indicates that "this rush of labor to the mountains brought about a scarcity of cultivated food … The people were forced to eat herbs and tree ferns, thus the famine [was] called Hi-laulele, Haha-pilau, Laulele, Pualele, ‘Ama‘u, or Hapu‘u, from the wild plants resorted to." Once Kamehameha realized that his people were suffering, he "declared all the sandalwood the property of the government and ordered the people to devote only part of their time to its cutting and return to the cultivation of the land" (Kamakau 1992:202). St. John (1947:20) deduced that "[t]he northern and southern slopes of the Schofield saddle apparently had much more extensive stands of sandalwood, from Waimano to Honouliuli, and from Pupukea to Makaleha." A historical account penned by ship surgeon and natural historian F. D. Bennett after an 1834 visit to O‘ahu and published in his book titled *Narrative of a Whaling Voyage Round the Globe* provides a succinct summary of land use practices and the economy at that time:

> The staple commodities of the [island] group are at present very few. Sandal-wood is the principal of these but the demands for it have been so urgent, and so much beyond the resources of the country, that nearly all the large trees have been destroyed, and for some time past the government has very prudently prohibited the cutting of young wood. The fossil salt of Oahu, and some hides, chiefly afforded by the wild cattle of Hawaii, are therefore the only available exports that remain; but the cultivation of sugar has been lately commenced under favourable [*sic*] auspices, and promises well for the commercial interests of the people. (Bennett 1840:237)

Sereno Bishop, one of the first generation missionaries provided the following description in which he details the changes in the natural environment to O‘ahu‘s central region in the 1830s:

> Our family made repeated trips to the home of Rev. John S. Emerson at Waialua during those years. There was then no road save a foot path across the generally smooth upland. We forded the streams. Beyond Kīpapa Gulch the upland was dotted with occasional groves of Koa trees. On the high plains the *ti* plant abounded, often so high as to intercept the view. No cattle then existed to destroy its succulent foliage. According to the statements of the natives, a forest formerly covered the whole of the then nearly naked plains. It was burned off by the natives in search of sandalwood, which they detected by its odor burning. (Bishop in Sterling and Summers 1978:89)

Māhele ‘Āina of 1848, Summary of *Kuleana* Claims

In 1795, the Hawai‘i Island chief, Kamehameha, had completed his conquest against Kalanikūpule and the Maui forces that had seized O‘ahu just a short time prior. Kamehameha began dividing up the lands (*kālai ‘āina*) of O‘ahu amongst his chiefs and loyal supporters and gave Honouliuli to Kalanimoku as a *panalā‘au* (conquered territory), thus allowing him to pass the land to his heirs (Kame‘eleihiwa 1992). Kalanimoku then gave Honouliuli to his sister, Wahinepi‘o. However, by 1848 the land division known as the *Māhele ‘Āina* ushered in widespread change in land ownership across the archipelago. During the early part of the 19th-century, as Hawaiian political elites sought ways to modernize the Hawaiian Kingdom and as the population of Western settlers increased, major socioeconomic and political changes began to take place. By 1840, the Hawaiian Kingdom, through the formal adoption of a constitution, became a constitutional monarchy which was soon followed by a reformation of the traditional land tenure system. By 1848, King Kauikeaouli (Kamehameha III), the reigning monarch, and his chiefs came together for the final land division.

Kepā and Onaona Maly conducted a review of all the *Māhele* records for Honouliuli Ahupua‘a recorded from 1847 through 1855 (Maly and Maly 2012a). The following discussion is taken from the paper in which they presented the results of their research, which included over 400 documents. According to Maly and Maly, “of the 106 native tenant claims and one chiefly claim identified from Honouliuli, 74 were awarded to the claimants or their heirs, and 33 were denied” (Maly and Maly 2012b:1). The sole chiefly or *ali‘i* claim (Land Commission Award No. 11216:8; Royal Patent No. 6971) was awarded to Mikahela Kekau‘onohi, (Kamehameha III’s niece and Kamehameha I’s granddaughter) who had inherited the *ahupua‘a* from her late husband High Chief Aarona Keli‘iahonui after his death in 1849 (Maly and Maly 2012:7). The current project area falls within a portion of this *ali‘i* award that comprises 43,250 acres of Honouliuli and originally included 2,610 acres of Pu‘uloa, an *‘ili* which Kekauonohi sold in 1849 to Issac Montgomery (Haun 1991; Kelly 1991). The 1920 map by W. E. Wall (Figure 7) shows Kekauonohi’s land claim for Honouliuli Ahupua‘a and the 1873 map of Honouliuli by W. D. Alexander (Figure 8) situates the project area in the land area identified as Kupehau.

No *kuleana* awards were granted within the immediate project area vicinity. All *kuleana* awards that were granted in Honouliuli were clustered in an area located *makai* of the project area near the northwestern portion of Ka-ihu-o-Pala‘ai (West Loch) along Honouliuli Stream. The distribution of the *kuleana* lands are shown in Hawai‘i Registered Map No. 630 prepared in 1878 by M. D. Monsarrat (Figure 9). A second un-dated map obtained from the Department of Accounting and General Services miscellaneous map collection shows the location of the *kuleana* award and the associated *‘ili* names (Figure 10).

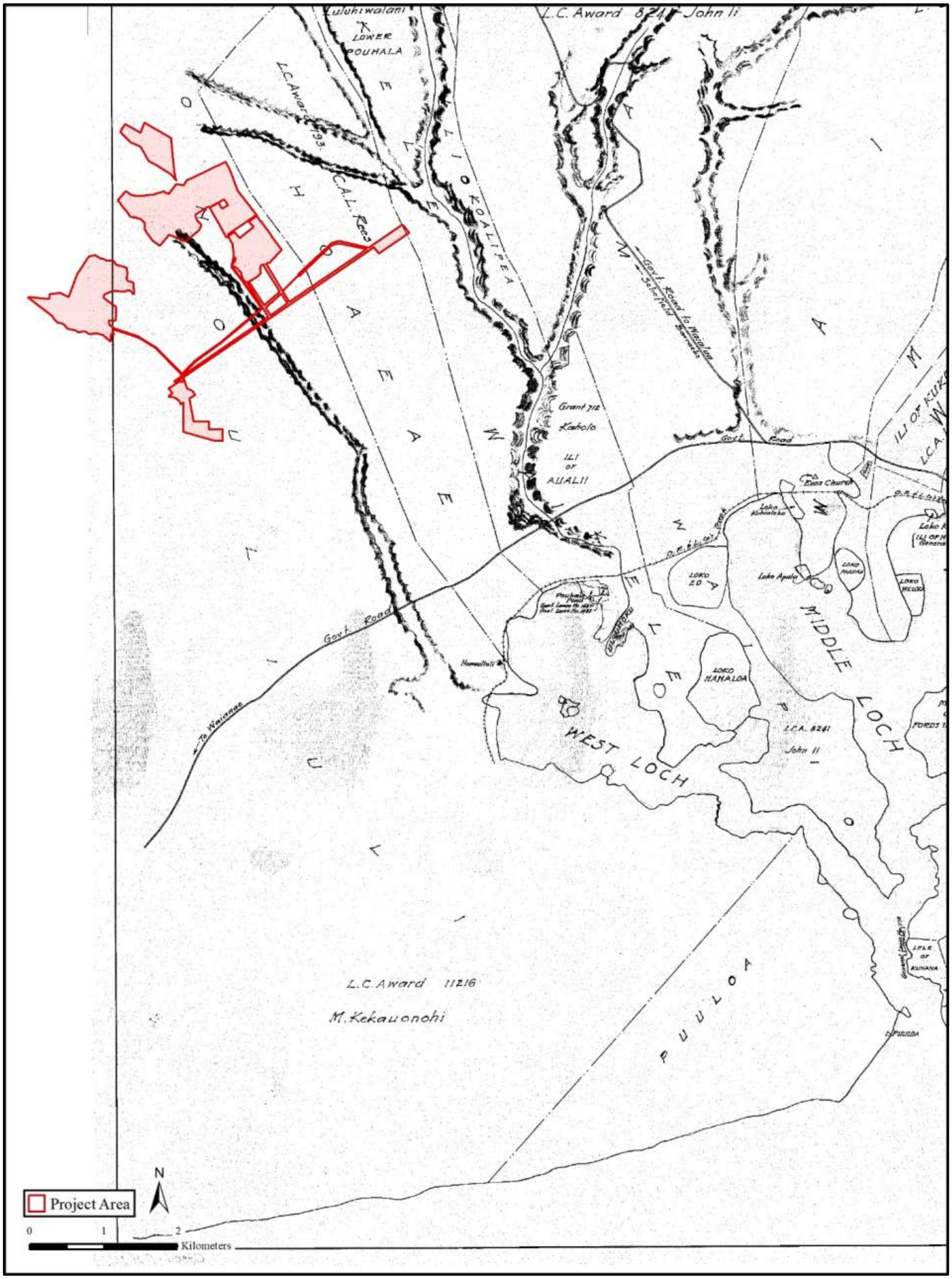

Figure 7. 1920 map of Pearl Harbor and adjacent lands by W. E. Wall showing LCAw 112616 to Kekauonohi (Department of Accounting and General Services).

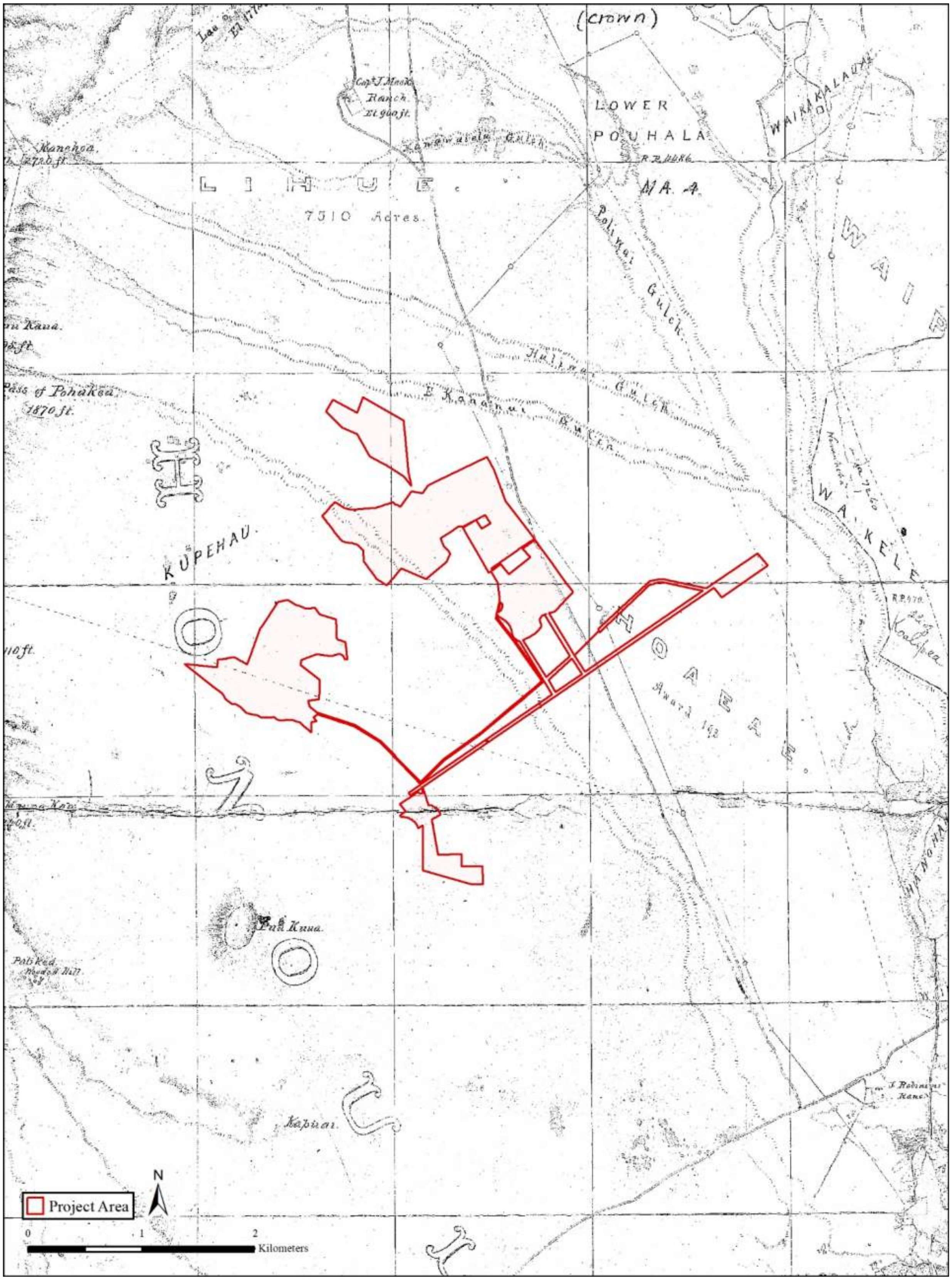

Figure 8. The 1873 Hawai‘i Registered Map No. 405 by W. D. Alexander of Honouliuli Ahupua‘a showing the project area and the location of *Kuleana* lands (Department of Accounting and General Services).

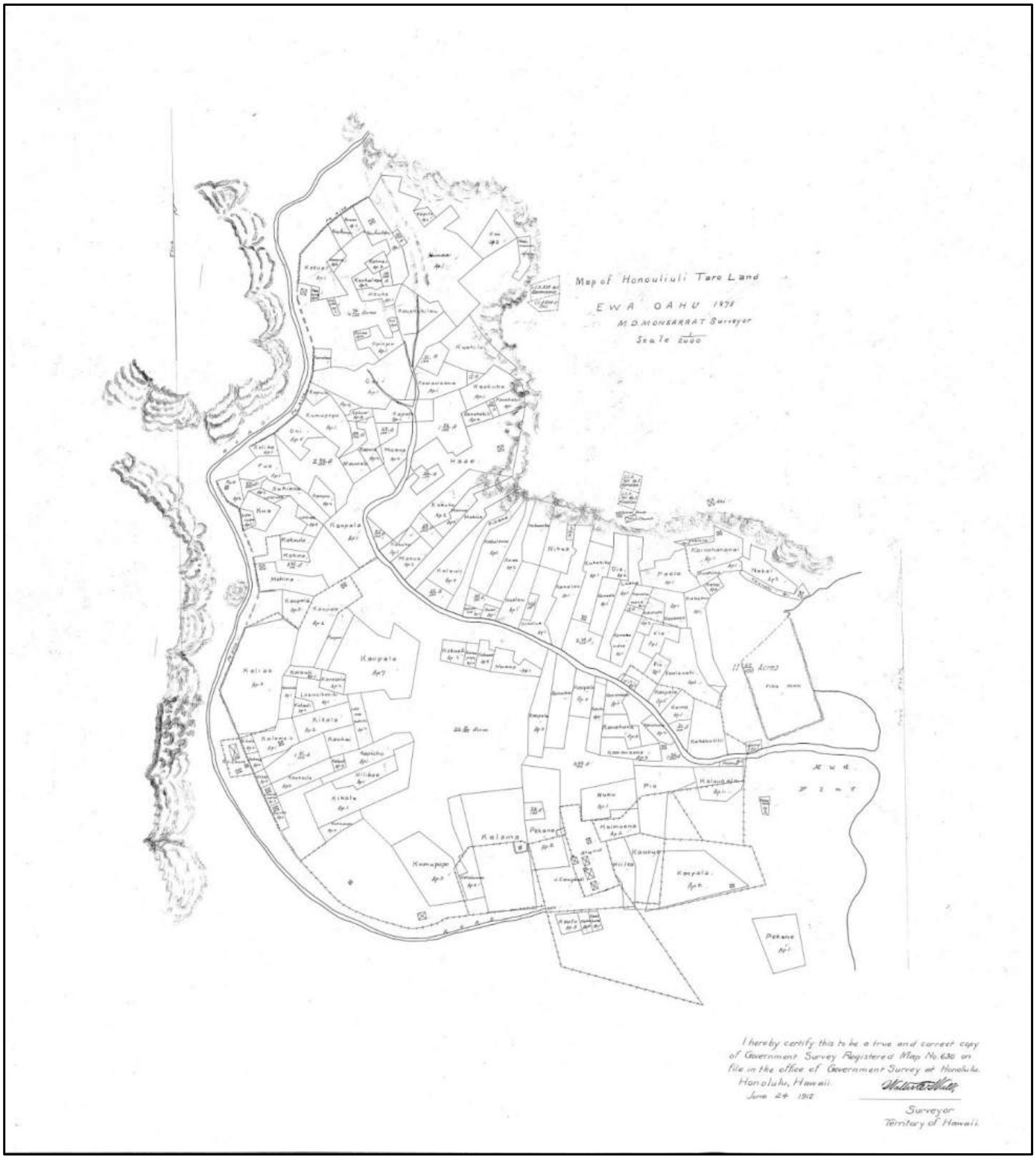

Figure 9. Hawai'i Registered Map No. 630 by M. D. Monsarrat from 1878, project area not shown (Department of Accounting and General Services).

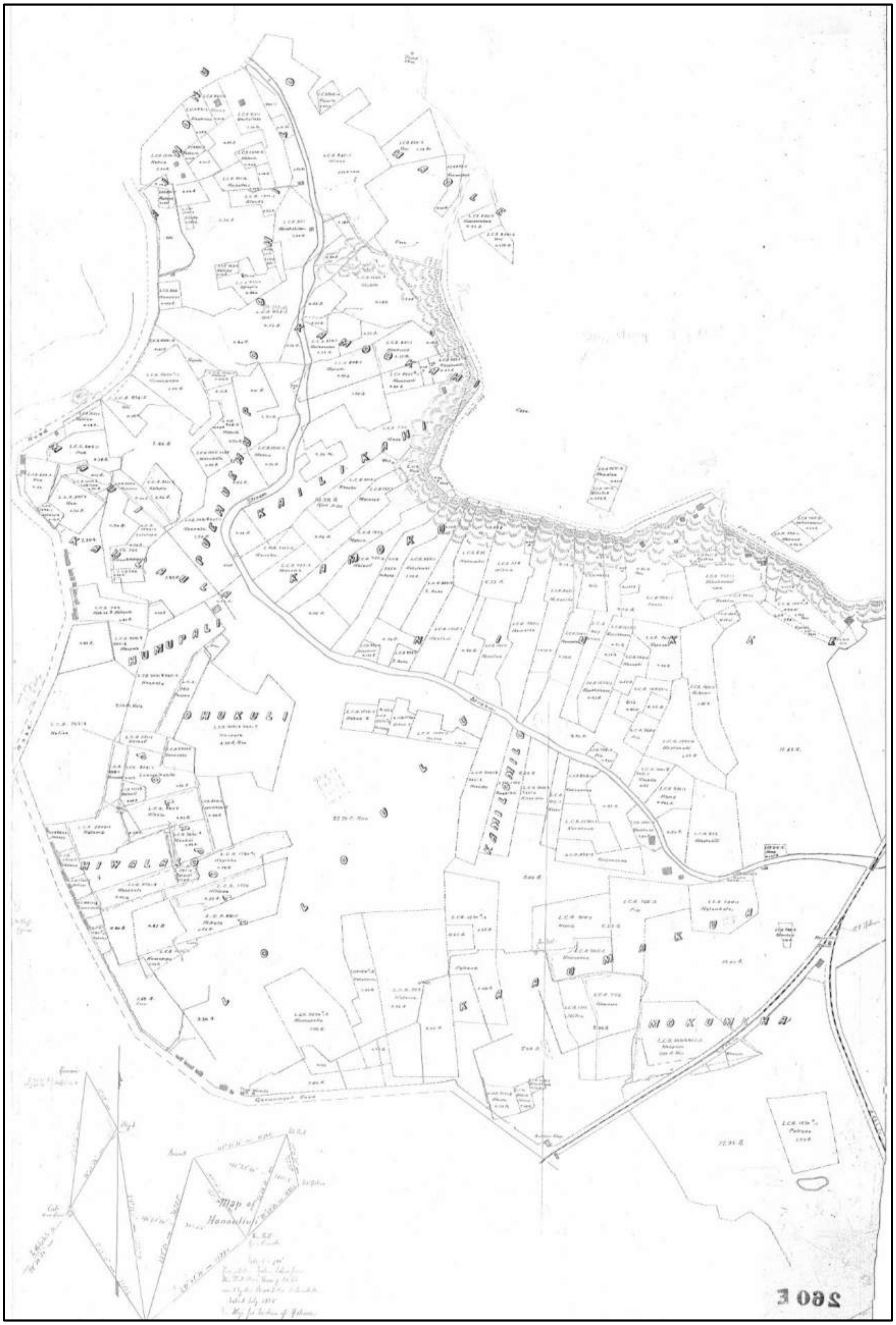

Figure 10. Undated map showing the location of *kuleana* in Honouliuli with associated *'ili* names, project area not shown (Department of Accounting and General Services).

Ranching and Rice Cultivation

By the 1840s, ranching operations began to develop in Honouliuli; soon foreigners such as John Meek, Isaac and Daniel Montgomery, James Dowsett, and James Campbell would control most of the acreage therein. In 1857, chief Levi Ha‘alele‘a deeded roughly 40,000 acres of Honouliuli Ahupua‘a, except for lands awarded to native tenants and the roughly 2,500 acres of Pu‘uloa previously conveyed to Isaac Montgomery, as a mortgage to Benjamin F. Snow. Upon his death, Ha‘alele‘a's widow (Anaderia Amoe Ha‘alele‘a) conveyed Honouliuli, including "all the goods, lands and chattels" to John H. Coney in 1867 (Bureau of Conveyances Liber 23 May 11, 1867: 319). Shortly thereafter, Coney leased the lands to James Dowsett and John Meek for grazing. During the early to mid-20th-century, ranching continued across most of Honouliuli. Lifelong resident, Thelma Parish recalled that the *makai* flats of Honouliuli were used as rotating pasture for cattle by her ancestors and others (Maly and Maly 2012a).

In 1877, James Campbell purchased roughly 43,640 acres in Honouliuli Ahupua‘a for a total of $95,000 from John H. Coney and his wife Ami (Bureau of Conveyances Liber 52 September 11, 1877: 201-201). In October of 1877, Campbell married Abigail Kuaihelani Maipinepine, who was of Māui royal lineage (James Campbell Company 1978). In a *Statistical Directory of the Island of O‘ahu* published in 1880, James Campbell's occupation is listed as "Landed Proprietor" and he appears as the owner of 43,250 acres of land cultivated for pasture; Campbell is also listed as the "Landowner of Kahuku Ranch" owning another 28,608 acres in pasture in Kahuku (Bowser 1880:298). Another entry for someone named Kaehuokalani lists his occupation as "Farmer" owning 4 acres of pastureland in Honouliuli (Bowser 1880:307). The third and final entry associated with Honouliuli is that of Lockgawk, a "Rice planter" by occupation who is listed as renting 140 acres in Honouliuli (Bowser 1880:314). Bowser (1880:409) states in a later entry found in the sugar plantations section of the same volume under the title "Honouliuli Estate" that the pastureland not only "affords grazing for much valuable stock," but that its soils are "suitable for agriculture," for "It is on this estate that Mr. Campbell's successful artesian boring has been made." He also adds "There are valuable fisheries attached to this estate," the area of which he qualifies as follows "the length of this estate is no less than 18 miles. It extends to within less than a mile of the seacoast, to the westward of the Pearl River inlet" (Bowser 1880:409). The location of Campbell's Honouliuli fisheries are shown in a 1913 map titled "No. 8 Oahu Fisheries Pearl Lochs Section" produced below as Figure 11. The success of Campbell's well would later prompt ‘Ewa ranchers and plantation developers to drill numerous wells to search of the much needed water.

In a section titled "An Account of the Sugar Plantations and the Principal Stock Ranches on the Hawaiian Islands," Bowser provides additional details regarding Campbell's Honouliuli estate (Figures 12 and 13). The account, reproduced below, emphasizes the installation of the first successful artesian well in the islands and concludes with a brief description of a village in Honouliuli:

> The Honouliuli Ranch is an extensive property. The main road runs through it for about twelve miles, and the general breadth is seldom less than four miles. One large tract of this land is perfectly level, with the exception of a few acres near the centre, where there is a knoll of rising ground. . . . The soil at Honouliuli is good, and, with the aid of irrigation, will grow anything. In the mean time, it is wholly pasture land, but the means of irrigation have recently been secured by Mr. Campbell, who has sunk an artesian well to the depth of 273 feet. This well has delivered a continuous stream of water equal to 2,400 gallons per hour, ever since the supply from which the present flow comes, was struck on the 22d of September, 1879. Besides Mr. Campbell's residence, which is pleasantly situated and surrounded with ornamental and shade trees, there are at Honouliuli two churches and a school house, with a little village of native huts. (Bowser 1880:495)

Figure 11. A 1913 O‘ahu Fisheries map by M. D Monsarrat, project area not shown.

Figure 12. Residence of James Campbell in Honouliuli (James Campbell Company 1978:10).

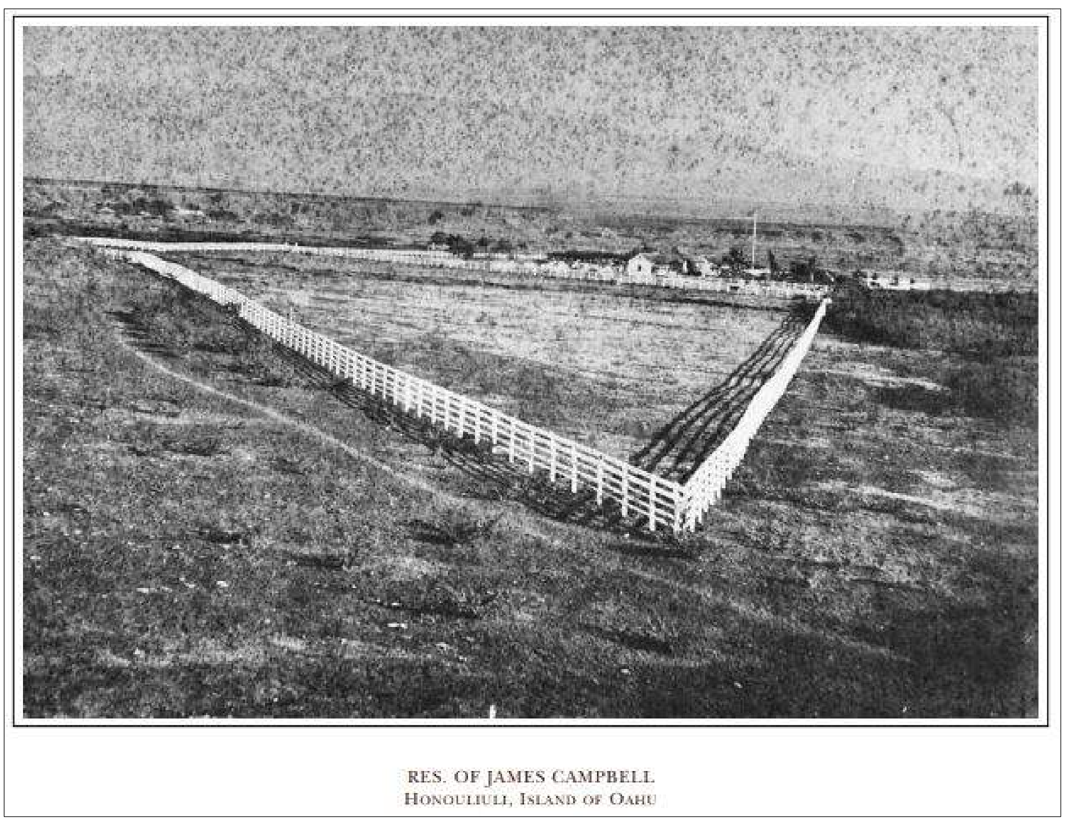

Figure 13. Residence of James Campbell in Honouliuli (James Campbell Company 1978:11).

In addition to ranching, during the second half of the 19th century as migrant contract sugar laborers from China settled in the islands to work on the sugar plantations, a local rice market began to develop. Although commercial sugar operations did not start in Honouliuli until 1890, by the 1880s and upon fulfillment of their contacts, Chinese laborer began leasing and buying taro lands from Hawaiians (Coulter and Chun 1937). Former taro lands located in the lowlands surrounding Pearl Harbor were converted from *lo'i* into rice paddies and by 1885, some 200 acres of Honouliuli prime taro lands were planted in rice (Cruz et al. 2011). In 1882, Frank Damon (1882:37) wrote the following description of rice cultivation in Honouliuli:

> Towards evening we reached Honouliuli, where the whole valley is leased to rice planters...This was one of the largest rice plantations we visited. Sometimes two or three men only, have a few fields which they cultivate for themselves, and we often too came upon houses where there were eight or ten men working their own land. But the larger plantations are owned by merchants in Honolulu, who have a manager acting for them.

In 1885, the first Japanese migrant laborer arrived and they soon joined the Chinese in rice farming. The Japanese farmers however, preferred short grain rice that was grown in California to the long grain variety grown locally by Chinese farmers. Although rice production was not a major economic contributor, it was an important industry for migrant laborers. By the early part of the 20th-century, the hand labor techniques employed by local rice farmers could not compete with the mechanized rice production in California. Despite efforts from the University of Hawai'i's agricultural extension to revive rice farming in 1906 and later in the early 1930, rice paddies were abandoned and the industry ceased (Haraguchi 1987).

Oahu Railway and Land Company and the Oahu Sugar Company

In 1889, B. F. Dilingham organized the Oahu Railway and Land Company (OR&L). The fate of the OR&L would prove to be inexorably linked to that of commercial sugar in 'Ewa and beyond. During the late 1880s, Dillingham promised investors that he would connect Honolulu with Pearl Harbor by means of a steam railroad. Although railroads largely associated with the sugar industry were already in operation on Hawai'i Island, O'ahu was undeveloped in comparison and the Pearl Harbor region was not yet known as a sugar production area (Yardley 1981). Furthermore, according to Dillingham's biographer Paul T. Yardley (1981:130), "the great dry plains of Ewa produced nothing but cattle and firewood." The main landholders of 'Ewa, including James Campbell, were all amenable to the planned railroad and the promise of increasing the value of their land holdings. On March 8, 1889, the formal groundbreaking for the railway took place at Moanalua near the intersection of Middle Street and Kamehameha Highway (Yardley 1981). By 1890 a route between Honolulu and Pearl City (Mānana) was laid and in 1895 the route into Wai'anae was set up. In 1898 and 1899 a connector line between Waialua Plantation and Kahuku and 'Ewa was put up (Kuykendall 1967). The complete OR&L railroad route is illustrated in Figure 14. The OR&L route appears to have followed the general alignment of earlier trails noted by John Papa 'Ī'ī (see Figure 6).

By July 1, 1890, the railroad reached Hō'ae'ae, east of the current project area (Yardley 1981). Later that same year, Dillingham shifted his focus to developing portions of Campbell's 60,000 acres in 'Ewa into sugar plantations and constructing a wharf in Honolulu Harbor that could accommodate ships loaded with sugar for export, as well as imports for transport by rail. Dillingham continued to run parts of the Campbell lands as ranches while renting out portions for other uses, which resulted in the establishment of Ewa Plantation Company in 1890. The Ewa Plantation cultivated the lower portions of Honouliuli and in 1897, Dillingham established the Oahu Sugar Company with its fields in the upper reaches of Honouliuli.

The development of sugar as an industry in the 'Ewa District was largely hampered by the arid condition and scant annual rainfall that was insufficient for producing profitable amounts of cane (Coulter 1933). However, the economic potential for developing a profitable sugar plantation was revealed in July 1879, when Campbell contracted John Ashley of California, who successfully drilled the first artesian well on Campbell's Honouliuli estate (see Figures 12 and 13), which Hawaiians had named Waianiani (Advertiser 1956b). Use of the well ceased in 1939, when the City and County of Honolulu sealed it (James Campbell Company 1978). By 1938, Oahu Sugar Company had sixty-three wells in operation (Advertiser 1956b). The availability of fresh water allowed for the expansion of commercial sugar into the 'Ewa District and the eventual establishment of several commercial sugar plantations in 'Ewa, two of which operated in Honouliuli, the Ewa Plantation and Oahu Sugar Company. Having successfully promoted the Ewa Plantation, Dilingham turned his attention to developing sugar plantations in the upper portions of Honouliuli. The Oahu Sugar Company leased roughly 12,000 acres of land from the estates of John Papa 'Ī'ī, Bishop, and Robinson and constructed its mill in what is known today as Waipahu in Waikele Ahupua'a (Dorrance and Morgan 2000). In an editorial printed in *The Honolulu Advertiser* concerning the naming of Waipahu, Mr. Simeon Nawa'a opined that:

> "Waipahu" is not a tract of land, but another present-day manipulation and discordant of truth, and creating falsehood and confusion. The Oahu Railway and Land Co. is the culprit responsible for all confusions when it built its station at Kaohai, Waikele, and named it "Waipahu Station," and from that time it stuck. The Oahu Mill is located on "Keonekuilimalaulaoewa" (the arm-in-arm plateau of ewa). (Nawaa 1956:4)

To irrigate the upper fields, water was pumped to roughly the 500 foot elevation (Dorrance and Morgan 2000). However, moving water to even higher elevations led plantation managers and owners to propose constructing a system that would bring water from the Koʻolau mountains into the upper portions of ʻEwa. In 1913, Waiahole Water Company, a wholly-owned subsidiary of Oahu Sugar Co. was formed. The Waiahole Water Company led the construction of the massive Waiahole Ditch and upon its completion in 1916 included twenty-seven tunnels that connected to thirty-seven stream intakes on the Koʻolau mountains with the main bore through Waiāhole Valley. This system connected to fourteen tunnels on the south side of the Koʻolau mountains at Waiʻawa thence by a westward ditch that brough water into Honouliuli. Upon its completion, the Waiahole Ditch extended for 21.9 miles, brought an estimated 32 million gallons of water daily to ʻEwa, and cost $2.3 million dollars to construct (Condé and Best 1973). The Waiahole Ditch, with some modifications, is still in used and has been listed on the State Inventory of Historic Places as Site 50-80-09-2268. While the 1913 Territory of Hawaiʻi survey map (Figure 15) does not depict the Waiahole Ditch in the project area vicinity, it does show the majority of the project area with the exception of a pie shaped section of land in the northeast corner to be mostly vegetated. A historic aerial taken thirty-eight years later between 1951-52 (Figure 16) shows that by this time, most of the project area had been cleared and planted in cane and the Waiahole Ditch is shown entering the project area from the east then meandering along the southern (*makai*) section of the fields. A 1953 USGS map (Figure 17) also shows the course of the Waiahole Ditch which matches the exact course shown in the 1951-52 aerial. In the immediate project area vicinity, a reservoir near the southern (*makai*) part of the project area is shown in both the 1951-52 aerial (see Figure 16) and the 1953 USGS map (see Figure 17. The 1953 USGS (see Figure 17) map also labels two water tanks, a flume, and two reservoirs along Kupehau Road, which is an access road leading from Kunia Road into the project area. In addition to showing the location of plantation infrastructure, the 1953 USGS (see Figure 17) map shows Pohakea trail extending through the northern section of the project area. Kluegel (1917:96) provides the following description of the Waiahole Ditch in the Honouliuli area:

> West of Waikakalaua Gulch, through Hoaeae and to the upper boundary of Oahu Plantation in Honouliuli, the conduit of 12,650 feet of cement-lined ditches, and three redwood pipes 5 feet in diameter, having an aggregate length of 2,830 feet.

With a steady and reliable source of water, the Oahu Sugar Company was able to expand its operations into the interior parts of Honouliuli, thus transforming this area into lush and profitable cane fields.

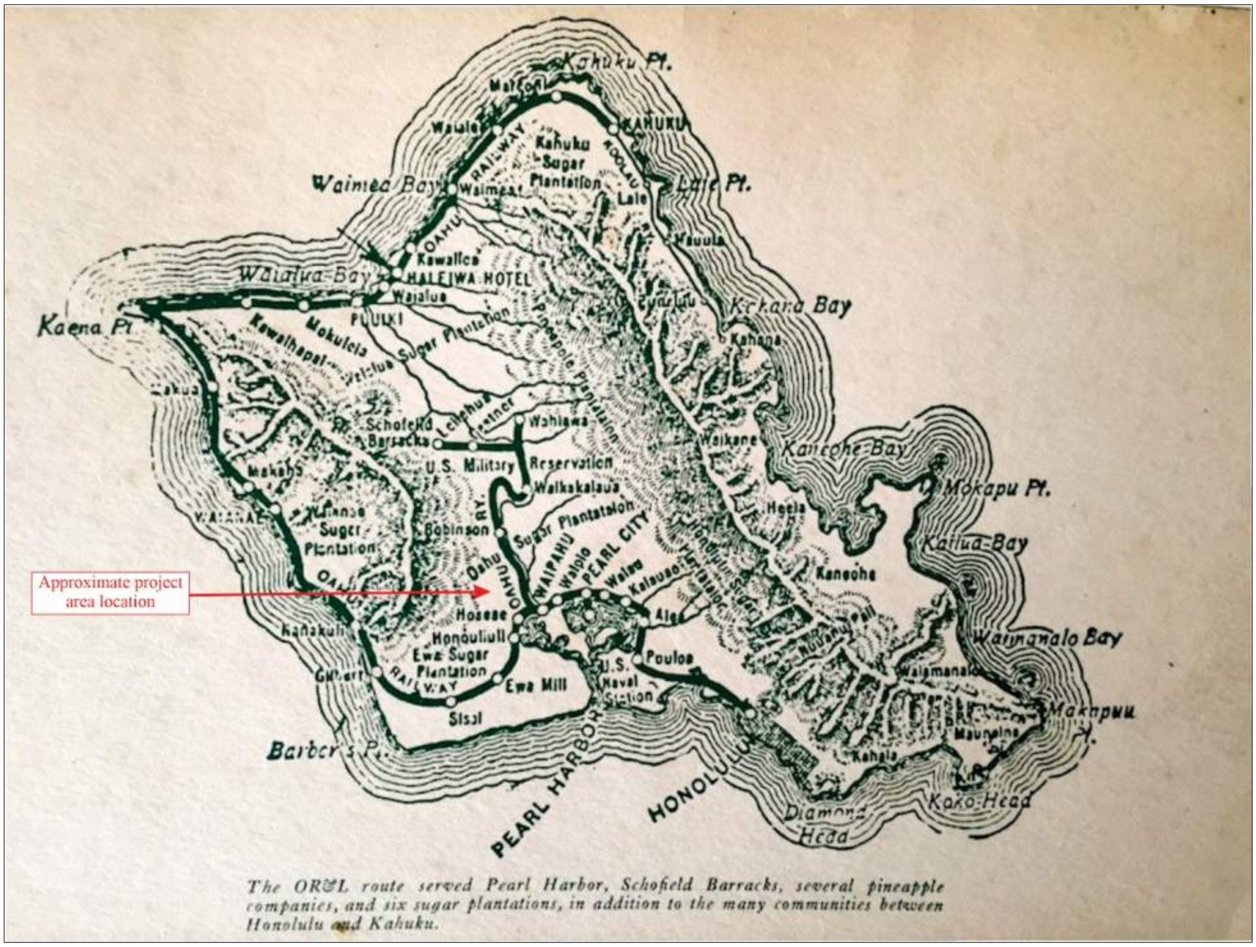

Figure 14. Map of completed OR&L railroad on Oʻahu.

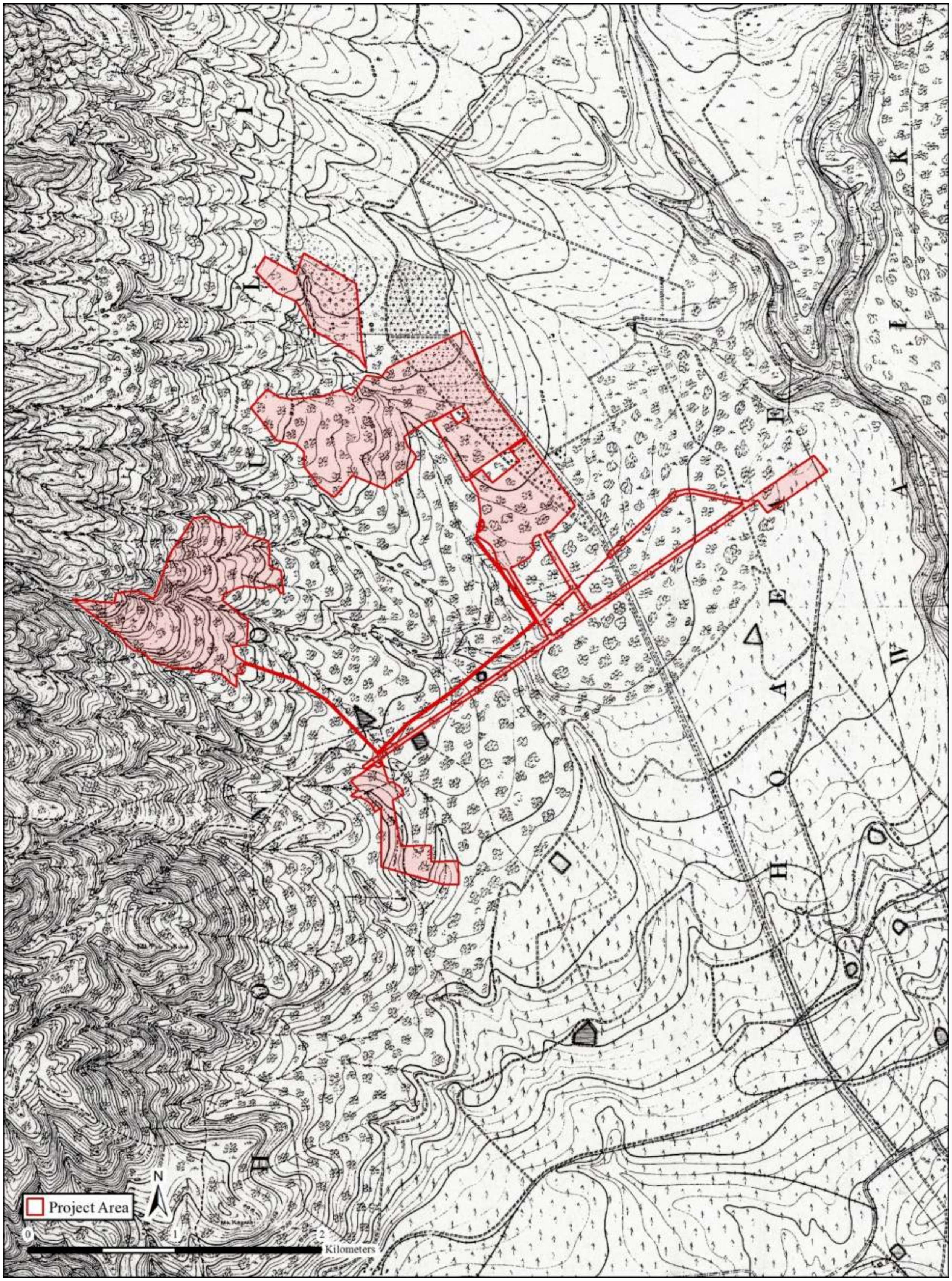

Figure 15. 1913 Terriitory of Hawai‘i Survey map, Schofield Barracks Quadrant.

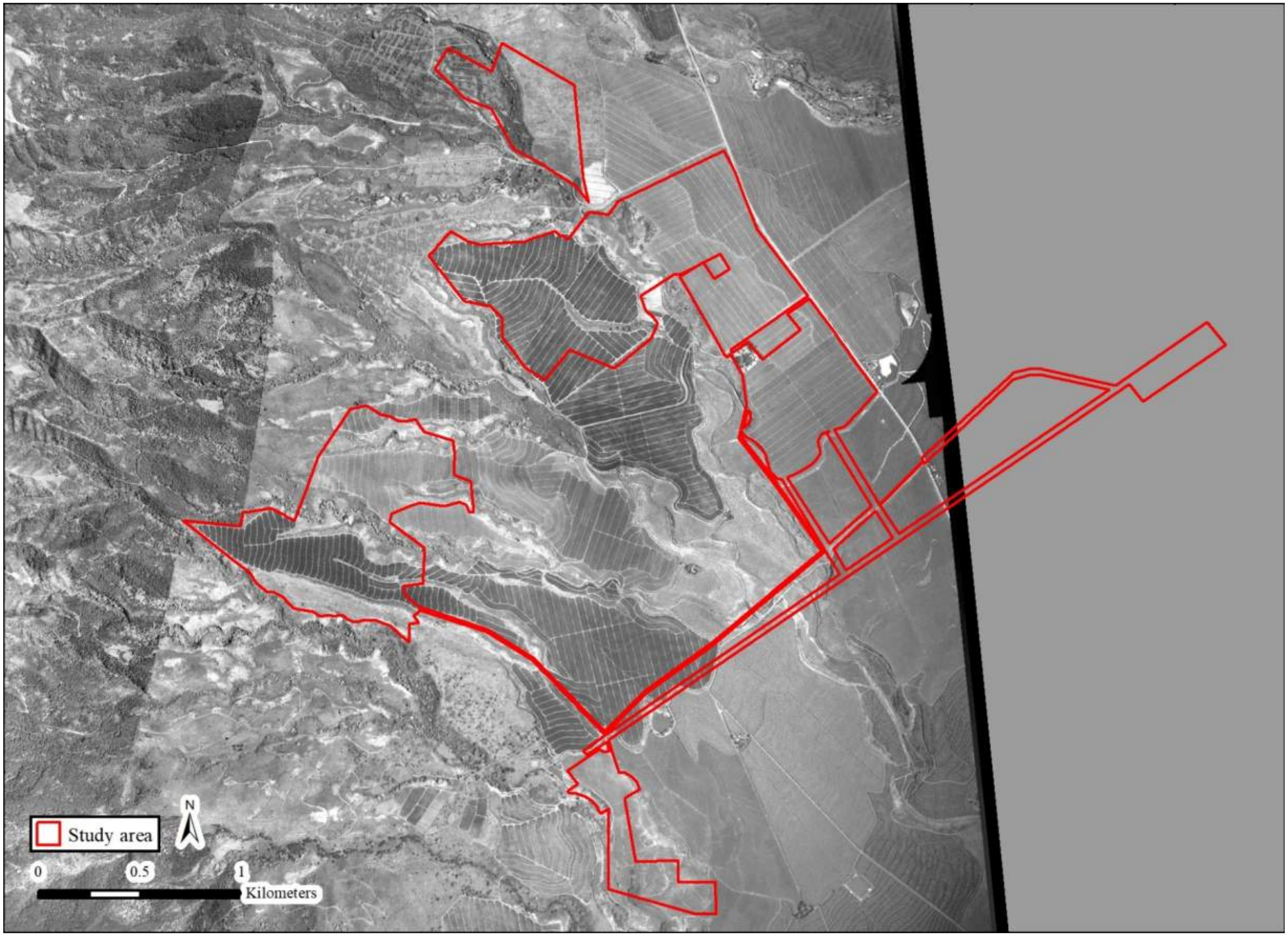

Figure 16. 1951-52 aerial photo of the project area showing Waiahole Ditch and associated reservoirs in the project area vicinity.

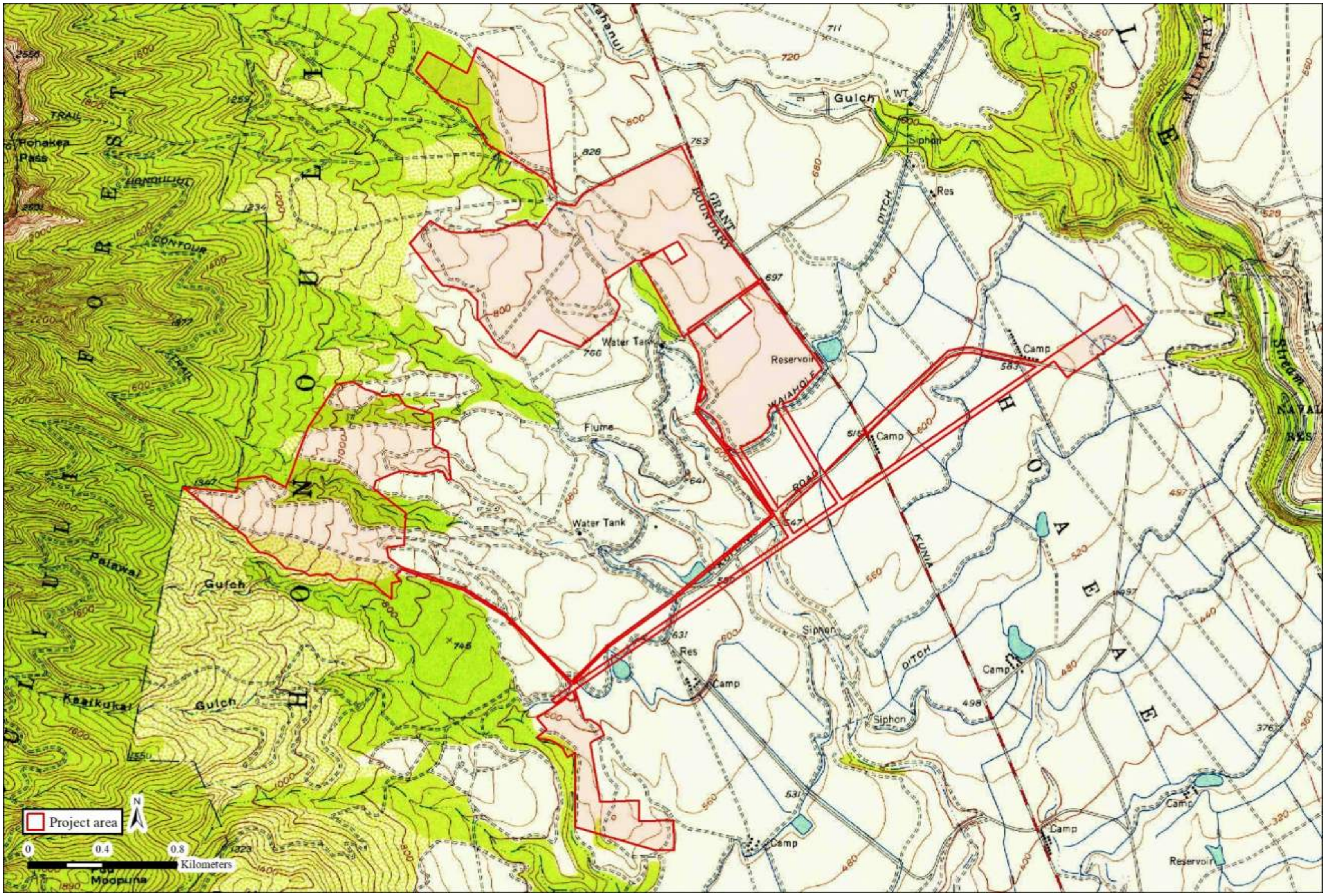

Figure 17. A portion of the 1953 USGS map, Schofield Barracks Quadrant showing project area and Waiahole Ditch and associated reservoirs.

Military Development

Pearl Harbor was used by foreigners as a military sea port in 1794 when John Kendrick used his ships to fire canon for several days at invading warriors from Kaua'i at the bequest of Chief Kalanikūpule of O'ahu during the "Battle of Kuki'iahu." Kotzbue (1821), a Russian sea captain, heard the name "Pearl Harbor" from Kamehameha I in 1816, and upon inspection of the port noted its depth and breadth, writing that it should be improved by Europeans. In 1824 an expedition was organized to take soundings of the depths of Pearl Harbor and the lochs by the HMS Blonde which arrived at Honolulu on May 3, 1825 (Byron 1826). In 1840 further survey of the harbor was conducted by Commodore Charles Wilkes of the U.S Exploring Expedition, who observed that:

> The inlet has somewhat the appearance of a lagoon that has been partly filled up by alluvial deposits. At the request of the king, we made a survey of it: the depth of water at its mouth was found to be only fifteen feet; but after passing this coral bar, which is four hundred feet wide, the depth of water becomes ample for large ships, and the basin is sufficiently extensive to accommodate any number of vessels. If the water upon the bar should be deepened, which I doubt not can be effected, it would afford the best and most capacious harbor in the Pacific. As yet there is no necessity for such an operation, for the port of Honolulu is sufficient for all the present wants of the islands, and the trade that frequents them (Wilkes 1845:79).

By the second half of the 19th century, U.S. nationals residing in Hawai'i began making serious efforts to secure Pu'uloa as an exclusive U.S. naval harbor (Kuykendall 1953). According to a newspaper article titled "Honolulu and Pearl Harbor Vital Centers of America's Power in Pacific," beginning in the 1840s, members of the U.S. government made it clear to all European countries who showed any interest in occupying the Hawaiian Islands that the U.S. would not allow it (Evening Bulletin 1908:9). After earlier failed attempts to secure a treaty with the U.S., in 1875, King Kalākaua signed the Treaty of Reciprocity, which established a free-trade agreement between the Hawaiian Kingdom and the U.S. (Kuykendall 1967). Despite U.S. attempts to gain control over Pearl Harbor in exchange for the free-trade agreement, King Kalākaua refused to surrender sovereign control. However, amendments were made and the treaty was renewed in 1887, which allowed the U.S. to enter a section of Pearl Harbor and create a naval coaling and repair station. Many Hawaiian nationals opposed the signing of a treaty and asserted that a treaty between the Hawaiian Kingdom and the U.S. would ultimately lead to cession or annexation (Kuykendall 1967). Then, as countries in Asia began to show interest, the U.S. shifted their focus to the east. As the Spanish-American war unfolded, the U.S. worked "to acquire the sovereignty of the Hawaiian Islands, both for the protection of the [U.S.] Pacific coast and in order to make it possible to maintain any naval base in the Far East" (Evening Bulletin 1908:9). The need for a mid-Pacific base highlighted the importance of Pearl Harbor and Hawai'i. In 1898, under the administration of President William McKinley, the U.S. government approved a joint resolution of annexation that purportedly established the Republic of Hawai'i as a U.S. Territory (Sai 2011). On April 30, 1900, President McKinley had signed the Organic Act which organized the Territory of Hawai'i and defined the political structure of the newly established government (An Act to Provide for a Government for the Territory of Hawaii (Organic Act), 31 Stat. 141, 56th Cong. Sess. 1 (April 30, 1900)) in Justice 2000).

These events led to sweeping and long-lasting changes that altered the political, economic, and socio-cultural fabric of these islands. In light of this massive political transformation, in 1899, President McKinley issued the first of severeal executive orders that set aside 15,000 acres of O'ahu's public lands for military use. By 1908, the U.S. began its process of transforming Ke-awa-lau-o-Pu'uloa into a military installation through dredging, construting a dry dock, barracks, warehouses, submarine base, radio center, and a hospital. By the 1930s, the harbor had become a mjor industrial base for the U.S. Pacific Fleet and other parts of O'ahu were developed as Army bases including Schofield Barracks located upland of Honouliuli in Wai'anae Uka (Justice 2000). In 1931 on a 213-acre parcel, the Navy constructed an ammunition depot at West Loch (Cruz et al. 2011). Throughout the remainder of the 1930s, the U.S. Navy expanded its operations in Honouliuli to include the construction of the 'Ewa Field, installation of roads in the coastal area, and purchased 3,500 acres of land to construct Barbers Point Naval Air Station (ibid.). A 1944 aerial photo (Figure 18) of the project area shows continued agriculture while a 1959 map obtained at the collections of the University of Hawai'i at Mānoa library shows the military expansion around O'ahu and extensive naval operations in the 'Ewa region (Figure 19).

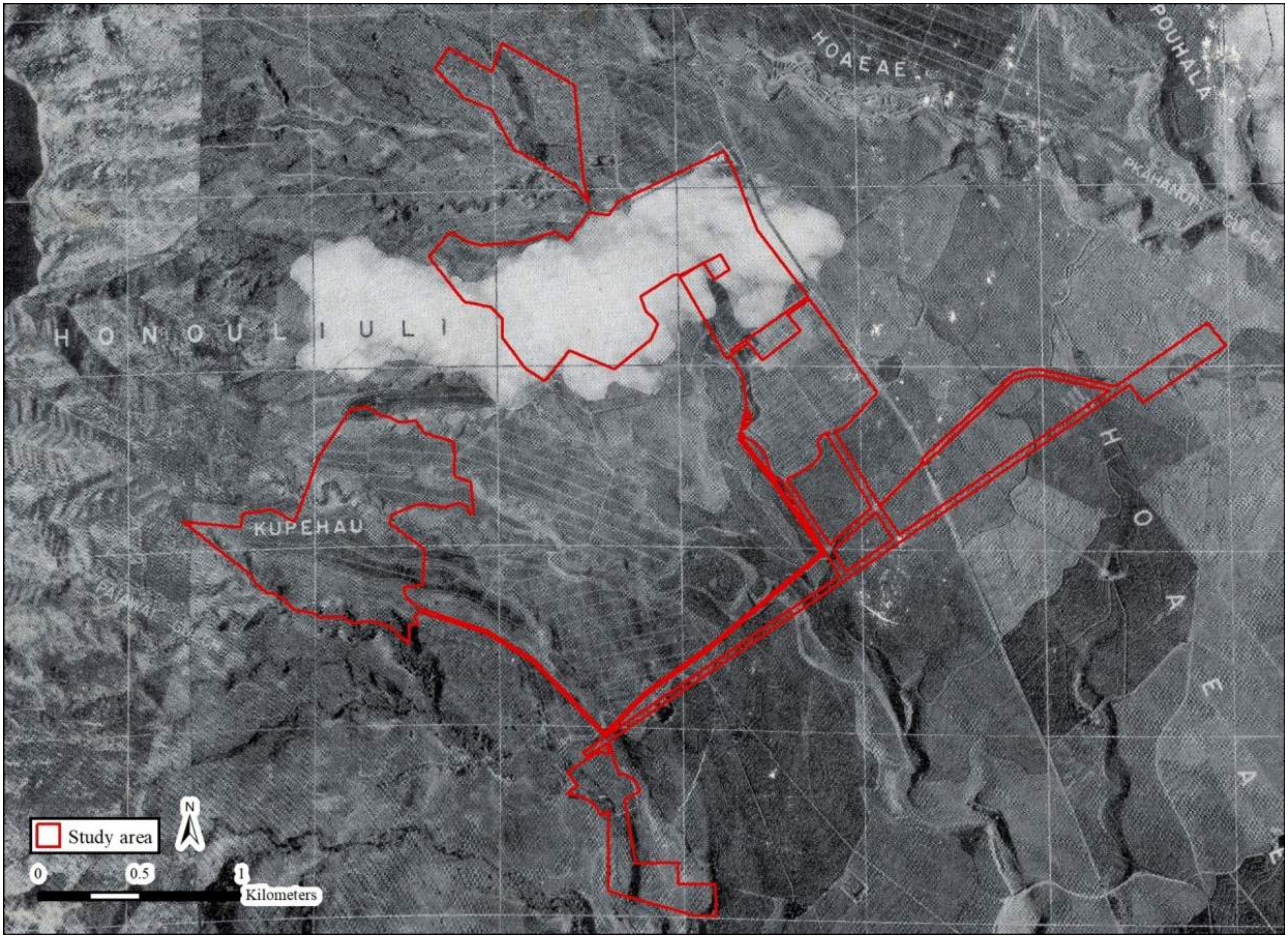

Figure 18. 1944 aerial of the project area showing continued agriculture.

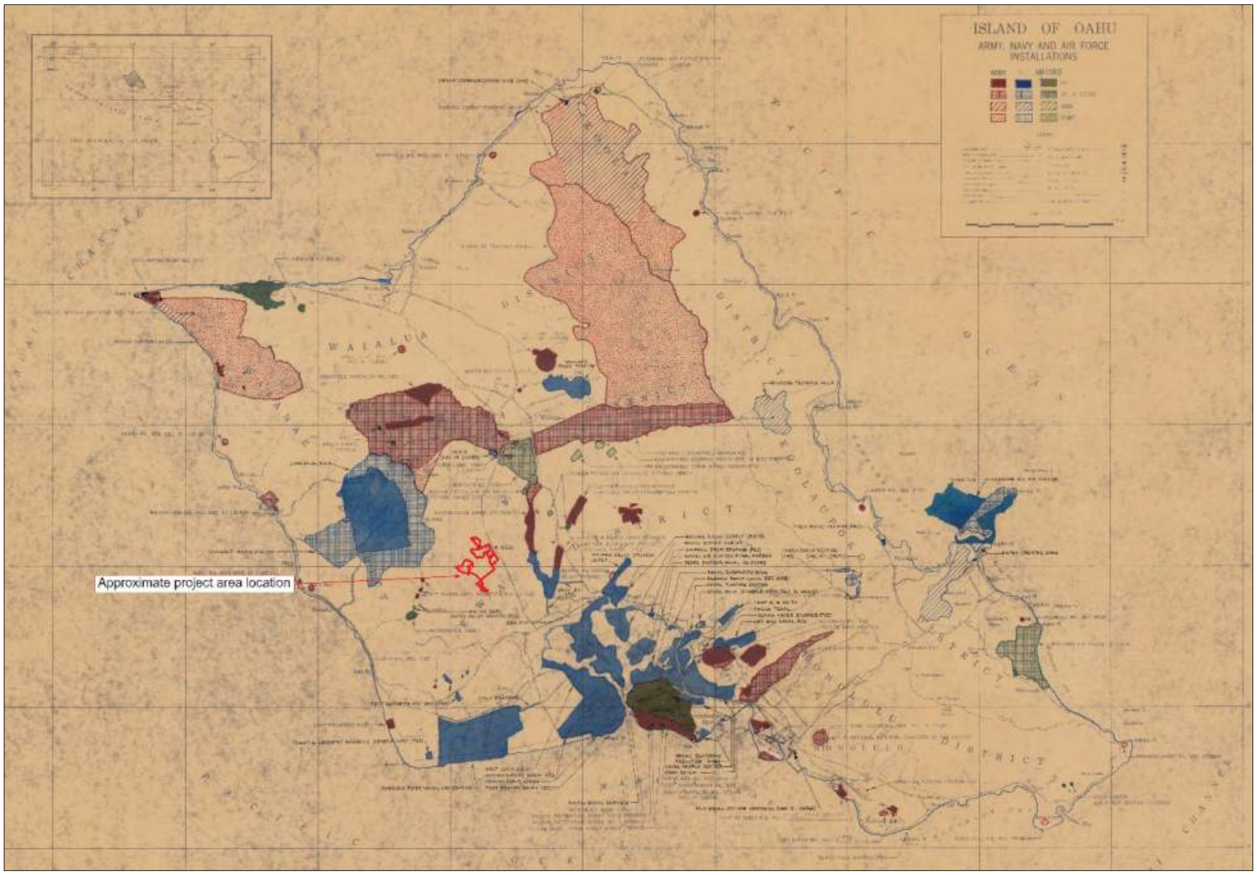

Figure 19. 1959 Oʻahu military installations map.

World War II and the Establishment of the Honouliuli Internment Camp

On the morning of December 7, 1941, the United States entered into World War II (WWII) after Japan launched an attack on U.S. Naval base in Pearl Harbor. By the afternoon, the Terrirotial Governor, Joseph B. Poindexter had declared martial law and hundreds of civilian arrest were made by the Federal Bureau of Investigation (FBI) and the U.S. Army. After the initial arrests were made, the FBI transfered the prisoners to the military police and prisoners were detained at several facilities in Honolulu. By March of 1942, internees and Prisoners of War (POW), the majority of which were of Japanese ancesty, were relocated from Sand Island to the Honouliuli Internment Camp.

The camp was built by the U.S. military and was set up along the floodplains of Honouliuli Gulch, just south of the project area (Figure 20) on land leased by the Oahu Sugar Company from Campbell Estate (Burton and Farrell 2011). The camp "was designed to encompass up to 160 acres, with facilities for approximately 3,000 prisoners of war and civilian internees" and the "Army cleared trees and grass in the densely vegetated valley at Honouliuli to enhance security" (Burton and Farrell 2011:46). Honouliuli served as a base camp and a point of transfer for POW. The camp was also known by other names including Alien Internment Camp and later POW Compound Number 6, however, internees referred to it as *Jigoku-Dani* ("Hell Valley") because of its secluded location and often intense heat (Farrell 2017). "Honouliuli was divided into several compounds, so that prisoners of war and civilian internees were separated, and civilian Japanese Americans were separated from German Americans" (Nye in Farrell 2017:25). While there are no clear record of the number of individuals that were housed at the camp, it has been estimated that by 1945, the "prisoner population at Honouliuli may have reached 4,000 or more" thus exceeding the planned capacity (Falgout in Farrell 2017).

Figure 20. Honouliuli Internment and POW camp ca. 1945 (from Hawai‘i Plantation Village, Waipahu in Burton and Farrell 2011:26).

According to Burton and Farrell (2011:47), archaeological and archival research inidicates that the "...Honouliuli internment camp was expanded at some point in its occupation..." With the lifting of martial law on October 24, 1944, there was no legal basis for detaining citizens and by December of 1945, the repatriation of prisoners began. Sometime before 1948, the camp was abandoned and demolished by the U.S. Army Corps of Engineers (Figure 21). By 1958, the land was leased by Mr. Rodney Santiago for ranching which lasted until 2000 (Farrell 2017).

Archaeological investigations conducted between 2006 and 2017 resulted in the identification of 215 features, 175 of which are directly associated with WWII camp. The forty remaining features not associated with the camp includes two ditch systems that pre-date the camp as well as post-war agricultural features (Farrell 2017). In 2009, Burton and Farrell prepared a National Register nomination and three years later on February 21, 2012, the site was listed on the National Register of Historic Places. In 2015, under the administration of President Barak Obama, the Honouliuli Internment Camp was established as a national monument (Figure 22) (Secretary 2015). The northern most section of the Honouliuli National Historic Site is situated just beyond the project area's southern boundary (see Figure 22).

The Honouliuli National Historic Site is currently managed by the National Park Service (NPS) and is closed to the public until all of the NPS planning requirements have been completed. NPS along with various community stakeholders including The Japanese Cultural Center of Hawai‘i, Pacific Historic Parks, and the University of Hawai‘i West O‘ahu are currently in the strategic planning phase, which is necessary for the establishment of any national park.

Figure 21. Abandoned Honouliuli Internment Camp with the Waiahole Ditch in foreground (Hashimoto Collection in Farrell 2017:31).

Figure 6.2. Honouliuli National Monument boundary (yellow dashed line) and the location of World War II camp features derived from historic blueprints and photographs and archaeological data (in red).

Figure 22. Project area located north of the Honouliuli National Monument (Farrell 2017:268).

Residential and Commercial Development

Oʻahu Sugar Co. continued commercial sugar cultivation throughout the second half of the 20th century before it closed its operations in 1995. An aerial photo taken in 1962 (Figure 23) shows the project area under commercial sugar cultivation. The land then returned to the estate of James Campbell who then leased the property to Del Monte Fresh Produce , Inc. for pineapple cultivation. With respect to the current Hartung property which comprises the majority of the project area with the exception of the northern and southern most section, in 2008, Syngenta Hawaii, LLC a subsidiary of Syngenta Seeds, Inc. (an indirect subsidiary of Syngenta AG, a Switzerland-based multinational agricultural company) utilized the majority of the property for agricultural research, development, and seed corn production. In 2017, the Wisconsin corporation, Hartung Brothers Inc. purchased the property where they have continued to expand its agricultural operations for the cultivation of various food crops including beet, carrots, cucumbers, lima beans, peas, snapbeans, sweet corn, and seed corn (PBR Hawaii 2018).

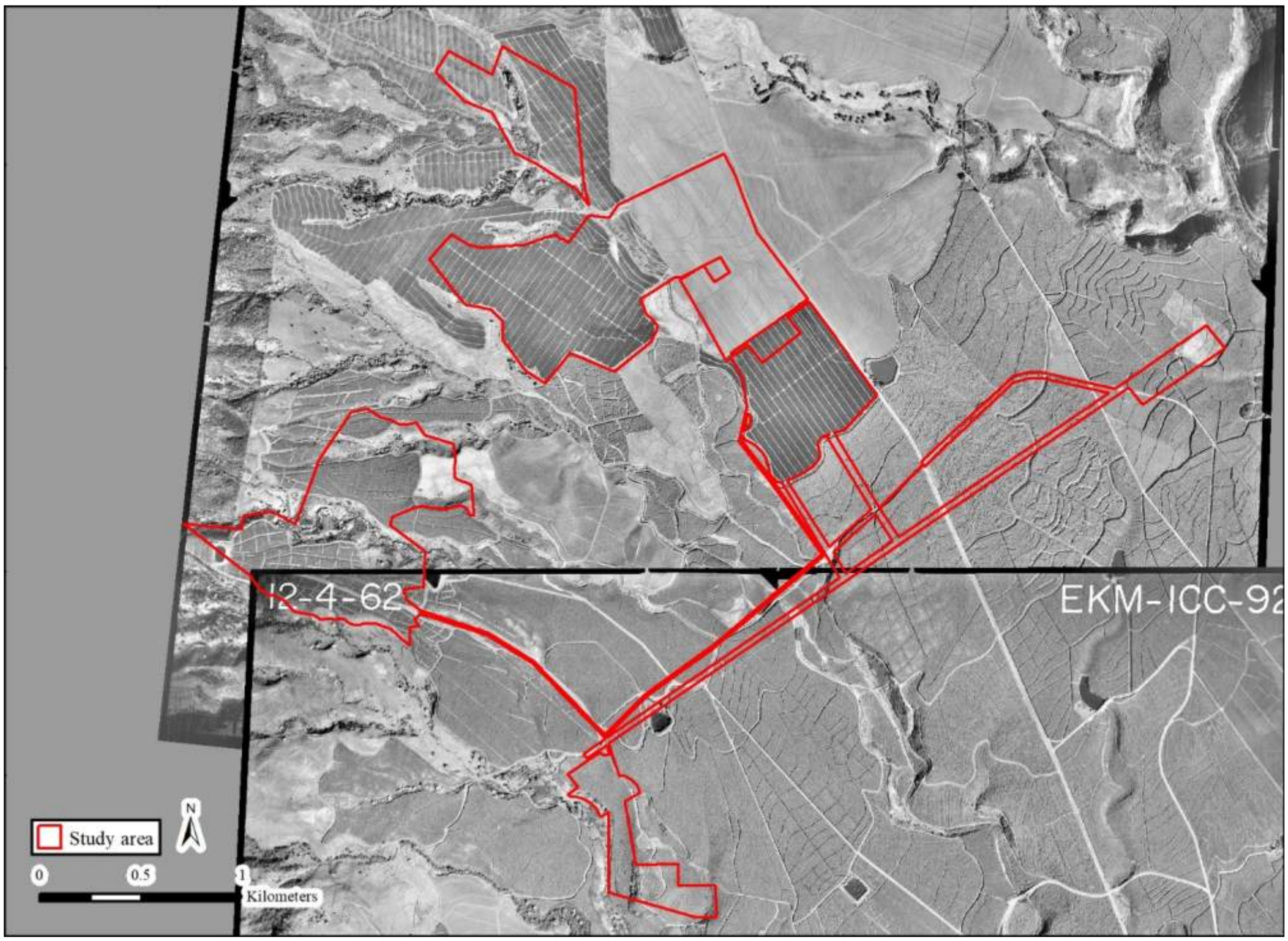

Figure 23. 1962 aerials of the project area.

INOA ʻĀINA (PLACE NAMES) SURROUNDING THE PROJECT AREA

The *inoa ʻāina* within a particular *ahupuaʻa* or broader region evidences the long-term relationship of various communities to their immediate environment. Although there is no word for "environment" in the Hawaiian language, there are other proximate terms, including "ʻano o ka nohona" (a person's relationship to their surroundings) and "nā mea e hoʻopuni ana" (the things in a person's environment that surrounds them) (Oliveira 2014:64). The following paragraphs contain a presentation of *inoa ʻāina* that were compiled from several map collections including Department of Accounting and General Services Hawaiʻi Registered Maps (RM), and the United State Geological Survey (USGS) that speak to Hawaiian relationships to their immediate environment. The earliest maps found in these collections date back to the 1870s. In addition to maps, *inoa ʻāina* are recorded and recounted in a variety of Hawaiian oral arts including, *oli* (chants), *mele* (songs), *moʻolelo* (stories), *nane* (riddles), and *ʻōlelo noʻeau* (proverb and poetical expressions). Since the introduction of the written language, place name information has been recorded in ethnographic surveys, historic maps, and a number of early historical documents including *Māhele ʻĀina* records and Boundary Commission testimonies. Kikiloi (2010:75) asserts that the recovery of traditional place names "help to transform once-empty geographic spaces into cultural places enriched with meaning and significance." In lieu of a comprehensive list of the hundreds of *inoa ʻāina* that are found in Honouliuli, place names within the immediate project area are listed in Table 1 and discussed below.

Table 1. *Inoa ʻāina* in the immediate project area vicinity.

Inoa ʻAina	*Notes*	*Reference Map*	*Interpretation*
Ekahanui	Gulch located north of the project area	Alexander 1873 (RM405)	*ʻēkaha-nui:* large *ʻēkaha* (*Asplenium nidus*) or many *ʻēkaha*
Huliwai	Gulch located north of the project area	Alexander 1873 (RM405)	*huli-wai:* turning waters
Kaaikukai/ Kaaikukui	Gulch. Soehren (2011) notes that the name is not Kaaikukai but Kaaikukui	USGS 1998	*Ka-ʻai-kūkai:* The food frequently dipped in the sea or excrement eater *Ka-ʻai-kukui: Kukui* (*Aleurites moluccana*) eater
Kupehau	Land where project area is located	Alexander 1873 (RM405)	*kupe-hau: hau* (*Hibiscus tiliaceus*) canoe end piece
Palawai	Gulch west of the project area	USGS 1998	*Palawai:* bottom lands or *Pālāwai:* a type of freshwater *limu* (algae)
Puu Kuina	*Heiau* located in Kaaikukai/Kaaikukui Gulch	McAllister 1930	*Puʻu Kuʻina:* pounding hill or *Puʻu Kuina:* joining hill
Puu Kuua	Hill and Heiau south of the project area	Alexander 1873 (RM405)	*Puʻu Kuʻua:* relinquished hill or hill where octopus lure stones are found
Puu Moopuna/ Namoopuna	Hill near Puu Kuua	USGS 1998	*Puʻu-moʻopuna:* Granchild Hill *Nā-moʻopuna:* the grandchildren

Ekahanui

Ekahanui is the name of a gulch north of the project area. The name "Ekahanui" can either be translated as "large *ʻēkaha"* (*Asplenium nidus*) OR "many *ʻēkaha.*" Known more commonly as bird's nest fern, *ʻēkaha* is typically found growing between the elevations of 1,000-3,000 feet on larger boulders and trees (Hillebrand 1888). The young shoots of the *ʻēkaha*, mixed with other medicinal plants into a poultice, were used to treat an array of ailments such as ulcers and sores (Kaaiakamanu and Akina 1922:22-23). The naming of the gulch as Ekahanui may allude to an abundance of *ʻēkaha* in the area at one time. No further information could be found at this time to verify this claim.

Huliwai

Huliwai, translated as "turning waters," is the name of a gulch north of the project, beyond Ekahanui gulch. No further information could be found about this place name.

Kaaikukai/Kaaikukui

Kaaikukai/Kaaikukui is a gulch located south of the project area and Palawai gulch. According to Soehren (2010), the proper name spelling is Kaaikukui, which translates to "*kukui* (*Aleurites moluccana*) eater." *Kukui*, commonly known as candlenut, served a number of purposes. The oily nut found within the hard black shell was used as a lamp and at times the nut was slow roasted then crushed with *paʻakai* (salt) to make the relish/seasoning known as *inamona* (Abbott 1992). The oily properties of this nut were also used medicinally as a laxative to helped expel waste from in the body (Abbott 1992). Hawaiian plant expert, Isabella Abbott further notes that "[a]ll parts of the tree—flowers, fruits (nuts), bark, and leaves—can be used for these purposes" (Abbott 1992:100). Fresh *kukui* leaves were prepared into a poultice and used to treat swelling, deep bruises, and other injuries. Red pigment was also extracted from the bark of old *kukui* trees and from this pigment a reddish color was produced that was used to dye *kapa* cloth and fishnets (Abbott 1992). The hard-black shells were also strung together into lei. It is within and along the edges of the old *kukui* forests that another agricultural method termed *pā kukui* or *pā kuikui* was practiced. Handy et al. write:

> In localities where planting was done along the edges and within the borders of old kukui forests, notably on the lower slopes of the Hamakua coast of Hawaii before the forest were cleared for sugar-cane plantations, taro was planted in clearings termed pa kukui or pa-kuikui. The trees were felled and allowed to decompose. The kukui rots very quickly when wet, and wood, bark, and foliage make rich humus. Large holes were then dug in the soil and filled with kukui leaves, and when these were decomposed the taro was planted. The plants are said to have grown luxuriantly in such localities, to a height of 7 feet and with corms weighing 20 pounds. (Handy et al. 1991:109-110)

Kukui also carried important spiritual significance and was seen as an identifyer for the domain of the pig-deity Kanepuaʻa or Kamapuaʻa, who was understood to be an embodiment of the deity Lono (Handy et al. 1991). Both names (Kaaikukai and Kaakukui) are provided here since Kaaikukai, translated either as "the food frequently dipped in the sea" or "excrement eater," is a name that continues to appear in numerous records.

Kupehau

As indicated on Hawaiʻi Registered Map No. 405 (see Figure 8), Kupehau is the name of the land area in which the proposed project area is located. Although there are other places known as Kupehau in Kalihi-uka on Oʻahu as well Kohala on Hawaiʻi Island, the historical references to these areas should not be confused with the Kupehau within Honouliuli. There are few sources that discuss or mention the Kupehau in Honouliuli. One source refers to Kupehau in poetic terms as a place where cold mists gather (Kapena 1862). Another discusses Kupehau as the name of a wind of the Waiʻanae region (Kapihenui 1862a). In 1936, Charles Sheldon Judd noted that a single fine specimen of *ʻiliahi* (*Santalum freycinetianum*) grew in along a ridgeline in Kupehau, a remnant of a larger forest that once existed in the area (Judd 1936). Translated, Kupehau means "*hau* (*Hibiscus tiliaceus*) canoe end piece." Krauss (1993:50) notes that "the end pieces, usually made from the wood of the breadfruit tree, helped prevent the entrance of seawater into the canoe; they were specifically designed planks for each side of the fore and aft sections of the hull." Typically, the light wood of the *hau* tree was used to make canoe outriggers and floats. The cordage that is produced from *hau* bark served as excellent lashing for canoes as well.

Palawai

Palawai is a gulch west of the project and north of Kaaikukai/Kaaikukui. The name can either be interpreted as Palawai, which is a term used to describe "bottom lands," or Pālāwai, which is the name for a variety of freshwater *limu* (algae, seaweed).

Puu Kuina

Puu Kuina was a *heiau* that McAllister (1933) reported as being once located in Kaaikukai/Kaaikukui gulch and possibly destroyed. No further information could be found about the site. Two possible interpretations of the *inoa ʻāina* are "pounding hill" (*Puʻu Kuʻina*) or "joining hill" (*Puʻu Kuina*).

Puu Kuua

Puu Kuua is a hill as well as the site of a *heiau* (ceremonial temple) located immediately south of the project area. Oftentimes translated as "relinquished hill," Puu Kuua is also said to be a place where Pele's sister, Kapōʻulakīnaʻu, left her *kohe lele* (flying vagina) for sometime (Pukui et al. 1974:200). McAllister in Sterling and Summers (1978:32) notes that the *heiau* was destroyed and "that portion of the heiau which has not been cleared for pineapple has been planted in ironwoods." Early in the reign of Kamehameha III, the lands surrounding Puu Kuua were populated enough for the government to erect a schoolhouse (Kamakau 1869). The *aliʻi* named Manuia was also noted as a resident of Puu Kuua prior to his departure with his relative, the *aliʻi* Boki, to the New Hebrides in search of sandalwood (Kapihenui 1862a:1). Puu Kuua is also mentioned in passing in numerous *oli* (chants) and *mele* (song) along with other prominent places within the *ahupuaʻa* of Honouliuli that appear in *moʻolelo* (legendary accounts) such as Hiʻiakaikapoliopele, Aʻahoaka, and Kalelealuakā (Kapihenui 1862b:4; Kaualilinoe 1870:1; Kuokoa 1877:1). A short story regarding the chiefs who once lived in Puu Kuua is provided in Sterling and Summers (1978:32-33). The source of the story is derived from "Na Wahi Pana o Ewa i Hoonalowaleia i Keia Wa a Hiki Ole Ke IkeIa" (The Famed Places of ʻEwa That Are Now Lost And Cannot be Seen), a serialized account documenting the travels of the gods Kāne and Kanaloa throughout the district of ʻEwa published in the newspaper *Ka Loea Kalaiaina* in 1899. When Kāne and Kanaloa reached Puu Kuua on their journey, the author of "Na Wahi Pana" recounted a tale associated with the area:

> The chiefs of old, who lived at that time, were of divine descent. The two gods looked down on the hollow and saw how thickly populated it was. The mode of living here was so that chiefs and commoners mixed freely and they were so like the lowest of people (Kauwā). That was what these gods said and that was the time when the term kauwā was first used, and was used for many years afterwards.
>
> After the first generations of chiefs had passed away and their descendants succeeded them, a chiefess became the ruler. It was customary for the chiefs of Oahu to visit this place to see the local chiefs. They did this always. When the time came in which a new chiefess ruled, an armless chiefess, she ran away to hide when other chiefs came to visit as usual because she was ashamed of her lack of an arm. Because she was always running away because of being ashamed the chiefs that visited her called her the low-born (kauwā). Thus the term remaiend in the thoughts down to this enlightened period. She was not truly a kauwā but was called that because she behaved like one. This was how they were made to be kauwās. When the ruling chief wished to go to Waikiki for sea bathing he asked the chief just below him in rank, "how are my planting places at Puu-Kuua, have they not produced young suckers?" The chief next to him answered, "There are some suckers," and sent someone for them. When the men, women and children least expected it, the messenger came to get some of the children. The father stood up and took his sons to Waikiki. Then when the ruling chief went sea bathing, he sent an attendant to get the boys and take them to a shallow place where the ruling chief would come. Then the ruler placed a hand on each of the boys, holding them by the necks. The words he uttered were, "My height has not been reaches!" (Aole i pau kuu loa, aole i pau kuu loa). He advanced and held on to the boys until the sea was up to his chest. The boys floated on the water face down. The father on shore called out, "Lie still in the sea of your Lord," and so on.
>
> The sea of Waikiki is said to have been used to kill men in and the other place is Kualoa. The inhabitants of Puu-Kuua were so mixed, like taro beside an imu.
>
> There were two important things concerning this place. (1) This place is entirely deserted and left uninhabited and it seems that this happened before the coming of righteousness to Hawaii Nei. Not an inhabitant is left. (2) The descendants of the people of this place were so mixed that they were all of one class. Here the gods became tired of working and returned to Kahiki. (Sterling and Summers 1978:32-33).

The value of this story is that it recounts how Puu Kuua was a densely populated area in the past. It was inhabited and frequently visited by members of the *aliʻi* class. Furthermore, the *moʻolelo* identifies Puu Kuua as the place where the term *kauwā* (servant) was first used.

Puu Moopuna/Namoopuna

Puu Moopuna/Namoopuna is a hill located south of the project area and near Puu Kuua. Puu Moopuna translates to "grandchild hill" and Namoopuna means "the grandchildren." No further information could be found regarding this *inoa ʻāina.*

3. CONSULTATION

In an effort to identify individuals knowledgeable about past and ongoing customary and traditional cultural practices associated with the project area, efforts were made by ASM staff to contact community members via email or phone. The names of the individuals are listed in Table 2 below. These individuals were identified as persons who were believed to have genealogical ties, long-standing residency, or knowledge of cultural and or historical properties in Honouliuli Ahupuaʻa. Of the ten individuals contacted, responses were received from five individuals. One individual, Mr. Thomas Lenchanko, provided written comments via email and his comments have been included below. Interviews were conducted with the remaining four respondents, Mr. Dietrix Ulukoa Duhaylonsod, Mr. Douglas "McD" Philpotts, Mr. Glen Kila, and Mr. Christophor Oliveira.

Additional consultation was also sought with lead staff from the Department of Land and Natural Resources (DLNR), State Historic Preservation Division (SHPD). On September 15, 2020, ASM and G70 staff met with Dr. Susan Lebo, Archaeology Branch Chief, and Mr. Hīnano Rodrigues, History & Culture Branch Chief. No specific information about known archaeological or cultural resources in the project area was identified.

Efforts were also made to consult with the Office of Hawaiian Affairs (OHA), lead compliance staff Kai Markell. Although no information about traditional cultural traditions and practices specific to the project area was identified, discussions focused more on broader issues such as how is the proposed project is seeking ways to re-engage with the Native Hawaiian community in more meaningful ways. One of the issues highlighted in the discussion focused on how traditional cultural practices have been interrupted as a result of historical events that have ultimately led to the displacement of Hawaiians from the *ʻāina* (land) and ways in which project proponents can mitigate such issues.

Table 2. Persons contacted for consultation.

Name	*Affiliation*	*Date Contacted*	*Response*
Susan Lebo	State Historic Preservation Division	September 15, 2020	Yes
Hīnano Rodrigues	State Historic Preservation Division	September 15, 2020	Yes
Kai Markell	Office of Hawaiian Affairs	September 16, 2020	Yes
Shad Kane		October 28, 2020	No
Dietrix Ulukoa Duhaylonsod	Resident of Honouliuli	October 27, 2020	Yes
Jo-lin Lenchanko-Kalimakapu	Hawaiian Civic Club of Wahiawā	October 28, 2020	No
Noelani DeVincent	Hawaiian Civic Club of Wahiawā	October 28, 2020	No
Jonah Laʻakapu Lenchanko		October 28, 2020	No
Mikiʻala Lidstone	Ulu Aʻe Learning Center	October 28, 2020	No
Douglas "McD" Philpotts	Resident of Honouliuli	October 28, 2020	Yes
Glen Kila	Marae Haʻa Koa Cultural Learning Center	October 28, 2020	Yes
Tom Lenchanko	Aha Ula Puuhonua Kukaniloko	October 28, 2020	Yes
Christophor Oliveira	Marae Haʻa Koa Cultural Learning Center	November 3, 2020	Yes

INTERVIEW METHODOLOGY

Prior to the interview, ASM staff provided information about the nature and location of the proposed project and informed the potential interviewees about the current study. The potential interviewees were informed that the interviews were completely voluntary and that they would be given an opportunity to review their interview summary prior to inclusion in this report. With their consent, ASM staff then asked questions about their background, their knowledge of past land use, and history of the project area, as well as their knowledge of any past or ongoing cultural practices. The informants were also invited to share their thoughts on the proposed development and offer mitigative solutions. Below are the interview summaries that have been reviewed and approved by the consulted parties.

THOMAS LENCHANKO

In a reply email dated, October 29, 2020, Mr. Thomas Joseph Lenchanko provided the following written statement:

> We, Aha Ula Puuhonua Kukaniloko – aha kukaniloko koa mana mea ola kanaka mauli hoalii iku pau the living evidence of those ancients buried in our homeland, continue our non - concurring posture to all injury, damages, ground disturbing activities, undertaking, programs and projects within and without the inviolable and sacrosanct kalana lihue wahiawa halemano… puuhonua kukaniloko, 36,000 acres Oahu island.
>
> Note: Please affirm and demonstrate proof of clear unbroken chain of ownership and the transfer of "exclusive territorial" jurisdiction of Kingdom of Hawaii property throughout the Hawaiian Archipelago to the United States federal government, its agent the State of Hawaii and the liable to public and private citizens working in their behalf. Also note, tax map key is an unlawful foreign lien against Kingdom of Hawaii property…
>
> hahai no ka ua i ka ulu laau

Thomas Joseph Lenchanko

Hawaiian National, Protected Person and Private Citizen

Aha Ula Puuhonua Kukaniloko

kahuakaiola ko laila waha olelo aha kukaniloko koa mana mea ola kanaka mauli hoalii iku pau

DOUGLAS MCDONALD PHILPOTTS

On October 29, 2020, Ms. Lokelani Brandt of ASM Affiliates conducted a phone interview with Mr. Douglas McDonalds "McD" Philpotts. Born on O'ahu, Mr. Philpotts has resided in the *ahupua'a* of Honouliuli for the past fifty years and is a descendant of Mr. James Campbell and Mrs. Abigail Kuaihelani Bright Campbell, thorough his grandmother Alice Kamokila. He is a professional woodworker and serves as Manager at Palehua Ranch, LLC. His understanding of his home comes from years of first-hand experience, family stories, and research.

In describing past land use and settlement patterns for Honouliuli, Mr. Philpotts explained that most of the Precontact habitation occurred in the *mauka* lands near the Wai'anae mountains and that agricultural fields were further inland of the habitation centers. He described how the people of old descended to the coast to gather marine resources. Mr. Philpotts explained that at one time there was an abundance of *lo'i* in coastal Honouliuli near West Loch. He shared that during the Historic Period as large-scale agriculture developed, many of the intact cultural sites were erased. He went on to note that for the most part, sugarcane and pineapple cultivation did not occur in the gulches and ridgelines, thus many cultural sites can still be found in these areas. He also spoke about an agricultural complex that has been identified in the gulches near the project area vicinity. Mr. Philpotts related that the Precontact population in this area was likely large however, the population dwindled as a result of introduced diseases and more notably after the 1853 smallpox epidemic. Also during the Historic Period, he remarked that when Campbell purchased the property, it came with cattle that belonged to Robinson and Dowsett. The cattle had overrun much of the uplands causing erosion. To remediate the erosion, Campbell sold off much of the cattle which supplied more than a third of O'ahu's beef consumption during this period.

Mr. Philpotts spoke at length about the cultural significance of the southern portion of the Wai'anae mountain range. He noted that from the ridgeline of Mauna Kapu all of the Hawaiian Islands are viewable and there is a solstice alignment between Haleakalā, Mauna Kapu, and Mokumanamana. Because of the observations that can be made from Mauna Kapu, he believes this place was significant to navigators. He touched upon the project area's connection to the interior plains of O'ahu where Kūkaniloko, the birth center for O'ahu island royalty, is located. Lastly, Mr. Philpotts spoke briefly about Pohakea and described it as the passages between the 'Ewa and Wai'anae lands and noted that it is an ancient place as it is mentioned in the account of Hi'iaka. He also noted Palikea Ridge as a culturally significant area because of a trail that connected 'Ewa with Lualualei and Nānākuli.

Further elaborating on place names, Mr. Philpotts explained that when Mr. Harry van Holt was in Honouliuli (post-1886-1887), he named several places including Palehua and many of van Holt's names were added to historical records produced after that time. In light of this, he added when trying to understand the cultural significance of the different places in Honouliuli, van Holt's influence must be taken into consideration.

In looking at the location of the proposed project area, Mr. Philpotts noted that the project area footprint appears to be mostly within agricultural fields and that he was not aware of any physical sites in the project area footprint. He did, however, caution that there may be cultural sites in the gulches and drainages and noted that in this part of Honouliuli, such resources have been found in these areas. Concerning the proposed solar project, Mr. Philpotts added that as long as we are on these islands we will be changing it in some way. In closing, he reflected that as we move towards green energy projects, we need to do these projects in the most appropriate places.

DIETRIX JON DUHAYLONSOD

On November 3, 2020, Ms. Lokelani Brandt of ASM Affiliates conducted a Zoom video conference interview with Mr. Dietrix Jon Duhaylonson. Born and raised in the area of Pūkaua in which the community of Honokaihale is located on the western side of Honouliuli Ahupua'a, Mr. Duhaylonsod shared that growing up this side of the island was considered remote. He described how the landscape was once dominated by *kiawe* (*Prosopis pallida*) trees and that the roads into Honokaihale were paved with white coral. In relating information about his family, Mr. Duhaylonsod stated that his mother's family was from Makaha and Kalihi and that his father's family was from Kahuku and Damon Tract. He recollected on his childhood and explained he was able to play in the mountains in the area known as Palehua and down to the coast from Kalaeloa to Anianikū (at Ko'olina) to Kahe. Mr. Duhaylonsod is also a Kumu Hula and works as an archaeologist and ethnographer.

Mr. Duhaylonsod listed various traditional place names in the area including Pūkaua which he described as the hilly area between Pu‘uokapolei and Kahe. He related that the *pu‘u* (hill) in which the water park is located is Pu‘u Pāla‘ila‘i and shared that *la‘ila‘i* is the name of a sweet potato variety. Other place names pointed out by Mr. Duhaylonsod included Waimanalo, a land area in the vicinity of and valley *mauka* of modern-day Ko‘olina; and Kaupe‘a, a plain in the area near Kalaeloa. With respect to other culturally significant places located in the southern Wai‘anae Mountain Range most visible from the project area, Mr. Duhaylonsod related insight shared with him by Aunty Nettie about the area near Makakilo She explained that this area was never developed because of how the land there was used by the ancient people. Mr. Duhaylonsod went on to share a possible connection with traditions that say that there was a population of *kauā* in Honouliuli (a caste that lived in the interior *mauka* portion apart from the general population and was drawn upon for human sacrifice). Additionally, when human sacrifices were needed, the *kauā* were taken down to the coast and drowned.[Note: Mr. Duhaylonsod thinks they were drowned in the Kona district; not sure if they were drowned in the ‘Ewa waters as well]. While there is an acknowledgement of these ancient practices, they are considered not good practices which have, in turn, affected the *mana* of the land.

In relating more insight into how the *kauā* came to this area, Mr. Duhaylonsod explained that during the period of Tahitian settlement on O‘ahu, there was a power struggle between the Tahitians and those of the earlier migration already settled in Hawai‘i. He went on to add that some say the Tahitians referred to the existing people as “manahune,” a variant of “menehune” meaning “little *mana*” as a way to diminish their existence. Mr. Duhaylonsod related that these “manahune” people were pushed out of the prime lands and into the mountains or more arid lands including the uplands of Honouliuli and the ‘Ewa-Wai‘anae District. In expanding on this, Mr. Duhaylonsod explained that much of the physical remains left by the people that settled in this part of Honouliuli (from Kalaeloa to Makakilo to Kupehau) are distinct and have been architecturally identified by cultural practitioners as being more synonymous with Marquesan culture. He added that after the Tahitian migration, many of the old *heiau* (temples) on O‘ahu were repurposed and consequently took on the architectural features of the newer settlers. Additionally, Mr. Duhaylonsod noted that some of what has been identified as older style *heiau* have been found in the Wai‘anae District.

Another culturally significant place discussed by Mr. Duhaylonsod was Pohakea, where there was a well-traveled path that connected the districts of ‘Ewa and Wai‘anae. He pointed out that this path is noted in several traditional accounts including that saga of Hi‘iaka. In further describing the saga of Hi‘iaka, Mr. Duhaylonsod recalled a portion of the story in which Hi‘iaka descends from Pohakea onto the plains of Keahumoa in Honouliuli where she met women who were gathering and stringing *lei* (garland) of *ma‘o* (*Gossypium sandvicense*) blossoms. He added that this traditional account mentions several other dryland plants that were once abundant in Honouliuli including *‘ilima* (*Sida fallax*) which was found in the lower elevations. Mr. Dyhaylonsod elaborated on the location and name variations for Keahumoa. He clarified that Keahumoa is present-day Kunia Village Park and Royal Kunia area. Concerning name variations, he shared that in the Kamapua‘a story, the name Keehumoe is used and in other accounts, it is known as Keehumoa. He opined that when the archaeologist McAllister came through the area, he documented the name as Keahumoa. In discussing other native plants that were common in Honouliuli, Mr. Duhaylonsod described reading in Handy and Handy’s book *Native Planters in Old Hawai‘i* about *wauke* (*Broussonetia papyrifera*) being found in the interior of Honouliuli.

Mr. Duhaylonsod shared that Kamapua‘a is a hero and *kupua* associated with the Pu‘u Kapolei area where he lived with his *kūpunahine* and older brother. He commented that bird catching was also a traditional practice that took place in the Honouliuli area and that the plain of Keehumoe (Keahumoa?) was a sweet potato planting area farmed by Kamapua‘a’s grandfather.

In sharing insight that had been shared with him by Mr. McD Philpott, a Campbell descendant about land use from the late 1800s and into the 20th century, Mr. Duhaylonsod shared that the main industries were cattle ranching and agriculture and that the Robinson and Campbell families held most of the land in Honouliuli. He shared that when Mr. Harry van Holt was ranch manager he named many places in Honouliuli and that many of these place names have been retained and can appear to be ancient names. He noted that place names that appear in historical records before the 1870s, before van Holt’s influence, are likely of an older origin. Mr. Duhaylonsod shared that after private ownership of lands in the mid 19th century, access to the uplands in Honouliuli has overtime become very restricted. He recalled hearing stories from *kūpuna* (elders) who remembered accessing the uplands using the old trails like the one at Pohakea. Mr. Duhaylonsod reflected on how overtime diminished access and a lack of a knowledgeable local community has made it difficult to maintain traditional knowledge and practices through the years. One example of this is the discrepancies in place names for the summit ridgeline and the gulches, which is something he would like to see clarified with local experts.

When asked if whether the project poses any potential impact to the cultural resources of this area and if he had any mitigative recommendations, Mr. Duhaylonsod prefaced that overall he supports the collective shift towards renewable energy. He went on to describe the importance of recognizing past adverse impacts on the land and thus to the traditions and practices of this area. He believes developers must recognize both the potential impacts their project may have as well as the historic impacts they are inheriting and finding ways to mitigate these impacts. For example, he related that because of past land-use activities, many of the tangible cultural resources in the project area and nearby vicinity have been destroyed, buried, or pushed into the nearby gulches. He added that any additional alteration to the land has the potential for destroying any remnant sites. To this end, Mr. Duhaylonsod imagines that there may still be intact sites and site remnants in the gulches. For these reasons, he stated "don't think everything is destroyed" and believes the gulches should be thoroughly surveyed for archaeological resources. He also believes there are opportunities for the developer to help restore some of the traditions through the replenishment of natural resources that were once abundant in this area and perhaps helping to coordinate access days for *hālau* and other cultural practitioners to carry out protocol at the culturally significant places in the area. He clarified that there may be descendants, *kūpuna*, and cultural practitioners who have a direct connection to the project area and humbly noted that if such persons are identified, he would respectfully defer to them for guidance and knowledge. He also would like the developer to ensure that they properly mitigate water runoff, which when concentrated, can cause extra damage. In summary, Mr. Duhaylonsod shared that as a whole the island of Oʻahu has been subject to an extensive amount of development and therefore there is a fervent desire from the community to value what is left, even if in small pockets. He hopes the developer is proactive in their efforts to restore, *mālama*, and give back to the community and the *ʻāina*.

GLEN KILA AND CHRISTOPHOR OLIVEIRA

On November 15, 2020, Ms. Lokelani Brandt of ASM Affiliates conducted a Zoom video conference interview with Mr. Glen Kila and his nephew Mr. Christophor Oliveira. Mr. Kila is the President of Marae Haʻa Koa Cultural Learning Center and Mr. Oliveira serves as the Executive Director of the organization. Both Mr. Kila and Mr. Oliveira are *kupu* (offspring) of the lands of Waiʻanae which they explained traditionally included the *ʻāina* (land) that makes up the central Oʻahu region. They have dedicated much of their lives to deepening their understanding of *ʻāina* and its many layers of *moʻolelo* (stories, history) and sharing their knowledge through their work at Marae Haʻa Koa.

In relating culture-historical information about the project area vicinity, Mr. Oliveira shared that this area of Oʻahu was home to the Lō Aliʻi, a special class of Oʻahu chiefs. As expressed by Mr. Oliveira, the Lō Aliʻi played an important role in maintaining genealogical purity for Oʻahu's *aliʻi* (chiefs), and over the generations, they became the parents of all ruling chiefs. Because of their status as Lō Aliʻi and more importantly as parents to the *aliʻi*, they were not required to adhere to certain *kapu* (taboos) associated with the chiefly class including the *kapu moe* (prostrating taboo). Mr. Oliveira noted a well-known Lō Aliʻi, Makakaualiʻi whose name translates to "place your eyes on the chief" and Kākuhihewa, who came to rule over Oʻahu. Concerning other *aliʻi*, Mr. Oliveira spoke about a battle during the reign of the *aliʻi* Mailikukahi where armies from Maui and Hawaiʻi Island attempted to invade Oʻahu but were routed inland to Waikakalaua where they were vastly outnumbered and eventually slaughtered. Concerning the life and reign of the *aliʻi* Mailikukahi, Mr. Oliveira and Mr. Kila shared that Mailikukahi had implemented certain practices including *hānai* (adopt, rear, feed) of every firstborn child born on Oʻahu. As a result of this practice of *hānai*, Mailikukahi bestowed genealogical rights to his *hānai* children to rule. Additionally, it is believed that Mailikukahi held high regard for human life because after he became *aliʻi*, he forbid the practice of human sacrifice.

Pertaining to the history of the *aliʻi* Kamehameha, Mr. Oliveira and Mr. Kila relayed that during his conquest of Oʻahu, the people of Waiʻanae sent their children to Kauaʻi, which was considered a *koʻa* (lit. fish house; fig. place of safety/refuge) as a way to preserve their lineage for being exterminated. In reflecting on their oral traditions, Mr. Oliveira highlighted the fact that during Kamehameha I's war campaigns, he sought to exterminate those who were not his loyal supporters and worked to replace Oʻahu's traditions and practices (e.g. temple architecture and rituals, and land management strategies) with those of Hawaiʻi Island. He added that many place names found in ʻEwa are also found on Kauaʻi which further demonstrates the relationship between these lands. In sharing insight about *aliʻi* customs as it pertains to the lands of ʻEwa and Waiʻanae, Mr. Kila opined that Līhuʻe (Kūkaniloko) in ʻEwa was the royal birthing center and that Waiʻanae was where the *aliʻi* were reared, one of which included Kauikeaouli (Kamehameha III). Mr. Kila noted that Maraehaakoa in Waiʻanae was the place where training/instruction occurred and that training often focused on one student rather than a group. The warm weather of Waiʻanae, fertile valleys, coupled with the persistence of ancient customs and temple rituals specific to Oʻahu made it the preferred location to train upcoming *aliʻi*. Mr. Oliveira and Mr. Kila expounded on this noting that temples were referred to as *unu* and that there were specific types of *unu* dedicated to a specific function.

Mr. Oliveira shared that traditionally, the people and *aliʻi* focused much time and energy on *kaʻananiau* (tracking the rolling beauty of time) which is a concept and practice that emphasizes a profound and intimate understanding of natural cycles and *kanaka* (human) relationship to nature. He shared that because the ancient people understood their environment so well, they knew when and where to go to secure more suitable living conditions. For example, during ʻEwa's dry season, the people often relocated to the uplands where water was more abundant. Mr. Oliveira spoke about the importance of the sun, which is a *kinolau* (embodiment) of the deity Kāne, to the people of Oʻahu. He added that Kāne is considered a vital life force for all living things as expressed in the *ʻōlelo noʻeau*, *Ua kapu ke ola nā Kāne* (life is sacred to Kāne). Kāne was also known by other epithets including Kānenuiākea and it was the latter to whom people prayed to. Other *kinolau* of Kāne noted by Mr. Oliveira included the *ʻamaʻama* (a young stage of a mullet fish), and ʻ*anae* (full-sized mullet), *wai* (freshwater), and *ʻawa* (kava). He shared how Kāne is a prominent natural force in this part of the island and that tracking its movement across the heavens was and still is an important cultural practice. He went on to explain that there were three particularly important times of the year in which observations of Kāne were made, Kāneloa (winter solstice), Wākea (equinox), and Kānenui (summer solstice). Additionally, tracking Kāne's movement across the sky was done by using certain geographical markers located around Oʻahu which included Kaʻaumākua found in Koʻolauloa, Mauna Kapu west of the project area, and Mākua in Waiʻanae as well as certain temples. While Kāne is particularly important to people of the ʻEwa area, Mr. Oliveira emphasized that there are many places on Oʻahu that honor Kāne through direct use of his name or his *kinolau* including (but not limited to) Waikāne, Wahiawākea (Wahiawā), and Waiʻanae.

Concerning cultural sites in the project area vicinity, Mr. Kila identified trails at Pohakea and Palikea, the former of which he first visited in 1978. Mr. Oliveira remembered first visiting Pohakea in 2013. Mr. Kila recalled visiting Pohakea with his Kumu Lei Fernandez who was the *kahu* (guardian, caretaker) for Kamokila Campbell. Mr. Kila recalled his Kumu Lei sharing how this upland area contained a variety of endemic plant species and that she accompanied several botanists to Pohakea but no credit was ever given to her for her knowledge of the area's plants. Concerning the trail, Mr. Oliveira shared that the route at Pohakea is an ancient one and was part of Oʻahu's *alaloa* trail system. He added that these trails were maintained by the *kukuihelepō*, a population known to travel at night with torches. Mr. Kila noted that the trail at Pohakea connected the lands of ʻEwa, which was rich in fishponds and marine resources to Lualualei in Waiʻanae which was considered the "breadbasket." He explained that most people associate Lualualei as a dry area, however, the back of the valley is well-watered and was extensively cultivated. Concerning the place name Kupehau, the area in which the proposed project is located, they shared that Kupehau is also the name of a rain carried by the wind.

In closing, Mr. Kila and Mr. Oliveira shared that it is important to understand the history of a place from the *kupu*, the people who have been there for multiple generations. They cautioned that although the project area has been subjected to decades of clearing for agriculture, there are likely remnant cultural and historic features that may be buried or located in the gulches. They noted that there has been extensive cultural sites found on the adjacent lands. Mr. Oliveira opined that if sites are found they should be preserved. He added that preserving sites is not just for preservation's sake but because they are evidence of who we (the people of this land) were prior to Kamehameha's persecution.

4. ASSESSMENT AND MITIGATIVE MEASURES

The select archival and ethnographic sources that are referenced throughout this *Ka Paʻakai* analysis illustrate a concise history of Honouliuli within and beyond the proposed project area from the Precontact to HistoricPeriod. Few sources were found that referred specifically to Kupehau, the land area where the project area is located, or the other *inoa ʻāina* (place names) listed in historical maps and other references. Other sources, however, mentioned Honouliuli in reference to the ʻEwa plains and the *puʻu* (hills) within the *ahupuaʻa*. The assessment offered below draws from these sources, as well as consultation with community members, to determine the extent to which identified natural, cultural, and historical resources, as well as traditional and customary Native Hawaiian rights, may potentially be affected through the construction of the Mahi Solar Facility.

IDENTIFY WHETHER ANY VALUED CULTURAL, HISTORICAL, OR NATURAL RESOURCES AREA PRESENT WITHIN THE PETITION AREA, AND IDENTIFY THE EXTENT TO WHICH TRADITIONAL AND CUSTOMARY NATIVE HAWAIIAN RIGHTS ARE EXERCISED

A review of the culture-historical background material in conjunction with the results of the consultation process has resulted in the identification of several resources, as well as traditional and customary practices that formerly took place within the general project area vicinity. These resources and customary practices are further described in the subsequent paragaphs.

Pohakea Trail

Mo'olelo such as Hi'iakaikapoliopele, Kahalaopuna, and Palila refer to the plains of Honouliuli in passing as the story's protagonist traverse through the area on trails that connected the lands of Honouliuli ('Ewa) and Lualualei (Wai'anae) via the Wai'anae Mountains. The trail most often referenced with respect to the project area, in traditional literature and by the consulted parties was Pohakea trail. John Papa 'Ī'ī also described this trail which was depicted in Rockwood's map (see Figure 6)as passing through the northern section of the project area. The 1953 USGS map (see Figure 17) also depicts the route of Pohakea trail passing through the northern portion of the project area. That portion of the trail within the project area is shown as a road, however, as the road ascends the Wai'anae Mountains, the road is shown as a foot trail. All of the consulted parties identified Pohakea trail as a valued cultural resource.

Based on the results of the consultation, all of the consulted parties have recalled or described walking Pohakea trail at some point in their lifetime. They also noted that access to the trail has been limited or restricted which has impacted their ability to carry out their traditional customary rights.

Traditional Hawaiian Agricultural Practices and Endemic Plant References and Uses

References to agricultural practices, specifically *'uala* (sweet potato) cultivation on Honouliuli's interior plains as well as *lo'i kalo* cultivation in the lowlands near West Loch was also identified in the historical literature. Mr. Duhaylonsod also discussed sweet potato cultivation in the land area known as Keahumoa (also spelled Keehumoe), which is located to the north of the project area. *Lo'i kalo* cultivation was also practiced in Honouliuli, however, this form of agricultural practice appears to have been concentrated in the lowlands of Honouliuli, along tributaries and in the vicinity of West Loch. In addition to agricultural practices, the account of Hi'iakaikapoliopele provides the most extensive references to the native plant regime in the *mauka* regions of Honouliuli as well as cultural uses of these plants.

For example, the *mo'olelo* includes a segment where Hi'iaka travels through Pohakea pass and the plains of Honouliuli. Traveling along a *mauka-makai* trail within Honouliuli, Hi'iaka meets women making *lei* made of *ma'o* (*Gossypium tomentosum*) blossoms, women-turned-*mo'o* who strung *'ilima* (*Sida fallax*) flowers into *lei*, and women resting idyly under the shade of *'ōhai* (*Sesbania tomentosa*) bushes near a hill. In most cases, Hi'iaka called out to these groups in the form of *oli* to determine whether or not she would be welcomed. In her *oli,* she describes a variety of plants that she may have seen on her journey through Honouliuli. Some of the plants that are listed include *koai'a* (*Acacia koaia*), *kukui* (*Aleurites moluccanus*), *wiliwili* (*Erythrina sandwicensis*), *nohu* (*Tribulus cistoides*), *'ōhi'a lehua* (*Metrosideros polymorpha*), and *kauno'a* (*Cuscuta sandwichiana*). The women's responses to Hi'iaka varied as some welcomed Hi'iaka into their village, others hid in fear, and the women resting under the *ōhai* bushes let Hi'iaka know that they could not host her properly. Of note is that these latter women described how they made their clothes out of the red *pilipili* grass (*Chrysopogon aciculatus*) that grew abundantly during certain seasons. Historical accounts also describes the presence of "extensive stands" of *'iliahi* (sandalwood) along mountain slopes near Pu'u Ku'ua (St. John 1947). However, by the early 20th century this prize resource was collected to the point where only remnants of the vast forest once found in the area were all that remained (Judd 1936; Kamakau 1869; St. John 1947). These forests were destroyed through the sandalwood industry, resulting in the barren landscapes that are seen today (Bishop in Sterling and Summers 1978:89). Manuia, an *ali'i* with ties to Boki and other ruling chiefs, is noted by Kamakau (1992) to have lived at Pu'u Ku'ua and harvested sandalwood in Honouliuli.

Historical records provide a rather clear account of traditional agricultural practices and native plant species once found in the uplands of Honouliuli. The results from consultation suggest that no traditional agricultural practices nor traditional gathering of plant resources are currently taking place in the project area. The fact that such customary practices are not being carried out is a result of decades of restricted access that has prevented community members and practitioners from accessing the uplands to gather plant resources for cultural purposes.

Ali'i Battle Sites

Kaua (warfare) took place in Honouliuli over the centuries as warring chiefs from inter-island polities sought more land and political prestige. The wars that are mentioned in historical sources specific to the uplands of Honouliuli as well as by several of the interviewees include those during the reigns of Kūali'i (A.D. 1720-1740) and Mā'ilikūkahi (Cordy 2002). Fornander (1916-1917:364-433) recounts the story of Kapaahulani and Kamakaaulani and the *mele* they composed and performed to appease Kūali'i on the plains of Keahumoa situated north of the project area (see Figure 6). Kamakau (1991) recounts Mā'ilikūkahi's birth at Kūkaniloko in central O'ahu (northeast of the project area), campaigns against the *ali'i* of Hawai'i and Maui, as well as his role in reordering and redistributing the lands of

Oʻahu. Through Māʻilikūkahi's land redistribution and leadership, the lands and people of Oʻahu experienced an era of prosperity resulting in population increase.

Although use of the project area and or immedicate vicinity as a traditional battle site has not been practiced for many generations, the consulted individuals still recognize this as an important aspect of Oʻahu's Hawaiian history and heritage.

Cultural Sites and Resources in the Vicinity of Puʻu Kuʻua

The southwestern portion of the project area is situated at the base of Puʻu Kuʻua, a hill that is named in Kamakau's (1991) description of Maʻilikūkahi's reign and provides us with an indication of intensive land use in the area prior to Western contact (Sterling and Summers 1978:32-33). As previously discussed, Puʻu Kuʻua was known for its extensive stands of sandalwood. Additionally, Mr. Philpotts described a *heiau* atop Puʻu Kuʻua as culturally significantly and possibly associated with the deity Lono due to various alignments that can be seen during the winter solstice. Mr. Philpotts comments regarding astronomical observations at Puʻu Kuʻua relate to Kamakau's description of Puʻu o Kapolei being used as a site to track the changing seasons (in Sterming and Summers 1978:34). Mr. Duhaylonsod, Mr. Kila, and Mr. Oliveira's comments regarding a population of *kauā* that once lived at Puʻu Kuʻua is supported by earlier accounts (in Sterling and Summers 1978:32-33). By the early 19th century, Puʻu Kuʻua and the surrounding area was sparsely populated and nearly abandoned. Early explorers such as Vancouver noted the lack of a substantial population in the region, in contrast to the populated areas in the *makai* region of Honouliuli along the lochs.

Possibility of Remnant Cultural Sites in Gulches, Ravines, and Along Ridgelines

All of the consulted parties acknowledged the history of intensive agriculture practices and its resulting impacts on the natural and cultural resources once located in the project area. Several of the consulted parties did note that historical agriculture practices (i.e. sugarcane and pineapple cultivation) was not often conducted in the gulches, ravines, and ridgelines and thus they cautioned of the possibility of findings such resources in these areas. The also cautioned of the possibility of finding remnant subsurface features in formerly cultivated areas. All of the consulted parties referenced previous archaeological studies conducted in the adjacent areas or recalled personal experience in which such resources were found in the gulches, ravines, and ridgelines. The possibility of findings sites in the vicinity of Puʻu Kuʻua is supported by historical records which describe it as a well populated area during the Precontact Era.

Freshwater and the Waiāhole Ditch

As pointed out by Mr. Duhaylonsod and Mr. Philpotts, freshwater, valued as both a natural and cultural resources, can be found along the base of Waiʻanae Mountains as well as the gulches and ravines. Historical records and maps have also identified the Waiāhole Ditch, portions of which can be found extending through portions of the project area as well as along portions of the project area boundaries.

IDENTIFY THE EXTENT TO WHICH THOSE RESOURCES AND RIGHTS WILL BE AFFECTED OR IMPAIRED BY THE PROPOSED ACTION

The proposed project has the potential to impact all of the above-identified resources and associated practices to a degree if proper mitigative measures are not thoughtfully considered and implemented. Concerning Pohakea trail, if access remains obstructed, then the proposed project infringes upon customary access rights and any concomitant resources and traditional customary practices (i.e. gathering of plant resources for cultural purposes) that would otherwise occur along this trail.

With respect to plant resources, while the majority of the project area is dominated by non-native species, a biological survey of the project area resulted in the identification of several native species including scattered individuals of *ʻiliahialoʻe* (*Santalum ellipticum*), scattered individuals of *wiliwili* (*Erythrina sandwicensis*) in the dry lower gulches, and *ʻuhaloa* (*Waltheria indica*) found in fallow fields and roadsides (Breeden et al. 2020). The former two plant species were noted in historical literature and traditional accounts. If the proposed project footprint extends into native plant habitat then such resources would be adversely impacted. Conversely, if the project footprint does not extend into native plant habitat then there would be no impact on such resources.

Concerning potential impacts to the battle site associated with the *aliʻi* Māʻilikūkahi, based on the available information it is difficult to ascertain the exact location of the battle site. Historical records indicate that the battle occurred on the plains of Keahumoa which is located to the area north of the project area. While there may be few, if any, remnant sites or resources directly associated with the battle site, it is unlikely the proposed project would have any direct adverse impacts to the battle site. Notwithstanding, this battle site is still important to Oʻahu's history.

A substantial portion of the project area is within formerly cultivated and existing fields which are devoid of any surface archaeological sites and features. Although surface features may not be present within these extensively plowed areas, encountering subsurface features, although unlikely, remain a possibility. Additionally, in locations where the project area footprint extends into gulches, ravines, and previously undisturbed areas, the possibility of encountering archaeological and cultural resources increases substantially and thus the proposed project has the potential of impacting such resources.

Portions of the proposed project appear to cross over at least four natural waterways as well as small segments of the historic Waiāhole Ditch (SIHP Site 50-80-09-2268). The proposed project does not appear to alter, modify, or redirect the existing flow of freshwater nor the Waiāhole Ditch, thus no apparent impacts to water resources or to the Waiāhole Ditch are anticipated.

SPECIFY ANY MITIGATIVE ACTIONS TO BE TAKEN TO REASONABLY PROTECT NATIVE HAWAIIAN RIGHTS IF THEY ARE FOUND TO EXIST.

Concerning Pohakea trail, it is recommended that consultation be conducted with the appropriate agencies and persons who would have more knowledge of the trail's historical location and possible status. Such action would ensure that Longroad Energy Management, LLC consider the trail in their development plans. Concerning plant resources, efforts should be made to avoid all native plant species and their associated habitat. Such areas should be identified and avoided. Similarly, archaeological resources should also be identified and avoided. If the above-described recommendations are considered and implemented, impacts to traditional and customary practices would be mitigated.

REFERENCES CITED

Abbott, I. A.

1992 *Lā'au Hawai'i, Traditional Hawaiian Uses of Plants*. Bishop Museum Press, Honolulu.

Advertiser, T. H.

1956a Pearl Harbor Rich In Legend. *The Honolulu Advertiser* [Honolulu]. May 27, 1956, accessed October 19, 2020.

1956b Story of Water Is Story of Sugar. *The Honolulu Advertiser* [Honolulu]. July 03, 1956: 44, accessed October 19, 2020.

Beckwith, M. W.

1951 *The Kumulipo A Hawaiian Creation Chant*. University of Hawaii Press, Honolulu.

1970 *Hawaiian Mythology*. University of Hawai'i Press, Honolulu.

Bennett, F.

1840 *Narrative of a Whaling Voyage Round the Globe*. R. Bentley, London.

Bingham, H.

1848 *A Residence of Twenty-One Years in the Sandwich Islands*. First ed. Sherman Converse, New York.

Bowser, G.

1880 *The Hawaiian Kingdom Statistical and Commercial Directory and Tourists Guide*. George Bowser and Co., Honolulu.

Breeden, J., A. Lau, and A. Ehrenkrantz

2020 Mahi Solar Project Biological Resources Report. SWCA Environmental Consultants SWCA Project No. 61736. Prepared for Longroad Energy Management, LLC, Honolulu.

Burton, J. F. and M. M. Farrell

2011 National Register of Historic Places Registration Form Honouliuli Internment Camp, Honolulu County, Hawaii. Trans-Sierran Archaeological Research. Prepared for National Register of Historic Places, California.

Byron, G.

1826 *Voyage of the H.M.S. Blonde to the Sandwich Islands, in the Years 1824-1825*. John Murray, London.

Campbell, A.

1817 *A Voyage Round the World, from 1806 to 1812, In Which Japan, Kamschatka, The Aleutian Islands, and The Sandwich Islands Were Visited*. Van Wrinkle, Wiley & Co., Printers, New York.

1967 *A Voyage Around the World from 1806 to 1812*. University of Hawai'i Press, Honolulu.

Condé, J. C. and G. Best

1973 *Sugar Trains: Narrow Gauge Rails of Hawaii*. Glenwood Publishers, Felton, California.

Cordy, R.

2002 *The Rise and Fall of the O'ahu Kingdom*. Mutual Publishing, Honolulu.

Coulter, J. W.

1933 The Oahu Sugar Cane Plantation, Waipahu. *Economic Geography* 9(1 (Jan)):60-71.

Coulter, J. W. and C. K. Chun

1937 *Chinese Rice Farmers in Hawaii*. University of Hawai'i Research Publication, vol. Number 16. University of Hawai'i, Honolulu.

Cruz, B., C. O'Hare, D. Shideler, and H. H. Hammatt
2011 Cultural Impact Assessment for the Honouliuli/Waipahu/Pearl City Wastewater Facilities, Honouliuli, Hōʻaeʻae, Waikele, Waipiʻo, Waiawa, and Mānana, and Hālawa Ahupuaʻa, ʻEwa District, Oʻahu Island, TMK: [1] 9-1, 9-2, 9-4, 9-5, 9-6, 9-7, 9-8, 9-9 (Various Plats and Parcels). Cultural Surveys Hawaiʻi, Inc., Kailua, HI Job Code: HONOULIULI 35. Prepared for AECOM Pacific, Inc.

Damon, F.
1882 Tours Among the Chinese, No. 1. *The Friend* [Honolulu]. April 1882, accessed 10/27/2020.

Dorrance, W. and F. Morgan
2000 *Sugar Islands: The 165-Year Story of Sugar in Hawaii*. Mutual Publishing, Honolulu.

Ellis, W.
1963 *Journal of William Ellis, Narrative of a Tour of Hawaii, or Owhyee; with remarks on the History, Traditions, Manners, Customs and Language of the Inhabitants of the Sandwich Islands*. Advertiser Publishing Co., Ltd., Honolulu.

Emerson, N. B.
1893 The Long Voyages of the Ancient Hawaiians. *Papers of the Hawaiian Historical Society Number Five*.

Evening Bulletin
1908 Honolulu and Pearl Harbor Vital Centers of America's Power in Pacific. *Evening Bulletin* [Honolulu]. 16 July: 39. Electronic document, https://chroniclingamerica.loc.gov/lccn/sn82016413/1908-07-16/ed-1/seq-9/.

Farrell, M. M.
2017 Honouliuli POW and Internment Camp Archaeological Investigations at Jigoku-Dani 2006-2017. Japanese Cultural Center of Hawaiʻi. Prepared for National Park Service, Honolulu.

Fornander, A.
1880 *An Account of the Polynesian Race: Its Origins and Migrations, and the Ancient History of the Hawaiian People to the Times of Kamehameha I*, vol. II. Trübner & Co., London.

1916-1917 *Fornander Collection of Hawaiian Antiquities and Folk-lore*. Memoirs of the Bernice Pauahi Bishop Museum, vol. IV. Bishop Museum Press, Honolulu.

1918-1919 *Fornander Collection of Hawaiian Antiquities and Folk-lore. The Hawaiians' Account of the Formation of their Islands and Origin of their Race, with the Traditions of their Migrations, etc., as Gathered from Original Sources.* Memoirs of the Bernice Pauahi Bishop Museum Volume V. Bishop Museum Press, Honolulu.

Handy, E. S. C. and E. G. Handy
1972 *Native Planters in Old Hawaii: Their Life, Lore, and Environment*. Bernice P. Bishop Museum Bulletin 233. Bishop Museum Press, Honolulu.

Handy, E. S. C., E. G. Handy, and M. K. Pukui
1991 *Native Planters in Old Hawaii: Their Life, Lore, and Environment*. Bernice P. Bishop Museum Bulletin 233. Bishop Museum Press, Honolulu.

Haraguchi, K.
1987 *Rice in Hawaii A Guide to Historical Resources*. Humanities Program of the State Foundation on Culture and the Arts and the Hawaiian Historical Society, Honolulu.

Haun, A. E.
1991 An Archaeological Survey of the Naval Air Station, Barber's Point, Oʻahu, Hawaiʻi. Prepared for Applied Research Group of Bishop Musum, Honolulu.

Hillebrand, W.

1888 *Flora of the Hawaiian Islands: A Description of their Phanerograms and Vascular Chryptograms*. Hafner Publication Company, New York.

Hoʻoulumāhiehie

2006a *The Epic tale of Hiʻiakaikapoliopele*. Translated by M. P. Nogelmeier. Awaiaulu, Honolulu.

2006b *Ka Mo'olelo o Hiʻiakaikapoliopele*. Awaiaulu, Honolulu.

Ii, J. P. (John Papa ʻĪʻī)

1993 *Fragments of Hawaiian History*. 2nd revised ed. Originally published 1959. Edited by D. Barrère. Translated by M. K. Pukui. B.P. Bishop Museum Special Publication 70. Bishop Museum Press, Honolulu.

James Campbell Company, LLC.

1978 *James Campbell ESQ*. 7th ed. Estate of James Campbell, Kapolei, HI.

Judd, C. S.

1936 Sandalwood, Once the Gold Mine of Hawaii, is Coming Back. *Honolulu Star-Bulletin* [Honolulu]. 8 February: 46, 52. Electronic document, https://www.newspapers.com/, accessed October 19, 2020.

Justice, DOI and DOJ

2000 From Mauka to Makai: The River of Justice Must Flow Freely. Department of the Interior and Department of Justice, Washington, D.C.

Ka Loea Kalaiaina

1900 He Moolelo nona Wahi Pana o Ewa I Huna Keleloaia me ka nalowale loa a hiki ole ke ikeia. *Ka Loea Kalaiaina* [Honolulu]. 13 Januari: 4. Electronic document, www.papakilodatabase.com, accessed 10/13/2020.

Kaaiakamanu, D. M. and J. K. Akina

1922 *Hawaiian Herbs of Medicinal Value: Found Among the Mountains and Elsewhere in the Hawaiian Islands, and Known to the Hawaiians to Possess Curative and Palliative Properties Most Effective in Removing Physical Ailments*. Board of Health of the Territory of Hawaii.

Kamakau, S. M.

1869 Ka Moolelo Hawaii, helu 181, No ka Noho Alii ana o Kauikeaouli Maluna o ke Aupuni, a Ua Kapaia o Kamehameha III. *Ka Nupepa Kuokoa* [Honolulu]. 30 September: 4. Electronic document, https://www.papakilodatabase.com, accessed 12/10/2020.

Kamakau, S. M.

1964 *Ka Poʻe Kahiko: The People of Old*. B.P. Bishop Museum Special Publication 51. Bishop Museum Press, Honolulu.

1991 *Tales and Traditions of the People of Old, Nā Moʻolelo a ka Poʻe Kahiko*. Bishop Museum Press, Honolulu.

1992 *Ruling Chiefs of Hawaii*. Revised ed. Kamehameha Schools Press, Honolulu.

Kameʻeleihiwa, L.

1992 *Native Land and Foreign Desires: Ko Hawaii ʻĀina a Me Nā Koi Puʻumake a Ka Poʻe Haole, Pehea lā e Pono ai? How Shall We Live in Harmony?* Bishop Museum Press, Honolulu.

1996 *He Moʻolelo Kaʻao O Kamapuaʻa An Annotated Translation of a Hawaiian Epic from Ka Leo O Ka Lāhui June 22, 1891-July 23, 1891*. Bishop Museum Press, Honolulu.

Kapena, B.

1862 He Inoa No Ailuene. *Ka Hoku O Ka Pakipika* [Honolulu]. 27 March: 4. Electronic document, https://www.papakilodatabase.com, accessed 12/10/2020.

Kapihenui, M. J.

1862a He Moolelo no Hiiakaikapoliopele. *Ka Hoku O Ka Pakipika* [Honolulu]. 20 March: 4. Electronic document, https://www.papakilodatabase.com, accessed 12/10/2020.

1862b He Moolelo no Hiiakaikapoliopele, Helu 11. *Ka Hoku O Ka Pakipika* [Honolulu]. 3 April: 4. Electronic document, https://www.papakilodatabase.com, accessed 12/10/2020.

Kaualilinoe, J. W. K.

1870 Ka Moolelo o Kalelealuaka. Ka Ihu Kae-a-e-a o Lihue, Kauai, Ka Olali Hoi O Kona Mau La U-i. *Ka Nupepa Kuokoa* [Honolulu]. 14 September: 4. Electronic document, https://www.papakilodatabase.com, accessed 10/28/2020.

Kelly, M.

1991 Notes on the History of Honouliuli Appendix A. Department of Anthropology, Bernice P. Bishop Museum *An Archaeological Inventory Survey of the Naval Air Station, Barber's Point O'ahu, Hawai'i*. Prepared for Naval Facilities Engineering Command, Honolulu.

Kikiloi, S. K.

2010 Rebirth of an Archipelago: Sustaining a Hawaiian Cultural Identity for People and Homeland. *Hūlili: Multidisciplinary Research on Hawaiian Well-Being* 6:73-115.

Kluegel, C. H.

1917 Engineering Features of the Water Project of the Waiahole Water Company. In *Hawaiian Almanac and Annual for 1916*, pp. 93-109. edited by T. G. Thrum. Thos G. Thrum, Honolulu.

Kotzbue, O. v.

1821 *A Voyage of Discovery into the South Seas and the Bering Straits in Search of a North-East Passage Undertaken in the Years 1815, 16, 17, and 1818, in the ship Rurick*. Richard Philips and Co., London.

Krauss, B. H.

1993 *Plants in Hawaiian Culture*. A Kolowalu Book. University of Hawaii Press, Honolulu.

Kuokoa, K. N.

1877 He Moolelo no Aahoaka ke Koa a me Kona Hanau Kupanaha Ana, He Moolelo Kahiko no Kauaia, Helu 6. *Ka Nupepa Kuokoa* [Honolulu]. 24 February: 4. Electronic document, https://www.papakilodatabase.com, accessed 10/27/2020.

Kuykendall, R.

1953 *The Hawaiian Kingdom Volume II 1854-1874. Twenty Critical Years*, vol. 2. 3 vols. University Press of Hawaii, Honolulu.

1967 *The Hawaiian Kingdom: Volume III: 1874-1893. The Kalakaua Dynasty*, vol. 3. 3 vols. University of Hawaii Press, Honolulu.

Macrae, J.

1922 *With Lord Byron at the Sandwich Islands in 1825. Being Extracts from the Diary of James Macrae, Scottish Botanist*. Edited by W. Wilson, Honolulu.

Maly, K. and O. Maly

2012a He Moʻolelo ʻĀina– Traditions and Storied Places in the District of ʻEwa and Moanalua (in the District of Kona), Island of Oʻahu : A Traditional Cultural Properties Study – Technical Report TMK Overview Sheets Zone 9-1 To 9 (Various Parcels); and Zone 1-1 (Various Parcels). Kumu Pono Associates, LLC Study No. 131 (April 21, 2012). Prepared for SRI Foundation, Rio Rancho, New Mexico.

2012b Honouliuli Land Tenure in the Māhele ʻĀina (1847-1855): A Study Prepared for the Hoakalei Foundation. Kumu Pono Associates, LLC. Prepared for Hoakalei Foundation. L. Kumu Pono Associates, Hilo.

Manu, M.
2002 *Keaomelemele: "He Moolelo Kaao no Keaomelemele"*. Edited by M. P. Nogelmeier. Translated by M. K. Pukui. Bishop Museum Press, Honolulu.

McAllister, J. G.
1933 *Archaeology of Oahu*. Bernice P. Bishop Museum Bulletin 104. Published by the Museum, Honolulu, Hawaii.

McElroy, W. K., M. Elison, and D. Duhaylonsod
2013 FINAL—Cultural Impact Assessment for a Proposed Solar Farm in Kalaeloa, Honouliuli Ahupua‘a, ‘Ewa District, Island of O‘ahu. Keala Pono Archaeological Consulting, LLC. Prepared for Mana Elua, Honolulu, Honolulu.

Meyen, F.
1981 *A Botanist's Visit to Oahu in 1831. Being the Journal of Dr. F.J.F. Meyen's Travels and Observations about the Island of Oahu*. Edited by M. A. Pultz. Translated by A. Jackson. Press Pacifica, Ltd., Honolulu.

Nakuina, E.
1904 *Hawaii, Its People. Their Legends*. The Hawaii Promotion Committee, Honolulu.

Nawaa, S. K.
1956 Hawaiiana Note. *The Honolulu Advertiser* [Honolulu]. October 20, 1956: 18, accessed October 19, 2020.

Oliveira, K.-A.
2014 *Ancestral Places: Understanding Kanaka Geographies*. Oregon State University Press, Corvallis.

Oliver, D.
1961 *The Pacific Islands*. University of Hawaii Press, Honolulu.

PBR Hawaii
2018 Agricultural Land Assessment for Hartung Brothers Hawaii, LLC's Proposed Important Agricultural Land, Island of O‘ahu. PBR Hawaii. Prepared for Hartung Brothers Hawaii, LLC, Honolulu.

Pukui, M. K. (editor)
1983 *‘Ōlelo No‘eau: Hawaiian proverbs & poetical sayings*. Bishop Museum Press, Honolulu.

Pukui, M. K., S. H. Elbert, and E. Mo‘okini
1974 *Place Names of Hawaii*. Revised and Expanded ed. University of Hawaii Press, Honolulu.

Pukui, M. K. and L. Green
1995 *Folktales of Hawai‘i: He mau Ka‘ao Hawai‘i*. B. P. Bishop Museum Press, Honolulu.

Sai, D. K.
2011 *Ua Mau Ke Ea Sovereignty Endures: An Overview of the Political and Legal History of the Hawaiian Islands*. Pū‘ā Foundation, Honolulu.

Secretary, O. o. t. P.
2015 Presidential Proclamation Establishment of the Honouliuli National Monument. The White House, Washington, D.C.

Soehren, L.
2010 Hawaiian Place Names. *Ulukau: The Hawaiian Electronic Library*. Electronic document, http://ulukau.org/cgi-bin/hpn? , accessed September 14, 2016.

St. John, H.
1947 The History, Present Distribution, and Abundance of Sandalwood on Oahu, Hawaiian Islands. *Pacific Science* 1(1):5-20.

Sterling, E. and C. Summers
1978 *Sites of Oahu*. Bishop Museum Press, Honolulu.

Vancouver, G.
1801 *A Voyage of Discovery to the North Pacific Ocean and Round the World*, vol. III. John Stockdale, London.

Wilkes, C.
1845 *Narrative of the United States Exploring Expedition During the Years 1838, 1839, 1849, 1842*, vol. IV. Lea and Blanchard, Philadelphia.

Yardley, P. T.
1981 *Millstones and Milestones: The Career of B.F. Dillingham, 1844-1918*. University of Hawaii Press, Honolulu.

Appendix F

An Archaeological Inventory Survey for the Mahi Solar Project Area ASM Affiliates March 2021

An Archaeological Inventory Survey of the Mahi Solar Project Area

TMKs: (1) 9-2-001:020 (por.); and (1) 9-2-004:003 (por.), 006 (por.), 010 (por.), 012 (por.)

Honouliuli Ahupuaʻa
ʻEwa District
Island of Oʻahu

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An Archaeological Inventory Survey of the Mahi Solar Project Area

TMKs: (1) 9-2-001:020 (por.); and (1) 9-2-004:003 (por.), 006 (por.), 010 (por.), 012 (por.)

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ASM affiliates

EXECUTIVE SUMMARY

At the request of Deron Lawrence of Longroad Energy Management, LLC (Longroad), ASM Affiliates (ASM) conducted an Archaeological Inventory Survey (AIS) of a roughly 620-acre project area located on portions of several Tax Map Keys (TMKs: (1) 9-2-001:020 (por.); and (1) 9-2-004:003 (por.), 006 (por.), 010 (por.), 012 (por.), in Honouliuli Ahupuaʻa, ʻEwa District, Island of Oʻahu. Longroad will lease portions of these parcels and is proposing to construct a 120-megawatt solar energy generation and storage facility. The current study was conducted in anticipation of the Hawaiʻi Revised Statutes (HRS) Chapter 6E-42 review of a City & County of Honolulu Conditional Use Permit application and was undertaken in accordance with Hawaiʻi Administrative Rules (HAR) §13–284 and was performed in compliance with the *Rules Governing Minimal Standards for Archaeological Inventory Surveys and Reports* as contained in HAR 13§13–276. In March of 2018, ASM Principal Investigator Robert B. Rechtman, Ph.D. and Senior Archaeologist Teresa Gotay, M.A. conducted an initial site inspection to review the boundaries of the project area and develop a comprehensive fieldwork strategy to identify and document the historic properties contained therein. The survey fieldwork, site identification, and documentation were conducted between August 8 and 22, 2020 and from January 25 to 27, 2021 by Matthew Clark, M.A. (Principal Investigator), Teresa Gotay, M.A., Kimberly Lauko, B.A., Deidra Moore, B.A., and Daina Avila, B.A. A total of 185 person-hours was expended during the fieldwork. The entire project area was subject to intensive pedestrian transect survey and as a result of the fieldwork effort, two sites were defined, SHIP Site 50-80-09-2268 (Waiāhole Ditch) and SIHP Site 50-80-12-7346 (Oahu Sugar Company Irrigation features). The significance of Site 2268 with respect to both its engineering aspects and its effects on Oʻahu's physical and political landscapes cannot be overstated; thus, this site is considered significant under Criterion a and Criterion c. As the Waiāhole Ditch continues to be a functioning water source for irrigation and other purposes, and as it will remain beyond the footprint of any Mahi Solar ground lease areas, per HAR §13-284-8 (a)(1)(A) the recommended treatment for this site with respect to the current project is "avoidance and protection" during development activities. As the agricultural fields this infrastructure supported were significant in Hawaii's plantation history, Site 7346 is considered significant under Criterion a; and as the study of this site (both archaeologically and cartographically) has yield information on twentieth century land use practices, Site 7436 is also considered significant under Criterion d. While it is the contention of the current study that the archaeological research potential for Site 7436 within the current project area has likely been exhausted, the possibility (albeit remote) remains that as of yet significant undiscovered aspects of this site, or archaeological resources that predate this site, could be encountered within the current project area; therefore, per HAR §13-284-8 (a)(1)(C) the recommended treatment for this site with respect to the current project is "monitoring" during development activities. The HRS Chapter 6E-42 determination of effect for the proposed Mahi Solar Project is "effect with agreed upon mitigation." As mitigation for this effect, per HAR §13-279-3, archaeological monitoring will occur during ground-disturbing activities pursuant to an archaeological monitoring plan that will be prepared in accordance with HAR §13-279-4 and submitted to the DLNR-SHPD for review and acceptance prior to initiating any ground-disturbing activity. Per HAR §13-279-4(a)(1), the archaeological monitoring plan will describe Waiāhole Ditch (Site 2268) as a site requiring protection during construction and will contain protocols for the temporary protection of this historic resources during development activities.

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1. INTRODUCTION

At the request of Deron Lawrence of Longroad Energy Management, LLC (Longroad), ASM Affiliates (ASM) conducted an Archaeological Inventory Survey (AIS) of a roughly 620-acre project area located on portions of several Tax Map Keys (TMKs: (1) 9-2-001:020 (por.); and (1) 9-2-004:003 (por.), 006 (por.), 010 (por.), 012 (por.), in Honouliuli Ahupuaʻa, ʻEwa District, Island of Oʻahu (Figures 1, 2, and 3). The project area parcels are owned by various entities: Monsanto Company (TMK: (1) 9-2-001:020); Hartung Brothers Hawaii LLC (TMKs: (1) 9-2-004:003, 006, 012); and Fat Law's Farm LLC (TMK: (1) 9-2-004:010). Longroad will enter into long-term leases with the various property owners and is proposing to construct a 120-megawatt solar energy generation and storage facility, to include ground-mounted photovoltaic arrays, an electrical substation and switchyard, a Battery Energy Storage System (BESS), and other associated appurtenances including fencing, roads, and electrical infrastructure (Figure 4) on agriculture-zoned land. Longroad will use existing farm roads outside of their lease footprint and establish new road where necessary within their lease footprint. The current study was conducted in anticipation of the Hawaiʻi Revised Statutes (HRS) Chapter 6E-42 review of a City & County of Honolulu Conditional Use Permit application associated with the development of the proposed solar power generating facility.

The current study was undertaken in accordance with Hawaiʻi Administrative Rules (HAR) §13–284 and was performed in compliance with the *Rules Governing Minimal Standards for Archaeological Inventory Surveys and Reports* as contained in HAR 13§13–276. Compliance with the above standards is sufficient for meeting the historic preservation review process requirements of the Department of Land and Natural Resources-State Historic Preservation Division (DLNR-SHPD). This report contains background information describing the location and environment of the project area, a presentation of a culture-historical context for Honouliuli and the greater region, a summary of the previous archaeological work conducted in the vicinity of the project area, an explanation of the survey methods and results of the current fieldwork, evaluation of the identified resources, treatment recommendations, and a HRS Chapter 6E-42 statement of effects.

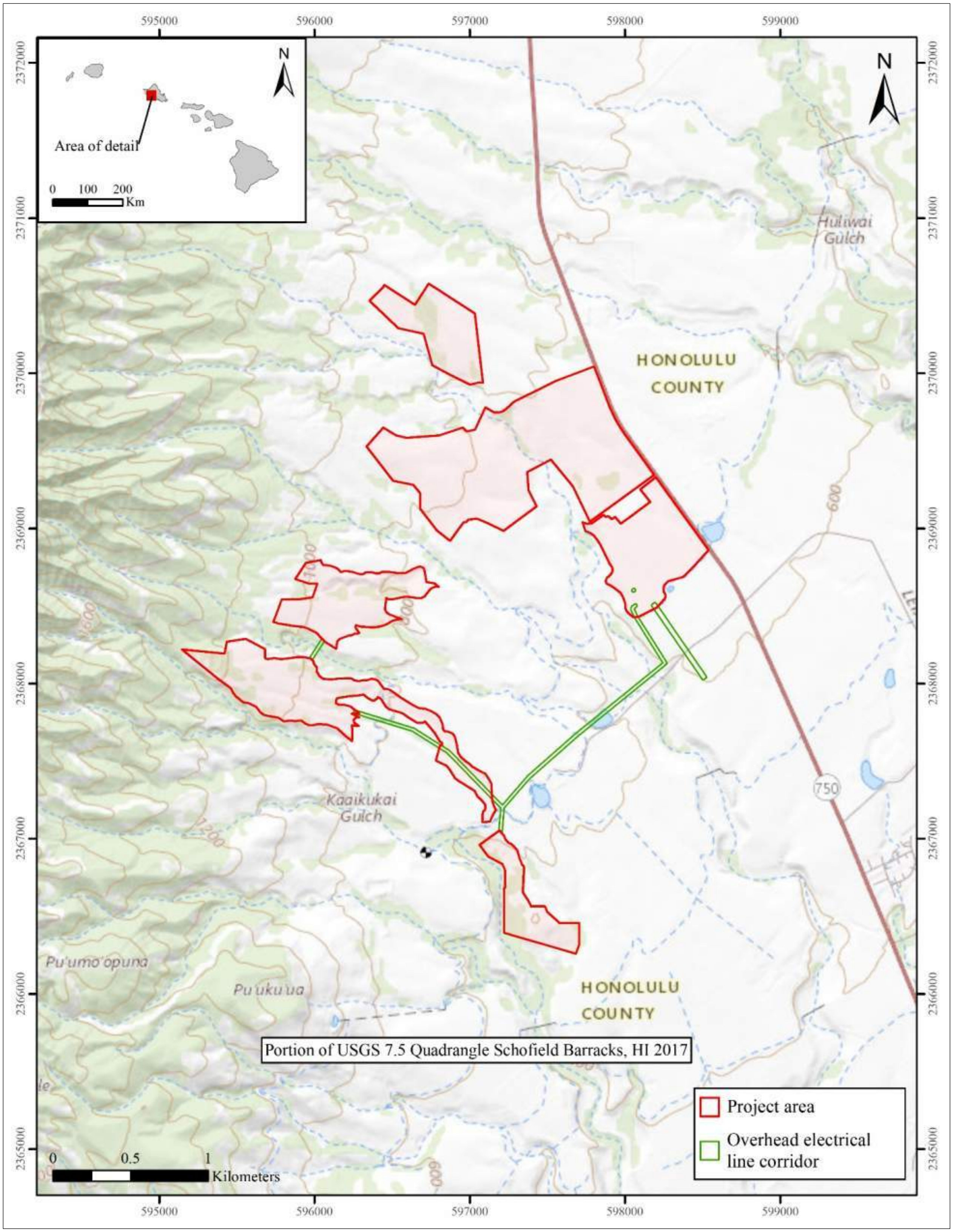


Figure 1. Project area location.

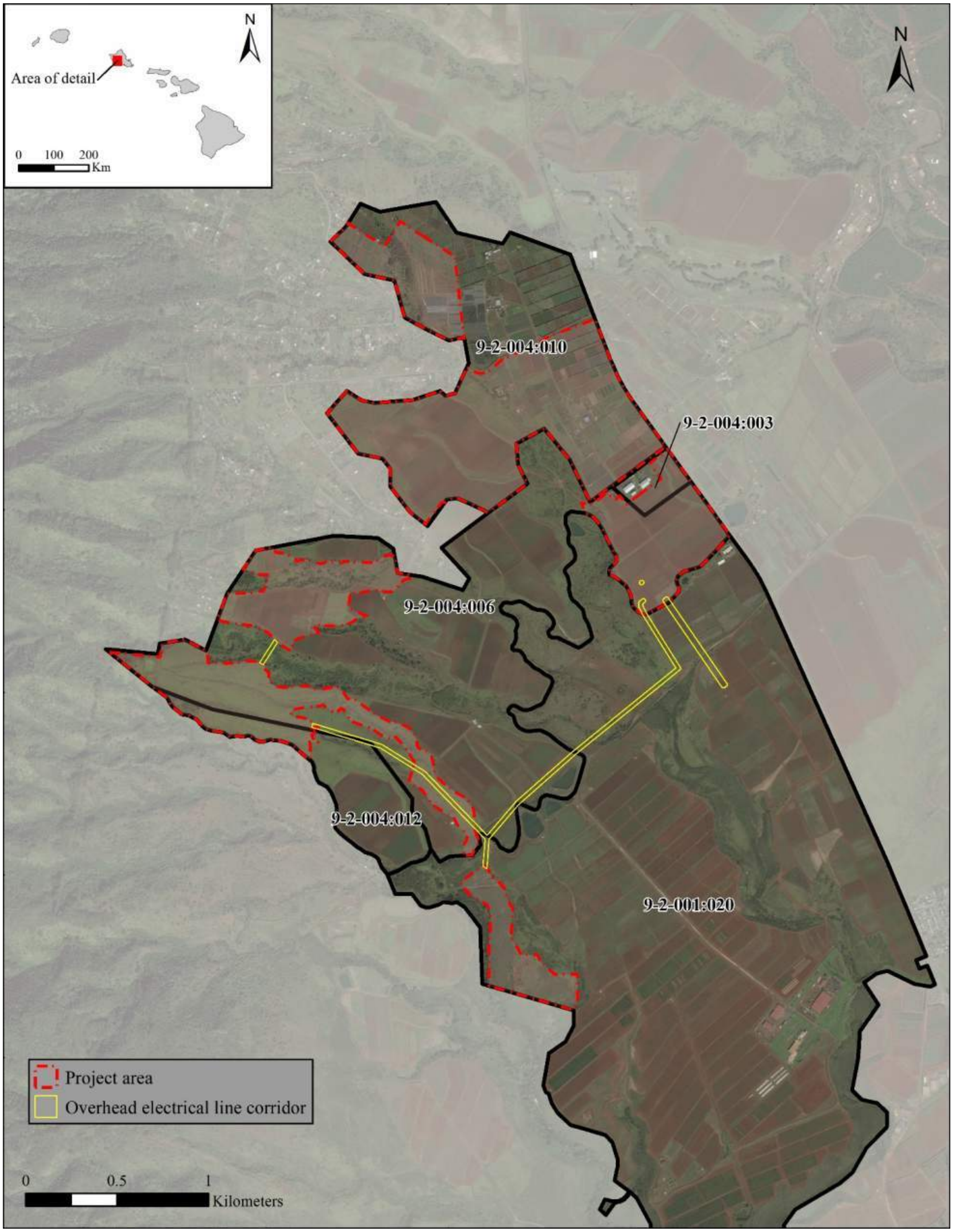


Figure 2. Tax Map Key (2) 2-5-001 showing location of current project area.

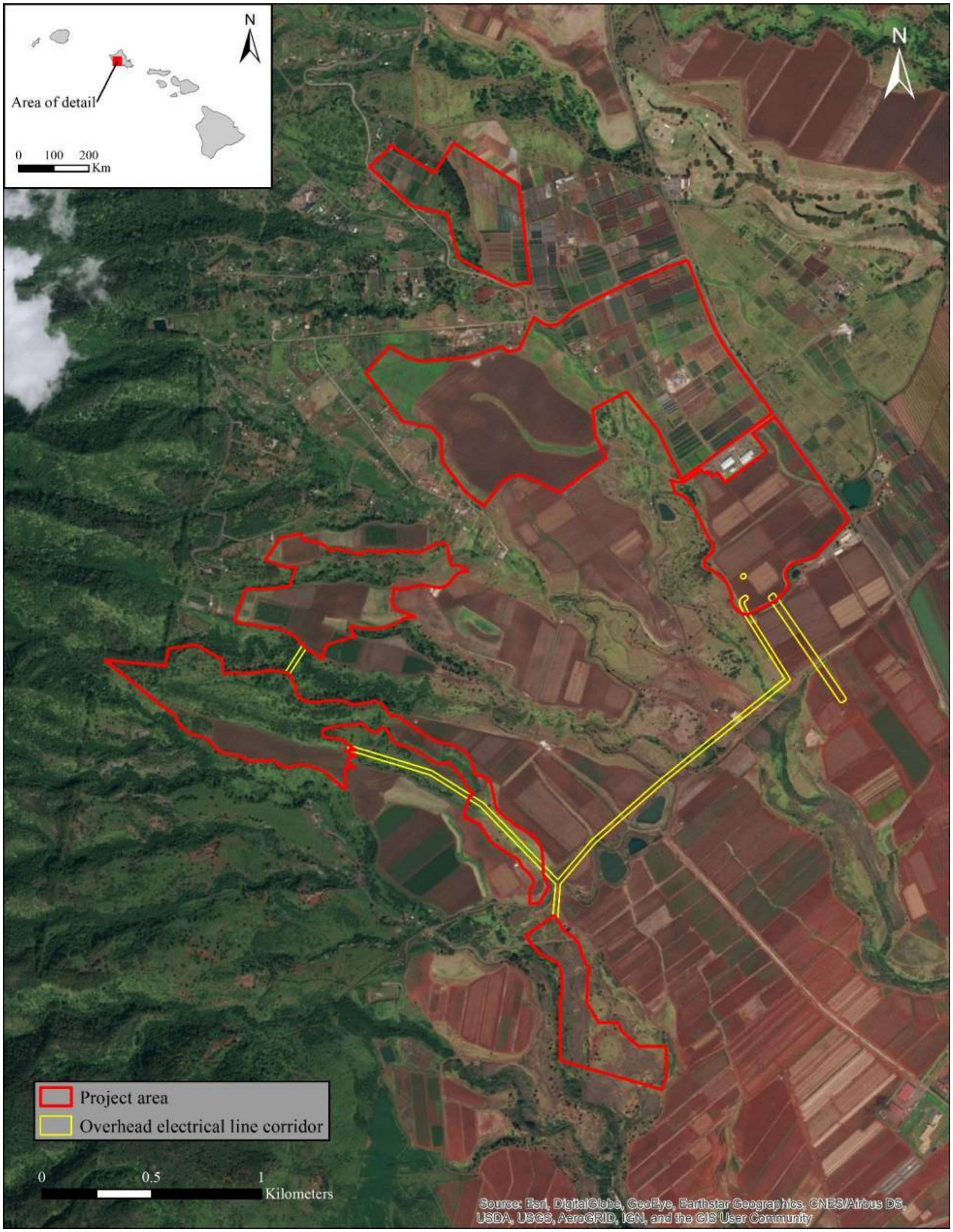


Figure 3. Recent satellite image showing the current project area.

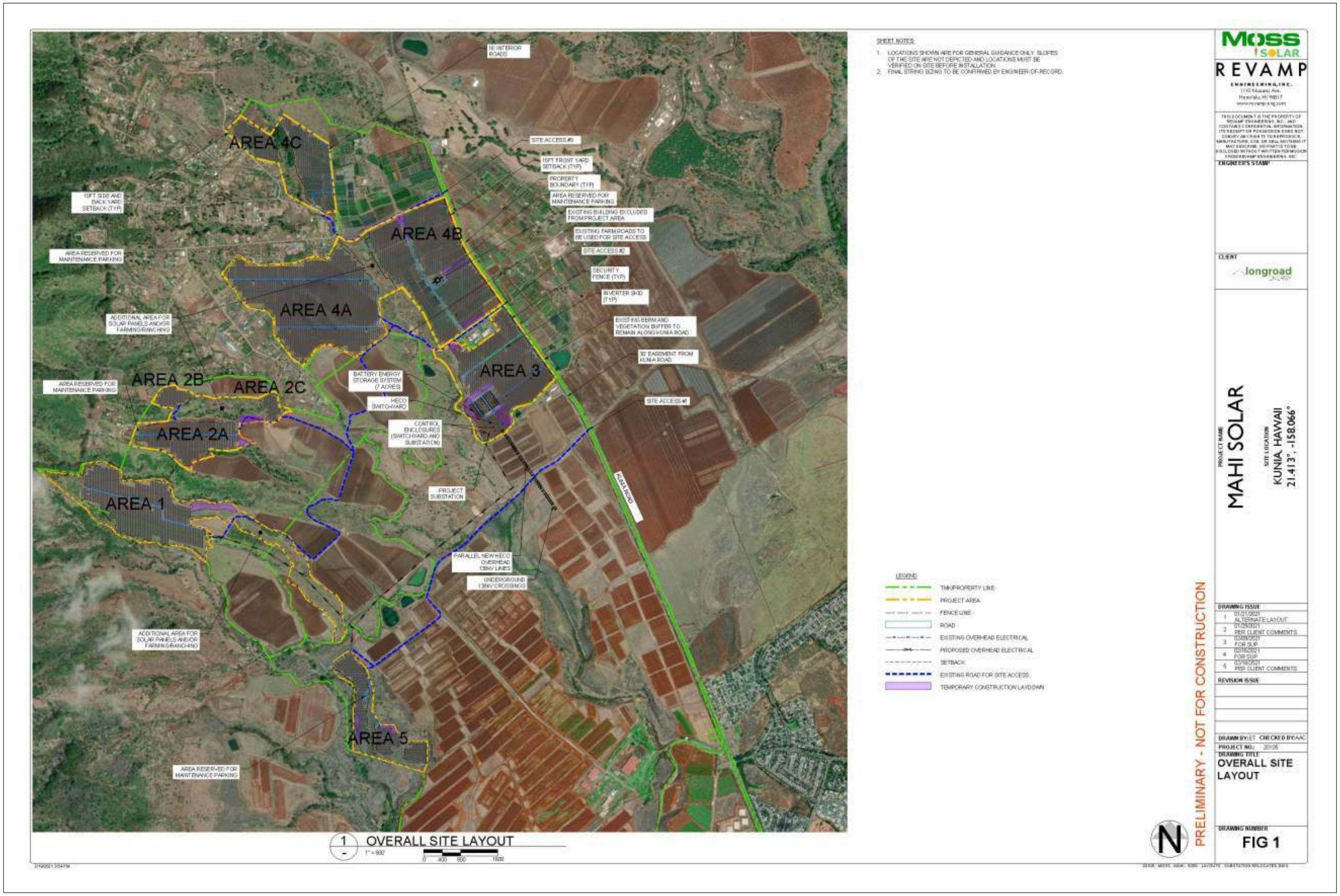


Figure 4. Development Plan.

PROJECT AREA DESCRIPTION

The proposed Mahi Solar project will occupy multiple locations within the five identified Tax map parcels (see Figure 2). The overall project area is surrounded by agricultural lands in all cardinal directions. Additionally, to the west of the project area, is the Honouliuli Forest Reserve and State of Hawai‘i-owned vacant preservation land; and to the south, the project area is bounded by land comprising the National Park Service Honouliuli National Historic Site. Elevation within the project area ranges from 525 feet in the Area 5 solar arrays to 1,230 feet in the Area 1 solar arrays (see Figure 36). Apart from one relatively short (roughly 500 feet) segment of overhead electrical lines connecting Areas 1 and 2A, all construction will occur within former and current agricultural fields.

Climate information provided by Giambelluca et al. (2014) indicates a mean annual rainfall in central portion of the project area of about 32 inches (812.8 millimeters), which is typically heaviest between October and March; and that the annual average daily air temperature ranges from 68.5° to 77.7°F, with January being the coldest and August being the warmest month. The underlying geology (Figure 36) of the project area has been identified primarily as Older alluvium (QTao) with a small section of younger Alluvium (Qa) and Koolau Basalt (QTkl) (Sherrod et al. 2007). The surface soils have been intensively mapped in the project area vicinity (Figure 6) and includes a variety of silty clay and silty clay loam soil series (Helemano silty clay [HLMG]; Kolekole silty clay loam [KuB, KuC, KuD]; Kunia silty clay [KyA, KyB, KyC]; and Mahina silty clay [McD2]), with minor distinctions based on percentage of slope.

Vegetation within the project area is variable, with some denuded areas (Figures 7 and 8), some areas under cultivation (Figure 9), some areas of former cultivation now covered with grass (Figure 10) and with stands of *koa haole* (*Leucaena leucocephala*) (Figure 11) and some area with a thick cover of Guinea grass (*Urochloa maxima*) (Figure 12). A recent biological resources study (Breeden et al. 2020) identified five vegetation regimes with the overall project area: 1) Cultivated croplands, 2) Fallow fields, 3) Grassland, 4) *Koa haole* forest, and 5) Non-native forest. Breeden et al. (2020:5) elaborate:

> . . . Cultivated croplands are dominated by corn (*Zea mays*), with sparse weedy vegetation such as koa haole (*Leucaena leucocephala*), golden crown-beard (*Verbesina encelioides*), and Guinea grass (*Urochloa maxima*). Fallow fields occur on level land that has recently been used for agriculture, and are dominated by greater than 95% Guinea grass, with occasional weedy vegetation such as koa haole, golden crown-beard, Formosan koa (*Acacia confusa*), and ‘uhaloa (*Waltheria indica*). Grasslands are also dominated by Guinea grass and occur on slopes, gulches, and other areas not recently used for agriculture. Koa haole forest is dominated by thickets of short-statured koa haole trees, with an understory dominated by Guinea grass or buffelgrass (*Cenchrus ciliaris)*. Non-native forest is made up usually of mixed non-native trees such as monkeypod (*Samanea saman*), Christmas berry (*Schinus terebinthifolius*), Formosan koa, and silk oak (*Grevillea robusta*), with an understory dominated by Guinea grass. Occasional stands of eucalyptus (*Eucalyptus* cf. *citriodora*) occur in several pockets in the study area, where thickets of these trees occur with an understory limited to bare ground or occasional Guinea grass.

Three native species were observed during the biological resources study (Breeden et al. 2020), and included a rare occurrence of a few individuals of *‘iliahialo‘e* (*Santalum ellipticum*), scattered individuals of wiliwili (*Erythrina sandwicensis*) in the dry lower gulches, and *‘Uhaloa* (*Waltheria indica*) was observed along roadsides throughout the project area.

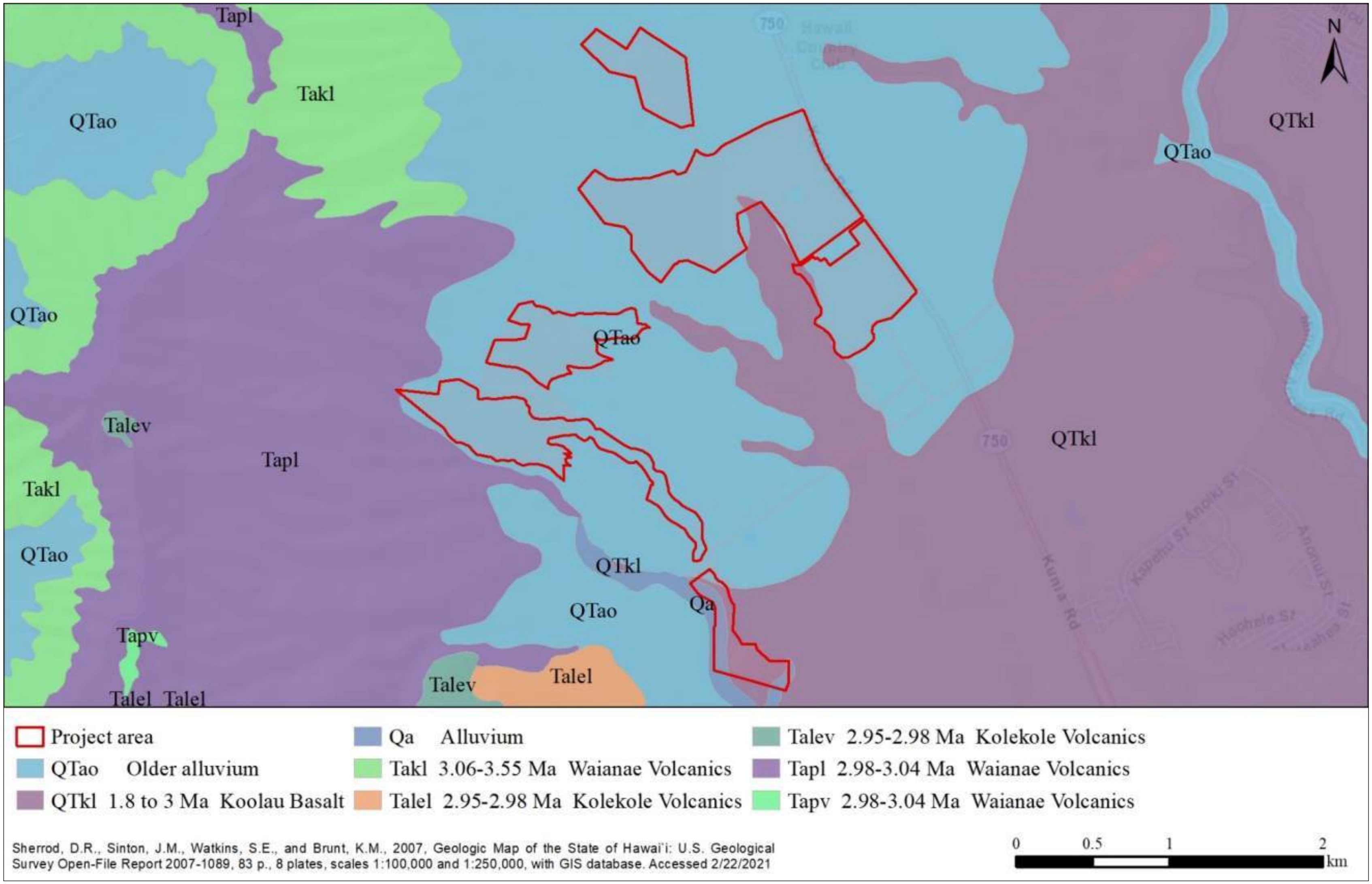


Figure 5. Geology in the current study area.

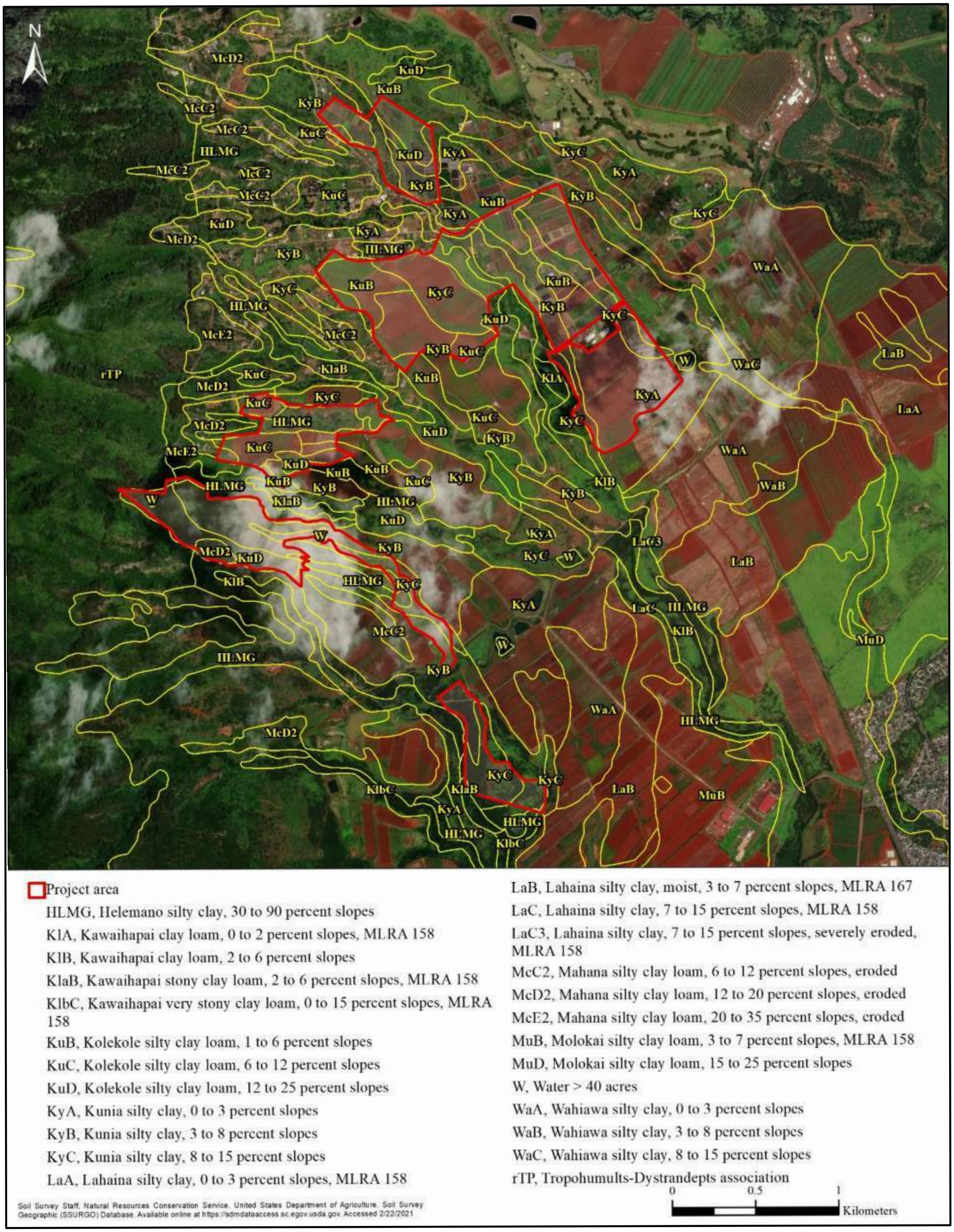


Figure 6. Soils in the current study area.

Figure 7. Bare ground surface within Area 5, view to the northwest.

Figure 8. Typical ground surface visibility in unused agricultural fields, view to the southwest.

Figure 9. Typical ground cover and vegetation in active corn fields, view to the southwest.

Figure 10. Typical ground cover and vegetation in fallow agricultural fields, view to the southeast.

Figure 11. Typical ground cover and vegetation in *koa haole* forest areas, view to the north.

Figure 12. Typical Guinea grass and non-native forest cover in gulch areas, view to the northwest.

2. BACKGROUND

To generate a set of expectations regarding the nature of archaeological resources that might be encountered within the current project area, and to establish an environment within which to assess the significance of any such resources, a general culture-historical context for the Honouliuli Ahupuaʻa and the greater ʻEwa District that includes specific information regarding the history of the current project area is presented. This is followed by a discussion of relevant prior archaeological studies conducted in the vicinity of the current project area.

CULTURE-HISTORICAL CONTEXT

The chronological summary presented below begins with the settlement of the Hawaiian Islands and includes a presentation of a generalized model of Hawaiian prehistory followed by a presentation of traditional place names in the current project area vicinity as a prelude to a discussion *moʻolelo* and settlement patterns in Honouliuli Ahupuaʻa and the greater ʻEwa District. The discussion shifts to a summary of historical events beginning with the arrival of foreigners in the islands and continues with the history of land use within the ʻEwa District. The summary includes a discussion of changing lifeways, a review of land tenure during the *Māhele ʻĀina* of 1848, and the subsequent transition into plantation life, military presence, and commercial agriculture.

A Generalized Model of Hawaiian Prehistory

While the question of the timing of the first settlement of Hawaiʻi by Polynesians remains unanswered, several theories have been offered that derive from various sources of information (i.e., genealogical, oral-historical, mythological, radiometric). However, none of these theories is today universally accepted because there is no archaeological evidence to support the proposed timing for the initial settlement, or colonization stage of island occupation. More recently, with advances in palynology and radiocarbon dating techniques, Kirch (2011) and others (Athens et al. 2014; Wilmshurst et al. 2011) have convincingly argued that Polynesians arrived much later in the Hawaiian Islands, sometime between a.d. 1000 and a.d. 1200 and expanded rapidly thereafter (c.f., Kirch 2011).

The initial settlement in Hawaiʻi is believed to have originated from the southern Marquesas Islands (Emory in Tatar 1982). During these early times, Hawaiʻi's inhabitants were primarily engaged in subsistence-level agriculture and fishing (Handy et al. 1991). This was a period of great exploitation and environmental modification when early Hawaiian farmers developed new subsistence strategies by adapting their familiar patterns and traditional tools to their new environment (Kirch 1985; Pogue 1978). Their ancient and ingrained philosophy of life tied them to their environment and kept order; which was further assured by the conical clan principle of genealogical seniority (Kirch 1984). According to Fornander (1969), the Hawaiians brought from their homeland certain universal Polynesian customs and belief: the major gods Kāne, Kū, and Lono; the *kapu* (taboo) system of law and order; cities of refuge; the *ʻaumakua* (family or person gods) concept; and the concept of *mana* (divine power).

The earliest inhabitants of the region emphasized the use of natural caves and overhangs, along with the construction of small, simple surface features for habitation purposes, but as populations increased and expanded, so did the occurrence of more permanent habitation structures in both the coastal and upland areas (Jensen 1994). A network of coastal and inland trails, over which the exchange of goods occurred, connected the coastal and upland population centers and resource areas (Hommon 1976). Over a period of a few centuries, the areas with the richest natural resources became populated and perhaps even crowded, and there was increasing separation of the chiefly class from the common people. As populations increased so did societal conflict, which resulted in hostility and war between neighboring groups (Kirch 1985). Soon, large areas of Hawaiʻi were controlled by a few powerful chiefs.

As time passed, a uniquely Hawaiian culture developed. The portable artifacts found in archaeological sites of this next period reflect an evolution of the traditional tools and distinctly Hawaiian inventions. The adze (*koʻi*) evolved from the typical Polynesian variations of plano-convex, trapezoidal, and reverse-triangular cross-section to a very standard Hawaiian rectangular quadrangular tanged adze. The two-piece fishhook and the octopus-lure breadloaf sinker are Hawaiian inventions of this period, as are ʻ*ulu maika* stones and *lei niho palaoa* (ivory pendant necklace). The latter was a status item worn by those of high rank, indicating a trend toward greater status differentiation (Kirch 1985). As the population continued to expand so did social stratification, which was accompanied by major socioeconomic changes and intensive land modification. Most of the ecologically favorable zones of the windward and coastal regions of all major islands were settled and the more marginal leeward areas were being developed. During this expansion period, additional migrations to Hawaiʻi occurred from Tahiti in the Society Islands. Rosendahl (1972) has proposed that settlement at this time was related to the seasonal, recurrent occupation in which coastal sites were occupied in the summer to exploit marine resources, and upland sites were occupied during the winter months, with a focus on agriculture. An increasing reliance on agricultural products may have caused a shift in social networks as well; as Hommon (1976) argues, kinship links between coastal settlements disintegrated as those links within the *mauka-makai* (mountain-sea) settlements expanded to accommodate the exchange of agricultural products for marine resources. This shift is believed to have resulted in the establishment of the *ahupua*ʻ*a* system sometime during the a.d. 1400s (Kirch 1985), which added another component to an already well-stratified society. The implications of this model include a shift in residential patterns from seasonal, temporary occupation, to the permanent dispersed occupation of both coastal and upland areas.

The *ahupuaʻa* became the equivalent of a local community, with its own social, economic, and political significance, which added another component to a then well-stratified society. *Ahupuaʻa* were ruled by *aliʻi ʻai ahupuaʻa* or chiefs who controlled the *ahupuaʻa* resources; who, for the most part, had complete autonomy over this generally economically self-supporting piece of land. *Ahupuaʻa* lands were in turn, managed by an appointed *konohiki* or lesser chief-landlord. The *aliʻi-ʻai-ahupuaʻa*, in turn, answered to an *aliʻi ʻai moku* (chief who claimed the abundance of the entire district). Thus, *ahupuaʻa* resources supported not only the *makaʻāinana* (commoners) and *ʻohana* (families) who lived on the land but also contributed to the support of the royal community of regional and/or island kingdoms. *Ahupuaʻa* are land divisions that typically incorporated all of the eco-zones from the mountains to the sea and for several hundred yards beyond the shore, assuring a diverse subsistence resource base (Hommon 1986). Although the *ahupuaʻa* land division typically incorporated all of the eco-zones, their size and shape varied greatly. This form of district subdividing was integral to Hawaiian life and was the product of resource management planning that was strictly adhered to. In this system, the land provided fruits and vegetables and some meat for the diet, and the ocean provided a wealth of protein resources (Rechtman and Maly 2003). In communities with long-term royal residents, divisions of labor (with specialists in various occupations on land and in the procurement of marine resources) were also strictly enforced.

Honouliuli Ahupuaʻa

The current project area is located within the *ahupuaʻa* (traditional land division) of Honouliuli (Figure 13), which has been translated by Pukui et al. (1974:51) as "dark bay" and may refer to the deep waters of Ka-ihu-o-Palaʻai, known today as West Loch of Pearl Harbor (McElroy et al. 2013). The *inoa ʻāina* (place names) within a particular *ahupuaʻa* or broader region evidences the long-term relationship of various communities to their immediate environment. Although there is no word for "environment" in the Hawaiian language, there are other proximate terms, including "ʻano o ka nohona" (a person's relationship to their surroundings) and "nā mea e hoʻopuni ana" (the things in a person's environment that surrounds them) (Oliveira 2014:64). The following paragraphs contain a presentation of *inoa ʻāina* that were compiled from several map collections including Department of Accounting and General Services Hawaiʻi Registered Maps (RM), and the United State Geological Survey (USGS) that speak to Hawaiian relationships to their immediate environment. The earliest maps found in these collections date back to the 1870s. In addition to maps, *inoa ʻāina* are recorded and recounted in a variety of Hawaiian oral arts including, *oli* (chants), *mele* (songs), *moʻolelo* (stories), *nane* (riddles), and *ʻōlelo noʻeau* (proverb and poetical expressions). Since the introduction of the written language, place name information has been recorded in ethnographic surveys, historic maps, and a number of early historical documents including *Māhele ʻĀina* records and Boundary Commission testimonies. Kikiloi (2010:75) asserts that the recovery of traditional place names "help to transform once-empty geographic spaces into cultural places enriched with meaning and significance." In lieu of a comprehensive list of the hundreds of *inoa ʻāina* that are found in Honouliuli, place names within the immediate project area are listed in Table 1 and discussed below.

Ekahanui is the name of a gulch north of the project area. The name "Ekahanui" can either be translated as "large *ʻēkaha"* (*Asplenium nidus*) or "many *ʻēkaha.*" Known more commonly as bird's nest fern, *ʻēkaha* is typically found growing between the elevations of 1,000-3,000 feet on larger boulders and trees (Hillebrand 1888). The young shoots of the *ʻēkaha*, mixed with other medicinal plants into a poultice, were used to treat an array of ailments such as ulcers and sores (Kaaiakamanu and Akina 1922:22-23). The naming of the gulch as Ekahanui may allude to an abundance of *ʻēkaha* in the area at one time. No further information could be found at this time to verify this claim.

Huliwai, translated as "turning waters," is the name of a gulch north of the project, beyond Ekahanui gulch. No further information could be found about this place name.

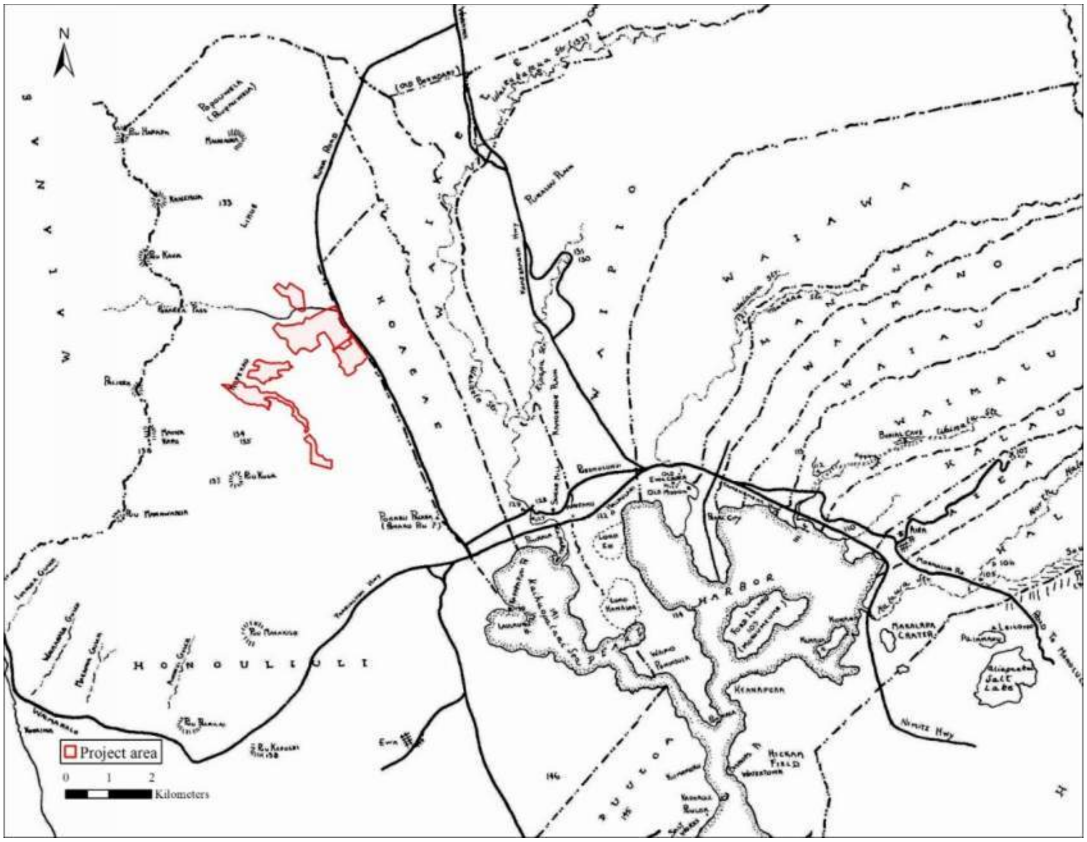


Figure 13. ‘Ewa district with showing *ahupua‘a*, current project area in red (Sterling and Summers 1978).

Table 1. *Inoa ‘āina* in the immediate project area vicinity.

Inoa ‘Aina	*Notes*	*Reference Map*	*Interpretation*
Ekahanui	Gulch located north of the project area	Alexander 1873 (RM405)	*‘ēkaha-nui:* large *‘ēkaha* (*Asplenium nidus*) or many *‘ēkaha*
Huliwai	Gulch located north of the project area	Alexander 1873 (RM405)	*huli-wai:* turning waters
Kaaikukai/ Kaaikukui	Gulch. Soehren (2011) notes that the name is not Kaaikukai but Kaaikukui	USGS 1998	*Ka-‘ai-kūkai:* The food frequently dipped in the sea or excrement eater *Ka-‘ai-kukui: Kukui* (*Aleurites moluccana*) eater
Kupehau	Land where project area is located	Alexander 1873 (RM405)	*kupe-hau: hau* (*Hibiscus tiliaceus*) canoe end piece
Palawai	Gulch west of the project area	USGS 1998	*Palawai:* bottom lands or *Pālāwai:* a type of freshwater *limu* (algae)
Puu Kuina	*Heiau* located in Kaaikukai/Kaaikukui Gulch	McAllister 1930	*Pu‘u Ku‘ina:* pounding hill or *Pu‘u Kuina:* joining hill
Puu Kuua	Hill and Heiau south of the project area	Alexander 1873 (RM405)	*Pu‘u Ku‘ua:* relinquished hill or hill where octopus lure stones are found
Puu Moopuna/ Namoopuna	Hill near Puu Kuua	USGS 1998	*Pu‘u-mo‘opuna:* Granchild Hill *Nā-mo‘opuna:* the grandchildren

Kaaikukai/Kaaikukui is a gulch located south of the project area and Palawai gulch. According to Soehren (2010), the proper name spelling is Kaaikukui, which translates to "*kukui* (*Aleurites moluccana*) eater." *Kukui*, commonly known as candlenut, served a number of purposes. The oily nut found within the hard black shell was used as a lamp and at times the nut was slow roasted then crushed with *pa'akai* (salt) to make the relish/seasoning known as *inamona* (Abbott 1992). The oily properties of this nut were also used medicinally as a laxative to helped expel waste from in the body (Abbott 1992). Hawaiian plant expert, Isabella Abbott further notes that "[a]ll parts of the tree—flowers, fruits (nuts), bark, and leaves—can be used for these purposes" (Abbott 1992:100). Fresh *kukui* leaves were prepared into a poultice and used to treat swelling, deep bruises, and other injuries. Red pigment was also extracted from the bark of old *kukui* trees and from this pigment a reddish color was produced that was used to dye *kapa* cloth and fishnets (Abbott 1992). The hard-black shells were also strung together into lei. It is within and along the edges of the old *kukui* forests that another agricultural method termed *pā kukui* or *pā kuikui* was practiced. Handy et al. write:

> In localities where planting was done along the edges and within the borders of old kukui forests, notably on the lower slopes of the Hamakua coast of Hawaii before the forest were cleared for sugar-cane plantations, taro was planted in clearings termed pa kukui or pa-kuikui. The trees were felled and allowed to decompose. The kukui rots very quickly when wet, and wood, bark, and foliage make rich humus. Large holes were then dug in the soil and filled with kukui leaves, and when these were decomposed the taro was planted. The plants are said to have grown luxuriantly in such localities, to a height of 7 feet and with corms weighing 20 pounds. (Handy et al. 1991:109-110)

Kukui also carried important spiritual significance and was seen as an identifier for the domain of the pig-deity Kanepua'a or Kamapua'a, who was understood to be an embodiment of the deity Lono (Handy et al. 1991). Both names (Kaaikukai and Kaakukui) are provided here since Kaaikukai, translated either as "the food frequently dipped in the sea" or "excrement eater," is a name that continues to appear in numerous records.

As indicated on Hawai'i Registered Map No. 405 (Figure 14), Kupehau is the name of the land area in which the proposed project area is located. Although there are other places known as Kupehau in Kalihi-uka on O'ahu as well Kohala on Hawai'i Island, the historical references to these areas should not be confused with the Kupehau within Honouliuli. There are few sources that discuss or mention the Kupehau in Honouliuli. One source refers to Kupehau in poetic terms as a place where cold mists gather (Kapena 1862). Another discusses Kupehau as the name of a wind of the Wai'anae region (Kapihenui 1862a). In 1936, Charles Sheldon Judd noted that a single fine specimen of *'iliahi* (*Santalum freycinetianum*) grew in along a ridgeline in Kupehau, a remnant of a larger forest that once existed in the area (Judd 1936). Translated, Kupehau means "*hau* (*Hibiscus tiliaceus*) canoe end piece." Krauss (1993:50) notes that "the end pieces, usually made from the wood of the breadfruit tree, helped prevent the entrance of seawater into the canoe; they were specifically designed planks for each side of the fore and aft sections of the hull." Typically, the light wood of the *hau* tree was used to make canoe outriggers and floats. The cordage that is produced from *hau* bark served as excellent lashing for canoes as well.

Palawai is a gulch west of the project and north of Kaaikukai/Kaaikukui. The name can either be interpreted as Palawai, which is a term used to describe "bottom lands," or Pālāwai, which is the name for a variety of freshwater *limu* (algae, seaweed).

Puu Kuina was a *heiau* that McAllister (1933) reported as being once located in Kaaikukai/Kaaikukui gulch and possibly destroyed. No further information could be found about the site. Two possible interpretations of the *inoa 'āina* are "pounding hill" (*Pu'u Ku'ina*) or "joining hill" (*Pu'u Kuina*).

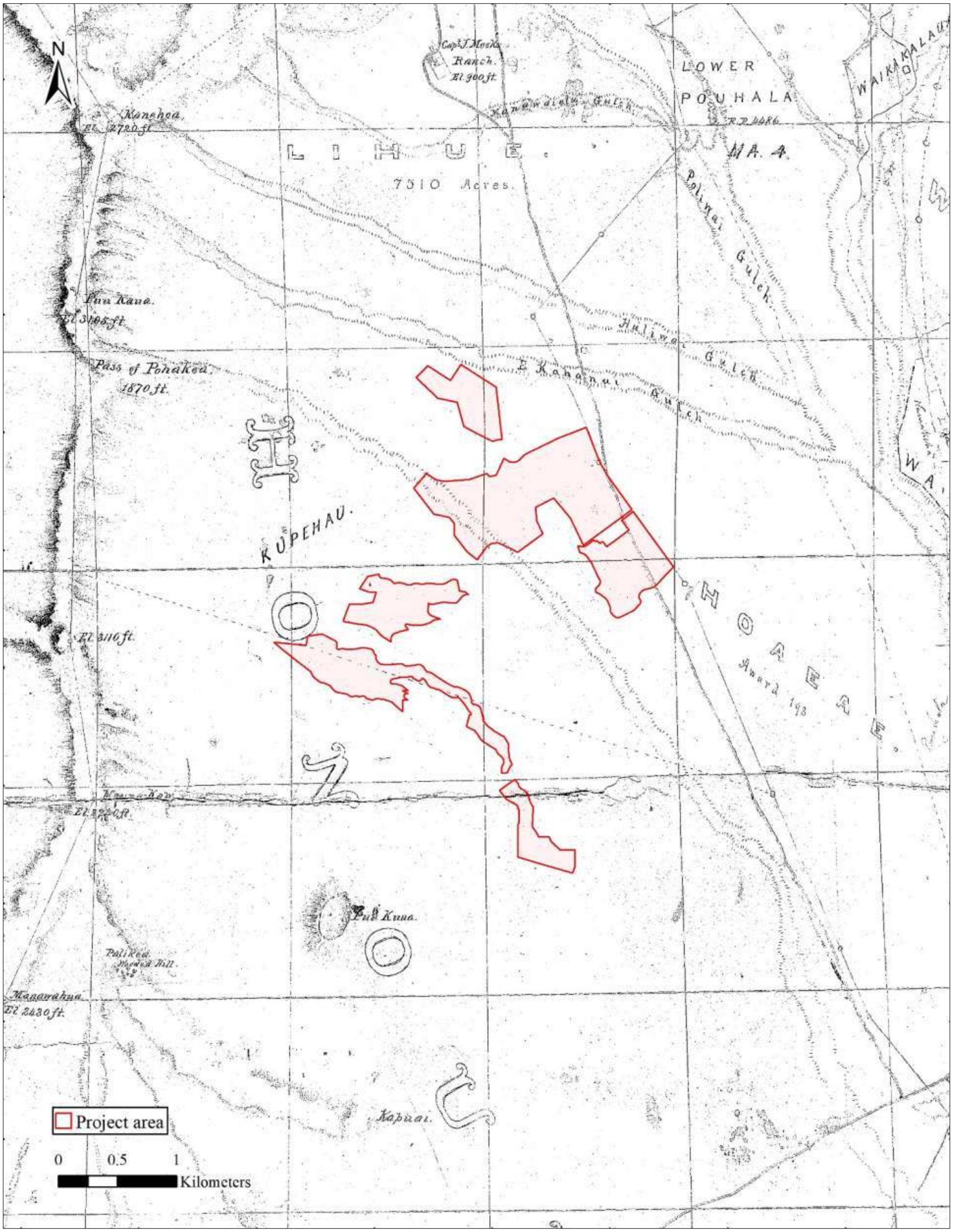


Figure 14. The 1873 Hawai‘i Registered Map No. 405 by W. D. Alexander of Honouliuli Ahupua‘a showing the project area and the location of *Kuleana* lands (Department of Accounting and General Services).

Puu Kuua is a hill as well as the site of a *heiau* (ceremonial temple) located immediately south of the project area. Oftentimes translated as "relinquished hill," Puu Kuua is also said to be a place where Pele's sister, Kapōʻulakīnaʻu, left her *kohe lele* (flying vagina) for sometime (Pukui et al. 1974:200). McAllister in Sterling and Summers (1978:32) notes that the *heiau* was destroyed and "that portion of the heiau which has not been cleared for pineapple has been planted in ironwoods." Early in the reign of Kamehameha III, the lands surrounding Puu Kuua were populated enough for the government to erect a schoolhouse (Kamakau 1869). The *aliʻi* named Manuia was also noted as a resident of Puu Kuua prior to his departure with his relative, the *aliʻi* Boki, to the New Hebrides in search of sandalwood (Kapihenui 1862a:1). Puu Kuua is also mentioned in passing in numerous *oli* (chants) and *mele* (song) along with other prominent places within the *ahupuaʻa* of Honouliuli that appear in *moʻolelo* (legendary accounts) such as Hiʻiakaikapoliopele, Aʻahoaka, and Kalelealuakā (Kapihenui 1862b:4; Kaualilinoe 1870:1; Kuokoa 1877:1). A short story regarding the chiefs who once lived in Puu Kuua is provided in Sterling and Summers (1978:32-33). The source of the story is derived from "Na Wahi Pana o Ewa i Hoonalowaleia i Keia Wa a Hiki Ole Ke IkeIa" (The Famed Places of ʻEwa That Are Now Lost And Cannot be Seen), a serialized account documenting the travels of the gods Kāne and Kanaloa throughout the district of ʻEwa published in the newspaper *Ka Loea Kalaiaina* in 1899. When Kāne and Kanaloa reached Puu Kuua on their journey, the author of "Na Wahi Pana" recounted a tale associated with the area:

> The chiefs of old, who lived at that time, were of divine descent. The two gods looked down on the hollow and saw how thickly populated it was. The mode of living here was so that chiefs and commoners mixed freely and they were so like the lowest of people (Kauwā). That was what these gods said and that was the time when the term kauwā was first used, and was used for many years afterwards.
>
> After the first generations of chiefs had passed away and their descendants succeeded them, a chiefess became the ruler. It was customary for the chiefs of Oahu to visit this place to see the local chiefs. They did this always. When the time came in which a new chiefess ruled, an armless chiefess, she ran away to hide when other chiefs came to visit as usual because she was ashamed of her lack of an arm. Because she was always running away because of being ashamed the chiefs that visited her called her the low-born (kauwā). Thus the term remaiend in the thoughts down to this enlightened period. She was not truly a kauwā but was called that because she behaved like one. This was how they were made to be kauwās. When the ruling chief wished to go to Waikiki for sea bathing he asked the chief just below him in rank, "how are my planting places at Puu-Kuua, have they not produced young suckers?" The chief next to him answered, "There are some suckers," and sent someone for them. When the men, women and children least expected it, the messenger came to get some of the children. The father stood up and took his sons to Waikiki. Then when the ruling chief went sea bathing, he sent an attendant to get the boys and take them to a shallow place where the ruling chief would come. Then the ruler placed a hand on each of the boys, holding them by the necks. The words he uttered were, "My height has not been reaches!" (Aole i pau kuu loa, aole i pau kuu loa). He advanced and held on to the boys until the sea was up to his chest. The boys floated on the water face down. The father on shore called out, "Lie still in the sea of your Lord," and so on.
>
> The sea of Waikiki is said to have been used to kill men in and the other place is Kualoa. The inhabitants of Puu-Kuua were so mixed, like taro beside an imu.
>
> There were two important things concerning this place. (1) This place is entirely deserted and left uninhabited and it seems that this happened before the coming of righteousness to Hawaii Nei. Not an inhabitant is left. (2) The descendants of the people of this place were so mixed that they were all of one class. Here the gods became tired of working and returned to Kahiki. (Sterling and Summers 1978:32-33).

The value of this story is that it recounts how Puu Kuua was a densely populated area in the past. It was inhabited and frequently visited by members of the *aliʻi* class. Furthermore, the *moʻolelo* identifies Puu Kuua as the place where the term *kauwā* (servant) was first used.

Puu Moopuna/Namoopuna is a hill located south of the project area and near Puu Kuua. Puu Moopuna translates to "grandchild hill" and Namoopuna means "the grandchildren." No further information could be found regarding this *inoa ʻāina.*

Honouliuli is the largest *ahupuaʻa* of Oʻahu and the westernmost within the ʻEwa District (see Figure 13). This *ahupuaʻa* extends from the emerged coral reef known as the ʻEwa Plain that comprises the southwestern extent of Oʻahu and runs along the windward side of the southern extent of the Waiʻanae Mountain Range (see Figure 13).

According to Handy and Handy (1972:469), the traditional *moku* (district) of ʻEwa "consisted of both seaward and high interior plains, the deep valleys of the Koʻolau mountain range, and the coastal region of the Waiʻanae range to the northwest." The name ʻEwa translates literally as "crooked" (Pukui et al. 1974:28), and according to Sterling and Summers (1978) the naming of this district is attributed to the male deities, Kāne and Kanaloa while attemping to survey the district boundaries:

> When Kane and Kanaloa were surveying the island they came to Oahu and when they reached Red Hill saw below them the broad plains of what is now Ewa. To mark the boundaries of the land they would throw a stone and where the stone fell would be the boundary line. When they saw the beautiful land lying below them, it was their thought to include as much of the flat level land as possible. They hurled the stone as far as the Waianae range and it landed somewhere in the Waimanalo section. When they went to find it, they could not locate the spot where it fell. So Ewa (strayed) became known by that name. The stone that strayed (Sterling and Summers 1978:1).

In citing the remander of this story as told to Sterling by Mr. Simeon Nawaʻa in 1954:

> Eventually the stone was found at Pili o Kahe. This is a spot where two small hills of the Waianae range come down parallel on the boundary between Honouliuli and Nanakuli (Ewa and Waianae). The ancient Hawaiian said the hill on the Ewa side was the male and the hill on the Waianae side was female. The stone was found on the Waianae side hill and the place is known as Pili o Kahe (Pili = cling to, Kahe = to flow*). The name refers, therefore, to the female or Waianae side hill. And that is where the boundary between the two districts runs. (Sterling and Summers 1978:1)

In providing a geographical description of the district, Handy and Handy state that:

> The salient features of ʻEwa, and perhaps its most notable point of difference, is its specious coastal plain, surrounding the deep bays ("lochs") of Pearl Harbor, which are acutally the drowned seaward valleys of ʻEwa's main streams, Waikele and Waipiʻo. The Hawaiian name Pearl Harbor was Ke-awa-lau-o-Puuloa, The-many (*lau*)-harbors (*awa*)-of Puʻuloa. Puʻuloa was the rounded area projecting into the sea at the long narrow entrance of the harbor. Another and more poetic name was Awawa-lei, Garland (*lei*)-of-harbors. The English name "Pearl" was given to it because of the prevalence of pearl oysters (*pipi*) in the deep harbor waters. (Handy and Handy 1972:469)

As a district, ʻEwa contains a diversity of environments. Well-watered lands are found along the central and eastern limits and many of these *ahupuaʻa* names are associated with *wai* (water) originating from the Koʻolau Mountains including, Waikele, Waipiʻo,Waiawa, Waimano, Waiau, and Waimalu (see Figure 13). The western extent of the district, which includes the subject *ahupuaʻa* of Honouliuli, is situated along the southeastern limits of the Waiʻanae Mountain Range and includes the ʻEwa plains which has been characterized in traditional and historic literature as arid. ʻEwa also known for its red earth is highlighted in *ʻōlelo noʻeau* (poetical expressions):

> *ʻĀina koi ʻula i ka lepo.*
> Land reddened by the rising dust.
> Said of ʻEwa, Oʻahu. (Pukui 1983:11)
>
> *O ʻEwa, ʻāina kai ʻula i ka lepo.*
> ʻEwa, land of the sea reddened by earth.
> ʻEwa was once noted for being dusty, and its sea was reddened by mud in time of rain. (Pukui 1983:257)

In an article published in the *Honolulu Star-Bulletin* on October 16, 1956, Mr. Simeon Nawaa clarified the extent of the ʻEwa district. That portion of his article which describes the ʻEwa district reads:

> The northern boundary of Ewa begins from the top of Kaala mountain and running towards Koolau mountain range, passing Wahiawa and Halemano; along this mountain range to Moanalua, thence to Keehi lagoon, passing Kapukaki (Red Hill). From the west of Honolulu Airport near Kapuaikaula (Fort Kamehameha), it runs to Barber's Point, thence to Piliokahe; from Piliokahe along Kaala mountain range to the beginning, comprising the following tracts of land: Halawa, Aiea, Kalaauao, Waimalu, Waiau, Waimano, Manana (Pearl City), Waiawa, Waikele, Hoaeae, Honouliuli and including Waikakalaua, Schofield Barracks, Wahiawa and Halemano. (Nawaa in Sterling and Summers 1978:1)

It is within this landscape that a great number of traditional accounts have been recorded. Having an understanding of these accounts helps to understand the layers of cultural meaning and value that have been ascribed to this very landscape.

Traditional Mo'olelo of Honouliuli

A great number of *mo'olelo* (story, myth, history, tradition, legend) that feature 'Ewa have been recorded and many of these accounts are centered around the seaward area known as Pu'uloa (see Figure 13), translated as "long hill." The lochs of this area were known traditionally as Ke-awa-lau-o-Pu'uloa (Pukui et al. 1974:201). West Loch, traditionally known as Ka-ihu-o-Pala'ai (see Figure 13), was a culturally significant area of Honouliuli Ahupua'a (Pukui et al. 1974). It was on the west end of Ka-ihu-o-Pala'ai along Honouliuli Stream that Honouliuli's prime taro lands, fishponds, and salt production areas were located (see Figure 13).

Concerning traditional *mo'olelo*, it is believed that the first *'ulu* (breadfruit) planted in the Hawaiian Islands was brought from Upolu, Samoa and planted at Pu'uloa in 'Ewa by Kaha'i (Fornander 1916-1917), the grandson of the great navigator and *ali'i nui* Mo'ikeha (Emerson 1893). In another story about Pu'uloa, Hawaiian Historian Samuel Kamakau recounts the legend of a *mo'o* (a shape-shifting water lizard) called Kanekua'ana who came from Kahiki and brought bounties of fish and bivalves with her which she gifted to the people of 'Ewa. According to Kamakau (1964:83), "Kanekua'ana was the *kia'i* [guardian]of 'Ewa, and the *kama'aina* from Halawa to Honouliuli relied upon her. Not all of the people of 'Ewa were her descendants, but the blessings that came to her descendants were shared by all..." According to Moses Manu's story of Keaomelemele, the *pipi* was brought to Hawai'i from the godly lands of Kuaihelani and Kealohilani by the matriach *mo'o* (water spirit) Mo'oinanea (Manu 2002). Manu goes on to explain how Kanekua'ana became the caretaker of the *pipi* of 'Ewa:

> Kanekuaana was a royal lizard whose home was the lochs of Ewa. This lizard who was said to have brought the pearl oysters to the sea of Ewa and this was the oyster that was referred to as "the silent 'fish' of Ewa; do not speak lest a wind arise." Many chants have been made with reference to the pearl oyster. In resididng there, this lizard was cared for and worshipped by the people for bringing the pearl oyster...From that time it was much found in Ewa up to recent years, about 1850-1853, the time when this race [Hawaiians] of people were being destroyed by smallpox. The oysters began to vanish from that time to the present. The people of the place believed that the lizard was angry because the konohikis [landlords] imposed kapus [prohibitions], were cross with the women and seized their catch of oysters. So this "fish" was removed to Tahiti and other lands. (Manu 2002:161)

Some of 'Ewa's most famed *mo'olelo* are those associated with the named *manō* (sharks) that protected the people of this land and engaged in epic battles against sharks from the outer island, including the famed chiefess *manō*, Ka'ahupahau, her brother Kahi'ukā, Kamoawa, and many others (Sterling and Summers 1978). Some have reported that Ka'ahupahau resided "in a great cavern on the Honouliuli side of the harbor" (Advertiser 1956a:11), however she was know to frequent other lands in 'Ewa including Waipahu, a spring in Waikele and Waimano (Pukui et al. 1974). Historian, Joseph Emerson explains that "...they [sharks] became the special object of worship for the people of the districts of Ewa and Waianae, with whom they maintained the pleasantest relations" (Emerson in Pukui and Green 1995:41).Several *'ōlelo no'eau* commemorate Ka'ahupahau's role in the history of 'Ewa:

> *Alahula Pu'uloa, he alahele na Ka'ahupāhau.*
>
> Everywhere in Pu'uloa is the trail of Ka'ahupāhau.
>
> Said of a person who goes everywhere, looking, peering, seeing all, or of a person familiar with every nook and corner of a place. Ka'ahupāhau is the shark goddess of Pu'uloa (Pearl Harbor) who guarded the people from being molested by sharks. She moved about, constantly watching. (Pukui 1983:14)
>
> *Ho'ahewa na niuhi ia Ka'ahupāhau.*
>
> The mandating sharks blamed Ka'ahupāhau.
>
> Evil-doers blame the person who safeguards the rights of others. Ka'ahupāhau was the guardian shark goddess of Pu'uloa (Pearl Harbor) who drove out or destroyed all the man-eating sharks. (Pukui 1983: 108)
>
> *Mehemeha wale no o Pu'uloa, i ka hele a Ka'ahupāhau.*
>
> Pu'uloa became lonely when Ka'ahupāhau went away.
>
> The home is lonely when a loved one has gone. Ka'ahupāhau, guardian shark of Pu'uloa (Pearl Harbor), was dearly loved by the people. (Pukui 1983:234)

Among the marine resources treasured by the people of ‘Ewa, were the various bivalves found in the waters of Ke-awa-lau-o-Pu‘uloa. This included the famed *pipi* or pearl oysters, from which the name Pearl Harbor is derived, as well as *pāpaua*, *‘owā‘owaka*, *nahawele*, *kupekala*, and the *mahamoe* (Pukui in Sterling and Summers 1978). According to Kamakau (1964:83) the *pipi* were so abundant that it was "...enough for all ‘Ewa." Kamakau goes on to add that:

> The *pipi* (pearl oyster)—strung along from Namakaohalawa to the cliffs of Honouliuli, from the *kuapa* fishponds of inland ‘Ewa clear out to Kapakule. That the oyster that came in from deep water to the mussel beds near shore, from the channel entrance of Pu‘uloa to the rocks along the edges of the fishpnds... (Kamakau 1964:83)

According to Mary Kawena Pukui, the *pipi* was introduced by the *mo‘o* Kanekua‘ana (in Sterling and Summers 1978). It is from the *pipi* that several *‘ōlelo no‘eau* specific to ‘Ewa are derived:

> *E hāmau o makani mai auane‘i.*
>
> Hush, lest the wind arise.
>
> Hold your silence or trouble will come to us. When the people went to gather pearl oysters at Pu‘uloa, they did so in silence, for they believed that if they spoke, a gust of wind would ripple the water and the oysters would vanish. (Pukui 1983:34)
>
> *Ka i‘a hāmau leo o ‘Ewa.*
>
> The fish of ‘Ewa that silences the voice.
>
> The pearl oyster, which has to be gathered in silence. (Pukui 1983:145).
>
> *Ka i‘a kuhi lima o ‘Ewa.*
>
> The gesturing fish of ‘Ewa.
>
> The *pipi*, or pearl oyster. Fishermen did not speak when fishing for them but gestured to each other like deaf-mutes. (Pukui 1983:148)
>
> *Haunāele ‘Ewa i ka Moa‘e.*
>
> ‘Ewa is disturbed by the Moa‘e wind.
>
> Used about something disturbing, like a violent argument. When the people of ‘Ewa went to gather the *pipi* (pearl oyster), they did so in silence, for if they spoke, a Moa‘e breeze would suddenly blow across the water, rippling it, and the oysters would disappear. (Pukui 1983:59)

While the *pipi* is celebrated resources of ‘Ewa, so to are certain fish species including the *nehu* (anchovy; *Stolephorus purpureus*) and *‘o‘opu* (general name for fishes included in the families Eleotridae, Gobiidae, and Blennidae), as shown in the following *‘ōlelo no‘eau*:

> *He kai puhi nehu, puhi lala ke kai o ‘Ewa.*
>
> A sea the blows up *nehu* fish, blows up a quantity of them, is the sea of ‘Ewa. (Pukui 1983:74).
>
> *Ke kai he‘e nehu o ‘Ewa.*
>
> The sea where the *nehu* come in schools to ‘Ewa.
>
> *Nehu* (anchovy) come by the millions into Pearl Harbor. They are used as bait for fishing, or eaten dried or fresh. (Pukui 1983:185)
>
> *Ka i‘a mili i ka poho o ka lima.*
>
> The fish fondled by the palm of the hand.
>
> When it was the season for the *hinana* (*‘o‘opu* spawn), they were so numerous that they could be scooped up in the palm of the hand. (Pukui 1983:149)

While many of the *mo‘olelo* of ‘Ewa are centered around its coastal area, the *mo‘olelo* of Honouliuli often focus on the *ali‘i* and the upland areas including prominent geological features found along the south and southeastern extent of the Wai‘anae Mountain Range, and the *kula* (plain) lands. The following paragraphs are a summary of *mo‘olelo* specific to Honouliuli.

Ka Moʻolelo O Hiʻiakaikapoliopele

A *moʻolelo* that features Honouliuli is that of Pelehonuamea's younger sister, Hiʻiaka-i-ka-poli-o-Pele (Hiʻiaka). Hiʻiaka made an epic journey from Puna on Hawaiʻi Island to the island of Kauaʻi to fetch her sister's lover, Lohiʻauipo. While at least a dozen versions of this *moʻolelo* have been published historically, the version utilized in this study was published by an author under the pen name of Hoʻoulumāhiehie. Hoʻoulimāhiehie's account was originally published in the Hawaiian language newspaper *Ka Naʻi Aupuni* between the years 1905-1906 and was compiled, transcribed, translated, and published in a double volume (one in Hawaiian and the other in English) by Hawaiian language scholar, Puakea Nogelmeier. According to Nogelmeier, it is believed that Hoʻoulumāhiehie was the pen name of the famed 19th-century writer/politician Joseph Mokuʻōhai Poepoe who served as the editor of several Hawaiian language newspapers including *Ka Naʻi Aupuni* (Hoʻoulumāhiehie 2006b). Hiʻiaka's journey through Honouliuli is of particular importance due to the various culturally significant places, some of which are viewable from the project area, endemic plant varieties, and traditional cultural practices that are mentioned.

While on her return trip from Kauaʻi, Hiʻiaka, Lohiʻau, and her companion, Wahineʻōmaʻo, stopped in the Waiʻanae District before heading towards Kou (the ancient name of Honolulu before 1800; Pukui et al. 1974). While Lohiʻau and Wahineʻōmaʻo traveled by canoe from Pōkaʻi in Waiʻanae to Kou, Hiʻiaka traveled by foot, entering ʻEwa from the heights of Pōhākea—a passage northwest of the project area—(see Figure 13) then across the plain of Honouliuli. From Pōhākea, she descended to Keahuamoa—a land area north of the project area—where she encountered several women gathering *maʻo* (*Gossypium tomentosum*, an endemic yellow-flowered hibiscus) blossoms from which they were making *lei* (garland). To secure a *lei maʻo* for herself, Hiʻiaka offered the following *oli* (chant) to the women:

E lei ana ke kula o Keʻehumoa i ka maʻo	The plains of Keʻehumoa are garlanded with maʻo
ʻOhuʻohu wale nā wāhine kui lei o ka nahele	The lei-stringing women of the forest are festively adorned
Ua like nō a like ma nā lehua o Hōpoe	Just like the lehua blossoms of Hōpoe
Me he pua koili lehua ala i ka lā	Like lehua blossoms ensconced in the sun
Ka ʻohi pua koaiʻa i ka pali	Gathering koaiʻa flowers on the cliffs
I nā kaupaku hale o ʻĀpuku	Those roof tops of ʻĀpuku
Ke kū nō ʻo ke alo o ka pali o Puʻukuʻua	The cliff face of Puʻukuʻua rises up
He aliʻi nō naʻe ka ʻāina	Yet the land is the chief
Ha kauā nō naʻe ke kanaka	Man is but a servant
I kauā nō naʻe au i ke aloha	As I am a servant to love
Na ke aloha nō i kono e haele nō māua	It was love that invited the two of us to go
E hele nō wau ē.	I must, indeed, go on.
(Hoʻoulumāhiehie 2006b:287)	(Hoʻoulumāhiehie 2006a:268)

Captivated by Hiʻiaka's chant, the women called out and welcomed Hiʻiaka by placing the *lei maʻo* around her neck and inviting her to their *kauhale* (village) for a feast. Hiʻiaka politely declined their request and bid the women farewell before proceeding to the coast of Honouliuli to Puʻuloa (Hoʻoulumāhiehie 2006b). As Hiʻiaka traversed the plain, she saw two women stringing *lei* of the *ʻilima* (*Sida fallax*) blossom beside the *ala loa* (trail). The two women recognized Hiʻiaka and feared she would kill them. To escape potential death, the two women transformed into their *moʻo* forms and hid in a depression of a stone located along the *ala loa* which continued on to Waiʻanae. In detailing the name of the place where the two *moʻo* hid, Hoʻoulumāhiehie (Hoʻoulumāhiehie 2006b) states:

> *A ua kapa ʻia nō ia wahi pōhaku e kū nei, ke ʻole naʻe e pau i ka wāwahi ʻia e ka poʻe hana alanu o kēia au hou nei, ma ka inoa o Peʻekāua, ʻo ia hoʻi, ka upeʻe ʻana o ua mau wahi moʻo nei ma loko o nā poli ʻālualua o ua pōhaku lā.* (Hoʻoulumāhiehie 2006b:288)
>
> That stone, which still stands there, if it has not been crushed by the road builders of these modern times, is called "Peʻekāua," or "let us hide," a reference to those two moʻo hiding in the holes of that stone. (Hoʻoulumāhiehie 2006a:269)

From the plain of Honouliuli, Hiʻiaka turned her gaze to Puʻu Kapolei and Nāwahineokamaʻomaʻo, both of whom were relaxing at the top of hill shaded by *ʻōhai* shrubs (Hoʻoulumāhiehie 2006a:270). Puʻu Kapolei is also the name of a *wahi pana* locate southwest of the current project area (see Figure 3). Careful not to offend Puʻu Kapolei and Nāwahineokamaʻomaʻo, Hiʻiaka acknowledged the women by offering the following chant:

Aloha ʻolua, e Puʻukapolei mā	Greetings to you, O Puʻuokapolei
E Nāwahineokamaʻomaʻo	O Nāwāhineokamaʻomaʻo
E nonoho maila i noho wale lā	Sitting there, there you dwell
I ka malu o ka ʻōhai	In the shade of the ʻōhai
I ke kui lei pua kukui i ka lā	Stringing kukui blossom garlands in the sun
Lei aku i ka pua o ka maʻomaʻo	Wearing lei of the maʻomaʻo flower
Lei kaunoʻa ʻula i ke kaha o Koʻolina lā	Lei of bright kaunoʻa upon the strand of Koʻolina
He ʻolina hele ē	Such a festive way, all about.
(Hoʻoulumāhiehie 2006b:289)	(Hoʻoulumāhiehie 2006a:270)

After hearing the chant, Puʻukapolei responded to Hiʻiaka thusly:

Aloha! Aloha ʻoe, e Hiʻiaka!! E hele nō ʻoe, a mai kipa mai ʻoe iā māua nei; ʻaʻohe a māua ʻai o neʻi nei e ola ai lāʻi ka maka pōniuniu pōloli e kipa mai.

ʻOia auaneʻi ke kipa ʻana mai iā māua nei a he mau ʻelemākule kāne māua, loaʻa ka mahiʻai aku i kēia kula panoa e waiho mai nei, a hiki hoʻi ke kanu aku kahi lau ʻuala a kupu aʻe hoʻi.

E laʻa nei hiki ʻana mai nei ou, he imu ka mea hoʻā aku, a ola nei lā pōloli. ʻAʻohe a māua ʻai, ʻaʻohe a māua iʻa, ʻaʻohe kapa. Hoʻokahi nō o māua kapa, ʻo ka mauʻu pilipili ʻula.

Hele aku māua a uhuki mauʻu a kū ka pūʻā, hoʻi mai a ulana iho i mau wahi ʻāleuleu kapa pua mauʻu no māua. A i ka wā e maloʻo mai ai ka mauʻu, noho ʻōlohelohe ihola nō māua.

Pā maila ke anu a ke Kēhau a me ka Waikōloa, ʻaʻohe anu a koe. Aia nō ko māua mehana a ulu hou mai ka mauʻu o ka ʻāina. (Hoʻoulumāhiehie 2006b:289)

Aloha! Welcome to you, Hiʻiaka!! You should, however, travel on, and not stay with us here; we have no food to stave off the dizzy eyes of hunger if you visit.

It would be all right to call on us here if only we were old men, for then we could do some tilling of this arid plain, and plant ʻuala leaves that would sprout and grow.

Your arrival is inopportune, for an oven should be set to cooking to appease hunger. Yet we have no vegetables or meat, no kapa for clothing or covers. Our only kapa is the red pilipili grass.

We go and pull up grass and bundle it, to bring back and weave into rough cloth of grass sheaves for ourselves. When the grass all dries up, we abide in our nakedness.

The chill comes with the Kēhau and Waikōloa winds, which are so very cold. We are only warmed again when the grasses of the land grew anew. (Hoʻoulumāhiehie 2006a:270)

After hearing the woeful cries of Puʻukapolei, Hiʻiaka descended towards the sea at Puʻuloa and noticed a *maʻo* blossom stunted by the stifling sun. Upon seeing this, Hiʻiaka raised her voice in chant:

Liua Kona i ka lā loa o Makaliʻi	Kona is dazed by the powerful Makaliʻi-season sun
Māewa ka wiliwili, hele i ka laʻi	The wiliwili trees sway, moving in the calm
Kūlōlia ka mauʻu o Kānehili	Longsuffering are the grasses of Kānehili
Welawela ka lā o Puʻuokapōlei	The sun is oppressively hot at Puʻuokapolei
ʻUkiki ka maʻo, kū lā i kai	The maʻo is stunted, standing at the shore
Me he kapa halakea lā ka pua o ke nohu	The blossom of the nohu is like a yellow halakea kapa
Ka ʻoaka, ka puaʻula i ke kaha o Kaupeʻa lā	Flashing, blooming bright in the strands of Kaupeʻa
A he hoa	As a companion
E hoʻohoa aku ana i ka makani he Nāulu	Befriending the wind, a gusting Nāulu
A he hoa ē.	A companion indeed.
(Hoʻoulumāhiehie 2006b:290)	(Hoʻoulumāhiehie 2006a:271)

Hiʻiaka continued *makai* down the trail until she reached Kualakaʻi on the coast of Honouliuli to the south of the project area (see Figure 13), where she found a freshwater spring called Hoakalei, which was flanked by two beautiful *ʻōhiʻa lehua* (*Metrosideros polymporpha*) trees from which she took blossoms to string into more *lei*. Hoakalei is located to the north of Kualakaʻi, near Kalaeloa (Barber's Point), and from there she walked on to Puʻuloa. With respect to Hiʻiaka's journey through ʻEwa, Pukui (1983:16) recorded the following *ʻōlelo noʻeau* in which Hiʻiaka uttered to Wahineʻōmaʻo as a caution not to speak to Lohiʻau while they were passing along ʻEwa in their canoe, "Anu o ʻEwa i ka iʻa hāmau leo e. E hāmau! *ʻEwa is made cold by the fish that silences the voice. Hush!"* Pukui (1983:16) interpreted this saying thusly, "A warning to keep still. First uttered by Hiʻiaka to her friend Wahineʻomaʻo to warn her not to speak to Lohiʻau while they were in a canoe near ʻEwa."

He Kaʻao no Kahalaopuna

The route at Pohakea (see Figure 13) taken by Hiʻiaka as she passed from Waiʻanae into ʻEwa is also mentioned in the account of Kahalaopuna, the young maiden of Mānoa. As recounted by Fornander (1918-1919), Kahalaopuna was betrothed by her parents to Kauhi, a man from Alele, Koʻolauloa. Kauhi with the hopes of securing her as a wife sent her many gifts. After one *anahulu* (ten-day period) had lapsed, rumors about Kahalaopuna being unfaithful had reached Kauhi and he sought to kill the young girl. Having arrived at her home in Mānoa, Kauhi asked Kahalaopuna to go with him to Pohakea to which she agreed. Kauhi subsequently bound her hands and he led her from Mānoa to Pohakea on trails that were not frequented by people. At Pohakea, Kauhi took her under a large *lehua* (*Metrosideros polymorpha*) tree, where he broke off a branch and in a jealous rage, beat Kahalaopuna. To save her life, she chanted to Kauhi but he persisted with his cruel acts until Kahalaopuna died. Kauhi concealed her body by covering it with leaves and ferns and returned to his home.

Kahalaopuna's spirit flew into the trees and upon seeing a company of travelers, she chanted informing them of her death. After her second attempt to get the attention of the travelers, they heard the calls of Kahalaopuna and returned to Mānoa to inform her parents. Her father and mother (Kauakuahina and Kahoiamano) retrieved their daughter's body from Pohakea and returned it to their home where they proceeded to restore her to life. News of the girl's restoration had spread to Koʻolauloa. Hearing the news, Kauhi returned to Mānoa to see for himself and to beg Kahalaopuna to take him back to which she staunchly refused (Fornander 1918-1919).

He Kaʻao no Palila

Several land areas in Honouliuli are briefly mentioned in the legend of Palila, a supernatural warrior from Kamoʻoloa, Kauaʻi. As told by Fornander (1918-1919), Palila was born as a piece cord to his parents Kaluaopalena and Mahinui, both of whom left the cord in a rubbish pile. The piece of cord was then taken by Palila's grandmother Hina, who, through a series of rituals and ceremonies, restored the cord to its human form and raised Palila on a diet consisting purely of bananas. Palila was taken by his grandmother to Alanapo where he was trained by spirits in the art of warfare. As such, Palila was able to assume a human or spirit form, a skill that provided him with further advantages over his enemies.

In one portion of the story, Palila traveled to ʻEwa to rid the area of a supernatural farmer named Kamaikaahui who could change his form into a bunch of bananas, a rat, a shark, and a human. When in his human form, it was the custom of Kamaikaahui to always wear a piece of *kapa* to conceal the shark mouth that located on his back. Wherever he went, Kamaikaahui terrorized the people and when he came to ʻEwa he followed his same practice. He had done these terrible acts so often that the people of ʻEwa began to fear him and he began to rule over them. Having heard of Kamaikaahui, Palila sought to put an end to his terror and restore peace to the land. With his magical club Huliamahi, Palila flew from Kauaʻi and landed at Kaʻena Point at Waiʻanae, then after leaving Kaʻena he flew:

> ...on to Pohakea, then to Maunauna, then to Kanehoa, then to the plain of Keahuamoa and looking toward ʻEwa. At this place he stood and looked at the dust as it ascended into the sky caused by the people who had gathered there; he then pushed his war club toward Honouliuli. (Fornander 1918-1919:142)

After landing at Honouliuli, Palila went on to Waikele (see Figure 13) where a great crowd had gathered to witness the athletic games of Ahuapau, the king of Oʻahu. Palila stood near the king and observed the spectacle before him. Palila proceeded to hurl insults to Kamaikaahui and at the sight of Palila, Kamaikaahui attempted to flee into the sea not before being caught by Palila. Palila lifted the *kapa* of Kamaikaahui and exposed the mouth on his back to the crowd before delivering his final blow and killing the supernatural farmer.

Ka'ao no Namakaokapaoo

In the story of the mysterious Namakaokapaoo, as told by Fornander (Fornander 1918-1919), the lands of Honouliuli and the plains of Keahumoa are noted. Namakaokapaoo's parents were Kauluakahai, a chief from Kahiki and his mother was Pokai. After conception, the father, Kauluakahai returned to his home in Kahiki and left his pregnant wife in a state of destitute. Pokai met a man named Pualii who was from the uplands of Līhu'e, north of the project area (see Figure 13), and the two became lovers. Pokai and her young son resided with Pualii at Kula-o-Keahumoa and there Pualii made two large potato patches, which he named Namakaokapaoo.

One day, Pualii went to the coast of Honouliuli to fish at which time, the young Namakaokapaoo told a group of boys to dig up the potatoes belonging to Pualii. The boys proceeded to dig up the potatoes but left behind the vines. Not having completed the requested task, Namakaokapaoo took it upon himself to pull up all of the vines, piled them in stacks, and set them on fire. When Pualii returned home from fishing, he went to his potato patch and saw that his patch had been stipped of potatoes. Angered, Pualii asked his wife about the situation to which she declined having any knowledge of. Pualii declared his anger and threatened to kill the boy with his ax. Namakaokapaoo raised his voice and uttered a death prayer to Pualii. In a fury, Pualii raised his ax at Namakaopaoo at which time, the ax turned back on Pualii severing his head. Namakaokapaoo proceeded to "...pick up Pualii's head and threw it towards Waipouli, a cave situated on the beach at Honouliuli..." (Fornander 1918-1919:276)

Accounts Associated with Pu'ukapolei

Pu'u Kapolei is located far south of the project area (Puuokapolei; see Figure 13) and is a *pu'u* (hill) that is mentioned frequently in *mo'olelo.* One example comes from the story of how Kamapua'a, the powerful pig-god and chief, took his grandmother to live there. Pertaining to the origins of Kamapua'a, Beckwith (1970) states that "[t]radition relates the immigration to the group of the Kamapua'a family during the colonizing period. His genealogy also appears in the fifth epoch of the cosmogonic chant, Kumulipo (Beckwith 1951). As a shape-shifter Kamapua'a was known to take on other forms including the *humuhumunukunukuapua'a* fish, and plants such as the *kukaepua'a, kukui*, *'uhaloa*, and *'ama'u* fern (Beckwith 1970). In addition to these plants being *kinolau* (body form) of Kamapua'a they were also valued for their medicinal and utilitarian properties with *kukui* perhaps having the most uses that included dye and *kapa* made from the bark, oil from the nut used for the skin, traditional lamps, and fishing, *lei* from the flowers and leaves, pigment from the burnt shell, and the wood from which various item could be made (Abbott 1992). The escapades of Kamapua'a, a *kupua* (demigod), was one of mischief and passion and often involved the epic love-hate affair between his lover and foe, Pele. This account includes details about the conditions of a residence formerly located there. That portion of the story referring Pu'uokapolei reads thusly:

> Kamapuaa subsequently conquered most of the island of Oahu, and, installing his grandmother as queen, took her to Puuokapolei, the lesser of two hillocks forming the southeastern spur of the Waianae mountain range, and made her establish her court there. This was to compel people who were to pay tribute to bring all the necessities of life from a distance, to show his absolute power over all.
>
> Puuokapolei. . . is as desolate a spot as could be picked out on the whole island. It is almost equally distant from the sea, from which came the fish supplies; from the taro and potato patches of Ewa, and from the mountain ravines containing the banana and sugar plantations.
>
> A very short time ago the foundations of Kamaunuaniho's house could still be seen at Puuokapolei; also the remains of the stone wall surrounding her home. It has even been said that her grave could then be identified, but since the extension of cane and sisal planting to the base of Puuokapolei, it is possible the stones may have been removed for wall-making. (Nakuina 1904:50-51)

Kame'eleihiwa (1996) noted that Pu'u O Kapolei was the hill where the body and spirit of Kamapua'a's brother Kekelei'akū was deposited after he had committed suicide in an act of grief over the death of their younger brother. Kame'eleihiwa (1996) recounted the following story of Kamapua'a journey through Honouliuli. The story opens with a description of eight canoes that were filled with foods and gifts intended for the kings of O'ahu 'Iouli and 'Iomea who had replaced 'Olopana as king after his death. The king's attendants had docked the well-stocked canoes near Kamapua'a's cave, Keanapua'a located on Moku'ume'ume (Fort Island) in Hālawa Ahupua'a to wait for the rising tide the following dawn. That night after the attendants drifted to sleep Kamapua'a snuck up and devoured six canoes worth of food then proceeded to filled the empty calabashes with his excrement and water grouds with urine. The following morning, the chiefs attendants rose and discovered the foul gifts left by the pig.

The attendants made preparations to depart 'Ewa with the two canoes that were left untouched by Kamapua'a. As the canoes were leaving 'Ewa, Kamapua'a appeared on the shore and the attendants returned to shore to fetch the pig as cargo. While the canoe approched Kepoʻokalā on the Waipiʻo Peninsula, Kamapuaʻa leaped out of the canoe and "began to climb upland of Honouliuli until he arrived at Honouliuli Pond" (Kameʻeleihiwa 1996:202). A footnote in the story suggest that Honouliuli Pond may actually be Kaloʻi, an old taro patch and freshwater spring that has been lost (Kameʻeleihiwa 1996:202). Upon reaching Honouliuli Pond, Kamapuaʻa observed his grandmother Kamaunuaniho gathering *ʻohā* (taro offshoots) floating on the water of a taro patch. Kamapuaʻa inquired as to why she was gathering the *ʻohā*, to which she replied "I am gathering a few *ʻohā* floating on the water, so that I may live. "This is a time of famine for the land" (Kameʻeleihiwa 1996:202). Kamapuaʻa then turned and pointed to another taro patch located on an open plain that contained mature taro and asked his grandmother "[y]ou should leave this place for another taro patch that is mature" (Kameʻeleihiwa 1996:203). She replied, "[t]hat mature taro patch belongs to the king" and "[i]t's not for the people like us" lest the king kill us (Kameʻelihiwa 1996:203). Despite the warnings from his grandmother, Kamapuaʻa headed to the king's taro patch and with great strength pulled up all the taro, bundled them, and loaded it onto his grandmother's back. To lesson the weight of the burden, Kamapuaʻa chanted to his grandfathers to aid with carrying the load. They returned to Puʻu O Kapolei where they lit an *imu* (underground oven) and cooked some of the taro.

In a description of Puʻukapolei published on January 13, 1900, in the Hawaiian language newspaper *Ka Loea Kalaiaina* (in Sterling and Summers 1978:33-34), it states that:

> If a traveler should go by the government road to Waianae, after leaving the village of gold, Honouliuli, he will first come to the plan of Puuainako and when that is passed, Ke-one-ae. Then there is a straight climb up to Puu-o-Kapolei. It is this hill that hides Ewa from view. When you go to that [Nānākuli] side of Waimanalo, you see no more of the sight back here.
>
> Let us go on to Puu-o-Kapolei. This was one of the most famous hills in the olden days. The chant composed for games in the olden days began with the name of this hill and went on (with the place names) all around the island. This chant was used for those who swung with ropes, played on wooden ukeke instruments, or those who juggled with stones, noni fruit or kukui nuts.

The place-name chant described in the passage above appears in the January 13, 1900 article and that portion of the chant specific to Puʻuokapolei and Honouliuli has been reproduced below and a translation provided:

E Kawelo e, e Kawelo—e	Kawelo, oh Kawelo
E Kawelo Mainui o Puuokapolei	Kawelo Mainui of Puʻuokapolei
O Puuokapolei—	Puʻuokapolei
Uliuli ka Poi a kaua e	The *poi* we consume is darkened
Ai nei—o Honouliuli...	Oh Honouliuli...
(Ka Loea Kalaiaina 1900:1)	(in house translation by L. Brandt and H. Kapuni-Reynolds)

In addition to the accounts detailed above, Kamakau tells of how Puʻuokapolei was used to track the changing seasons on the Island of Oʻahu. Kamakau states:

> In the same way, the people of Oʻahu reckoned from the time when the sun set over Puʻuokapolei until it set in the hollow of Mahinaona and called this period Kau, and when it moved south again from Puʻuokapolei and it grew cold and the time came when young sprouts started, the season was called from their germination (oilo) the season of Hoʻoilo. There were therefore two seasons, the season of Makaliʻi and the season of Hoʻoilo. (Kamakau in Sterling and Summers 1978:34)

Ka Hana Paʻakai (Salt Production)

Other traditional land use in Honouliuli Ahupuaʻa includes a renowned *wahi hana paʻakai* (salt-making area) that was formerly located along the leeward shores of the West Loch (see Figure 13) and continued to provide *paʻakai* (salt) well into the 20th century. In *The Archaeology of Oʻahu*, McAllister (1933:109) provided the following description of the salt production area near Puʻuloa:

> Site 146. Ewa coral plains, througout which are remains of many sites. The great extent of old stone walls, particularly near Puuloa Salt Works, belongs to the ranching period of about 75 years ago.

According to Maly's interview with Thelma Genevieve Parish, a resident of Honouliuli Ahupuaʻa and descendant of James Dowsett, some of the salt was bought by Alaskan fishing fleets and to salt the salmon catch (Maly n.d.:23). Additionally, she recalled that during her childhood many types of *limu*, as well as lobsters, and fish were plentiful in the coastal waters of Honouliuli, prior to the residential development of ʻEwa Beach, the marina, and military facilities (Maly n.d.).

Precontact Battles in Honouliuli

The bounty of land and marine resources made ʻEwa a place sought after by *aliʻi*. As a result, several accounts describe battles taking place in Honouliuli during the time of the *aliʻi* Kūaliʻi, who reigned sometime between 1720-1740, and Māʻilikūkahi and Kaʻihikapu-a-Manuia, whose reign predated that of Kūaliʻi (Cordy 2002). From the time of Māʻilikūkahi until the era of Kākuhihewa (A.D. 1640-1660), Oʻahu remained an independent chiefdom. However, over the next three generations, the island ruler gradually lost power to the district chiefs (Fornander 1880). When Kūaliʻi came to power, he defeated the island's district chiefs and acquired influence over windward Kauaʻi and initiated war on the windward parts of Molokaʻi and Hawaiʻi Island, thus marking the expansion of Oʻahu's independent chiefdom (Cordy 2002). As political expansion continued, kinship links were forged with outer island polities as intermarriage among Hawaiian nobility of different island chiefdoms occurred frequently (Cordy 2002). The shift from intra-island to inter-island warfare continued throughout the 18th century and persisted until the time of European contact in 1778.

Honouliuli and a few of its *wahi pana* are mentioned in a *mele* published as part of *Moʻolelo o Kūaliʻi* (History of Kūaliʻi) printed in *Collection of Hawaiian Antiquities and Folk-lore Volume IV* by Fornander (1916-1917:364-433). Kūaliʻi was a celebrated chief of Oʻahu. The following *mele* was composed by two brothers, Kapaahulani and Kamakaaulani (Fornander 1916-1917). These brothers devised a plan in which Kamakaaulani would give the chant's name to Kūaliʻi while Kapaahulani would urge his rival "to make war upon Kualii" and upon reaching the battlefield, Kapaahulani would chant their prayer, thus ending the battle before it began. Everything went according to plan and Kapaahulani chanted the *mele* of Kūaliʻi on the plains of Keahumoa, north of the project area in Honouliuli on the eve of Kāne (moon phase). After he finished, "the two armies came together and the battle was declared off" (Fornander 1916-1917: 400). As a result, "the king of Koolauloa then gave over, or ceded, the districts of Koolauloa, Koolaupoko, Waialua and Waianae" (Fornander 1916-1917). The following excerpt is from the *mele* for Kūaliʻi which makes specific referece to Honouliuli and other places in the ʻEwa District:

O Kawelo-e, e Kawelo-e	O Kawelo! Say, Kawelo!
O Kaweloiki puu oioi,	Kaweloiki, the sharp-pointed hill,
Puu o Kapolei e—	Hill of Kapolei.
Uliui ka poi e piha nei—o Honouliuli	Blue is the poi which appeases [the hunger] of Honouliuli
Aeae ka paakai o Kahuaiki—Hoaeae	Fine the salt of Kahuike—Hoaeae;
Pikele ka ia e Waikele—o Waikele (Fornander 1916-1917:401)	Slippery is the fish of Waikele—Waikele; (Fornander 1916-1917:400)

Kamakau (1991) tells of a battle between Māʻilikūkahi and chiefs of the islands of Hawaiʻi and Maui. Born at Kūkaniloko and later selected by the council of chiefs, Māʻilikūkahi took the role as *aliʻi* of Oʻahu at the age of twenty-nine. Among his many deeds, Māʻilikūkahi is perhaps most celebrated for reordering the land division system which brought about peace and prosperity over the land and people. According to Kamakau:

> When the kingdom passed to Māʻilikūkahi, the land divisions were in a state of confusion; the *ahupuaʻa* , the *kū* [*ʻili kūpono*], the *ʻili ʻāina*, the *moʻo ʻāina*, the *paukū ʻāina* , and the *kīhāpai* were not clearly defined. Therefore Māʻili-kūkahi ordered the chiefs, *aliʻi*, the lesser chiefs, *kaukau aliʻi*, the warrior chiefs, *pūʻali aliʻi*, and the overseers, *luna* to divide all of Oʻahu into *moku* and *ahupuaʻa*, *ʻili kūpono*, *ʻili ʻāina*, and *moʻo ʻāina*. There were six districts, *moku*, and six district chiefs, *aliʻi nui ʻai moku*. Chiefs were assigned to the *ahupuaʻa*—if it was a large *ahupuaʻa*, a high chief, and *aliʻi nui*, was assigned to it. Lesser chiefs, *kaukau aliʻi*, were placed over the *kūpono* lands, and warrior chiefs over *ʻili ʻāina*. Lands were given to the *makaʻāinana* al over Oʻahu. (Kamakau 1991:54-55)

After reordering the land division system, Māʻilikūkahi encouraged prosperity over the land. According to Kamakau (1991:55) "...the land was full of people. From the brow, *lae*, of Kulihemo to the brow of Maunauna in ʻEwa, from the brow of Maunauna to the brow of Puʻukua [Puʻu Kuʻua] the land was full of chiefs and people." The high state of prosperity of his kingdom had reached the chiefs of Hawaiʻi and Maui and in an attempt to seize Māʻilikūkahi's chiefdom, the outer island chiefs attempted to invade Oʻahu. In remarking on the battle, Kamakau writes:

> Hilo, the son of Hilo-kapuhi, Hilo-a-Luʻukapu, and Punaluʻu, chiefs of Hawaiʻi, and Luakoʻa, a chief of Maui, decided to go and make war on Māʻili-kūkahi. They sailed and landed in Waikīkī, then went to Kapuaʻikāula in ʻEwa with their canoes full of men. *Mauka* of Wai-kakala-ua gulch the battle was to begin. While they were going inland, they were cut off in the rear by the foster

> children of Māʻilikūkahi. Of the chiefs of Hawaiʻi and Maui, Punaluʻu was killed on the plain now called Punaluʻu. Corpses that "paved" a gulch gave the name Kīpapa to that place. Some of the invaders reached as far as the sea at ʻEwa and Waimano—the gulches were filled with their corpses. The heads of Hilo *ma* were cut off and taken to Honouliuli to a place now called Poʻo-hilo [located near the coast of West Loch]. (Kamakau 1991:56)

Kamakau mentions Honouliuli during the reign of Kaʻihikapu-a-Manuia, who ruled sometime after Māʻilikūkahi. Having deposed his elder brother Kū-a-Manuia, Kaʻihikapu-a-Manuia managed to have a rather peaceful reign. During his reign, Kū-a-Manuia made circuits around the island and on one such occasion:

> ...he came to Waikele in ʻEwa where his younger brother Haʻo was living. Cultivating and raising animals were the main occupations of Haʻo's people, and from Honouliuli as far as Wai-piʻo, the land was full of his men. Kaʻihikapu-a-Manuia noted the many men that swarmed about the land. He was afraid he might lose the chiefdom to Haʻo and became very anxious about it. (Kamakau 1991:64)

Early Historic Descriptions of Honouliuli

Historical accounts penned by visitors, missionaries, and residents are another means to reconstruct life in Honouliuli and the greater ʻEwa during the Precontact and early Historic periods. In 1793, just five years after Captain James Cook arrived in Hawaiian water, Captain George Vancouver, while anchored off the entrance of West Loch described the ʻEwa landscape:

> The part of the island opposite to us was low, or rather only moderately elevated, forming a level country between the mountains that compose the east [Koʻolau] and west [Waiʻanae] ends of the island. This tract of land was of some extent, but did not seem to be populous, nor to possess any great degree to natural fertility; although we were told that, at a little distance from the sea, the soil is rich, and all the necessaries of life are abundantly produced. (Vancouver 1801:361)
>
> Mr. Widbey observed, that the soil in the neighbourhood [*sic*] of the harbour [*sic*] appeared of a loose sandy nature; the country low for some distance, and, from the number of houses within the harbour, it should seem to be very populous: but the very few inhabitants who made their appearance was an indication of the contrary (Vancouver 1801:363)

In addition to the observations penned by Vancouver, cartographer, Lieutenant C. R. Malden, on this same trip, drafted a map of Oʻahu's south coast which included portions of Honouliuli in the vicinity of West Loch (Figure 15). Malden's map which was later published in 1825 depicts a cluster of houses, fish traps, and palm trees on the west end of West Loch. A trail network is also shown on Malden's map leading out in a westerly direction from what is presumed to be the main settlement area in Honouliuli. Of particular interest is the trail that branches *mauka* from the Waiʻanae route (see Figure 15). Malden's map is one of the earliest known cartographic records for this region and thus provides a glimpse into the early Historic settlement of this area.

Samuel Kamakau (1992) provided the following narrative of the ship *Arthur* under the command of Captain Henry Barber which ran aground at Kalaeloa. It was from this incident that the name Barber's Point is derived. Kamakau describes the account thusly:

> In October of 1796, a ship [*Arthur*, under Henry Barber] went aground at Kalaeloa, Oahu. This ship had visited the island on several occasions during the rule of Ka-lani-ku-pule. This was the first time a foreign ship had grounded on these shored. Kamahemaha was on Hawaii, but Young had remained on Oahu. All the men on the ship came ashore at night in their boats. At daylight when the ship was seen ashore Ku-i-helani placed a band on the property of the ship and took care of the foreigners. Hawaiian divers recovered the valuables, and they were given over to the care of Ku-i-helani, but part were given by Captain Barber to the men who had recovered them. (Kamakau 1992:174)

In 1809, Scottsman Archibald Campbell, wrote the following description of the Pearl Habor area. Before Campbell arrived at Oʻahu, he had been shipwrecked off the northwest coast of North America. Both of his feet were badly frostbitten and were subsequently amputated. With the aid of his guides, Campbell traveled through the ʻEwa District on the back of his guides, before settling on some land in Waimano Ahupuaʻa that was provided to him by King Kamehameha:

> In the month of November, the king was pleased to grant me about sixty acres of land, situated upon the Wymummee [Waimomi], or Pearl-water, an inlet at the sea about twelve miles to the west of Hanaroora [Honolulu]. I immediately removed thither; and it being Macaheite [*makahiki*] time,

> during which canoes are tabooed, I was carried on the men's shoulders. We passed by foot-paths, winding through an extensive and fertile plain, the whole of which is in the highest state of cultivation. Every stream was carefully embanked, to supply water for the taro beds. Where there was no water, the land was under crops of yams and sweet potatoes. The roads and numerous houses are shaded by cocoa-nut trees, and the sides of the mountains covered with wood to a great height. We halted two or three times, and were treated by the natives with the utmost hospitality. 160 (Campbell 1817:160)

Concerning his observations of the "Pearl River" area, Campbell noted:

> Wymumme, or Pearl River, lies about seven miles farther to the westward. This inlet extends ten or twelve miles up the country. The entrance is not more than a quarter of a mile wide, and is only navigable for small craft; the depth of water on the bar, at the highest tides, not exceeding seven feet; farther up it is nearly two miles across. There is an isle in it, belonging to Manina, the king's interpreter, in which he keeps a numerous flock of sheep and goats. The flat land along shore is highly cultivated; taro root, yams, and sweet potatoes, are the most common crops; but taro forms the chief object of their husbandry, being the principal article of food amongst every class of inhabitants. (Campbell 1967:114-115)

Figure 15. Hawai'i Registered Map 640 by Lt. Malden shows trails in the Honouliuli vicinity ca. 1793, project area not shown.

In his memoir Hawaiian historian Ioane (John) Kaneiakama Papa ʻĪʻī, who was born in 1800 in Waipiʻo, ʻEwa mentions a network of trails that extended across Honouliuli to neighboring lands. A portion of this trail network appears to correspond with the current alignment identified today as Farrington Highway and Kunia Road as shown in the map produced by Paul Rockwood (Figure 16). It is important to note that Rockwood's map is an artisitc rendering based on ʻĪʻī's recollection which not did not utilize formal land surveying techniques to ensure accuracy.

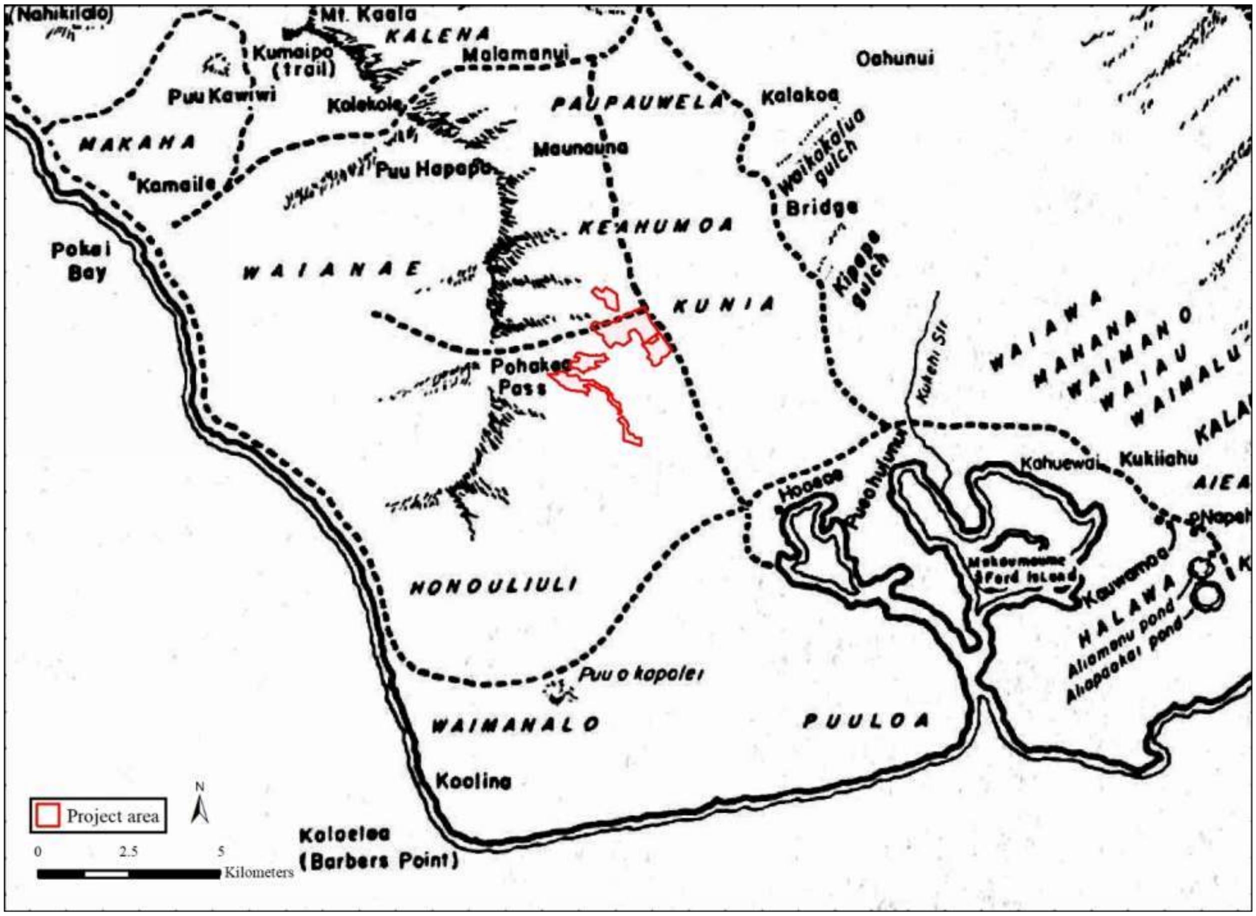


Figure 16. "Trails of leeward Oahu as described by Ii. Map by Paul Rockwood" (Ii 1993:96).

In Rockwood's map, the northern trail alignment (Kunia Road) is shown extending just beyond the eastern boundary of the project area and a secondary trail alignment (Pohakea Pass) is shown extending west through the northern portion of the project area where it ascends to Pohakea in the Wai'anae Mountains (see Figure 16). In addition to plotting the location of the region's trail, Rockwood's map also shows several place names in the Honouliuli area that were mentioned in traditional accounts including Keahuamoa, Pohakea, Maunauna, and Pu'u o Kapolei (see Figure 16). In relating information about the trails in the project area and the fishing practices, 'Ī'ī state:

> The trail went down to the stream and up again, then went above the taro patches of Waiau, up to a *maika* field, to Waimano, to Manana, and to Waiawa; then to the stream of Kukehi and up to two other *maika* fields, Pueohulunui and Haupuu. At Pueohulunui was the place where a trail branched off to go to Waialua and down to Honouliuli and on to Waianae. As mentioned before, there were three trails to Waianae, one by way of Puu o Kapolei, another by way of Pohakea, and the third by way of Kolekole.
>
> From Kunia the trail went to the plain of Keahuamoa, on to Maunauna, and along Paupauwela, which met with the trails from Wahiawa and Waialua. The trail continued to the west of Mahu, to Malamanui, and up to Kolekole, from where one can look down to Pokai and Waianaeuka... (Ii 1993:97)
>
> There [Kapuna, Waikele], patches of taro were grown, draw nets made, and houses built. The fishing was done in the sea of Honouliuli. Because the people of the place did not like Waikele's farm overseer, and for other reasons too, perhaps, they would say, "We are of Honouliuli." If the farm overseer went to Honouliuli, they would say, "We belong to Waikele." It was true that their homes were in Waikele, but all of their fishing was done in Honouliuli. It was laziness and dislike of the overseer that made them point one way and then another. (Ii 1993:32)

In 1820, American Missionary Hiram Bingham described the view from atop Punchbowl looking towards Barber's Point in ʻEwa as follows:

> . . . Below us, on the south and west, spread the plain of Honolulu, having its fish-ponds and salt making pools along the sea-shore. . . From Diamond Hill [Diamondhead], on the east, to Barber's Point and the mountains of Waianae, on the west, lay the sea-board plain, some twenty-five miles in length, which embraces the volcanic hills of Moanalua, two or three hundred feet high, and among them. . . . the lagoon of Ewa [Pearl Harbor/ Puʻuloa], and numerous little plantations and hamlets, scattered trees, and cocoanut [*sic*] groves. . . (Bingham 1848:93)

Early missionary, William Ellis described the ʻEwa area during his visit in 1823-1824. His comments read thusly:

> The plain of Eva is nearly twenty miles in length, from the Pearl River to Waiarua, and in some parts nine or ten miles across. The soil is fertile, and watered by a number of rivulets, which wind their way along the deep watercourses that intersect its surface, and empty themselves into the sea. Though capable of a high state of improvement, a very small portion of it is enclosed or under any kind of culture, and in travelling across it, scarce a habitation is to be seen. (Ellis 1963:7)

James Macrae, a Scottish botanist aboard the *HMS Blonde* which called into Honolulu in 1825 provided the following remarks about the Puʻuloa vicinity:

> Pearl River is about seven miles west of Hanarura [Honolulu], and is improperly called a river, being rather inlets from the sea, branching off in different directions. There are three chief branches, named by the surveyors, the East, Middle and West Lochs. The entrance to Pearl River is very narrow and shallow, and in its present state it is fit for very small vessels to enter, but over the bar there is deep water, and in the channel leading to the lochs there are from 7 to 20 fathoms. The lochs themselves are rather shallow.
>
> The coast from Hanarura to the west of Pearl River possesses no variety of plants beyond two or three species, such as Argemones, Portulacas, and a few other little annuals, intermixed
>
> The oysters that are found in Pearl River are small and insipid and of no value or consequence. (Macrae 1922:29-30)
>
> The neighborhood of the Pearl River is very extensive, rising backwards with a gentle slope towards the woods, but is without cultivation, except round the outskirts to about half a mile from the water. The county is divided into separate farms or allotments belonging to the chiefs, and enclosed with walls from four to six feet high, made of a mixture of mud and stone. The poorer natives live on these farms, also a few ragged foreigners who have a hut with a small spot of ground given to them, for which they must work for the chiefs a certain number of days besides paying an annual rent in dogs, hogs, goats, poultry and tapa cloths, which they have to carry to whatever spot their master is then living on the island. (Macrae 1922:31)

In his 1831 visit, botanist Franz Meyen commented on the high state of cultivation along the waters of Puʻuloa. He states:

> At the mouth of the Pearl River the ground has such a slight elevation, that at high tide the ocean encroaches far into the river, helping to form small lakes which are so deep, that the long boats from the ocean can penetrate far upstream. All around these water basins the land is extraordinarily low but also exceedingly fertile and nowhere else on the whole island of Oahu are such large and continuous stretches of land cultivated. The taro fields, the banana plantations, the plantations of sugar cane are immeasurable. (Meyen 1981:63)

Between 1840 and 1841, Commander Charles Wilkes (1845) of the U.S. Exploring Expedition made a tour of the Hawaiian Islands. In July of 1840, Wilkes and several other members in his party made of tour of the ʻEwa District and commented on the landscape and life of the people. After an uneventful trip to Mount Kaʻala, the party made their way towards Honolulu and:

> ...across the plain between the two ranges of mountains. This plain, in the rainy season, affords abundance of food for cattle in three or four kinds of grasses, and is, as I have before remarked, susceptible of extensive cultivation by irrigation from the several streams that traverse it. The largest of the streams is the Ewa. Scraggy bushes of sandalwood and other shrubs are now scattered over a soil fit for the cultivation of sugar-cane and indigo.

> At Ewa they were kindly received by the Reverend Mr. Bishop and lady, who have charge of the station. The district of Ewa commences about seven miles to the west of Honolulu, and extends twenty miles along the south shore, or from the hill in the vicinity of salt lake to beyond Laeloa or Barber‘s Point. There are no chiefs or any persons of distinction residing in the district; the people are labourers or Kanakas, and the landholders reside near the king at Lahaina, or at Honolulu. The taxes and occasional levies without any outlay have hitherto kept them poor.
>
> In this district is a large inlet of the sea, into the river Ewa empties; at the entrance of this inlet is the village of Laeloa: the whole is known by the name of Pearl River or harbour, from the circumfrance that the pearl oyster is found here; and it is the only place in these islands where it occurs.
>
> Pearl-River Harbour affords an abundant of fine fish. Two species of clams are procured here, called by the natives okupe and olepe. Mr. Drayton, who went to Pearl River for the purpose of examining its shores, and obtaining shells, reported that he found a large bed of fossil oyster-shells, extending into the bank in a bed from one to four feet wide, and half a mile in length: they were found cemented together with soft limestone and a reddish sand, and were so numerous that there was scarcely enough of the cement between to hold them together. The dredging was unsuccessful, a small spotted venus being the only shell that was obtained, although it was the general belief, among both the foreign and native inhabitants, that it would have produced an abundant reward for the trouble. (Wilkes 1845:78-79)

Wilkes goes on to describe the abundance of waters, soil, missionary presence, and changes to the native culture:

> The district, unlike otheres of the island, is watered by copious and excellent springs, that gush out at the foot of the mountains. From these run streams sufficient for working sugar-mills. In consequence of this supply, the district never suffers from drought, and the taro-patches are well supplied with water by the same means.
>
> The soil on the sides of the hills is a hard red clay, deemed useless except for pasturage. Here and there in the valleys passing through these hills and in the low grounds, is found soil capable of producing all the varieties of tropical vegetation.
>
> At Ewa, Mr. Bishop has a large congregation. The village comprises about fifty houses, and the country road is dotted with them. The village presents an appearance of health and cleanliness, clearly indicating the influence. Mr. Bishop has exerted over his flock, in managing which he is much aided by his lady.
>
> The church is a large adobe building, situated on the top of a small hill, and will accomodate a great number of persons. Mr. Bishop sometimes preaches to two thousand persons.
>
> The native have made some advance in the arts of civilized life; there is a small sugar-mill which, in the season, makes two hundred pounds of sugar a day. They have been taught, and many of them area now able to make their own clothes, after the European pattern. There is a native blacksmith and several native carpenters and masons, who are able to work well.
>
> In 1840, the church contained nine hundred members, seven hundred and sixty of whom belong to Ewa, the remainder to Waianae; but the Catholics have now established themselves at both these places, and it is understood are drawing off many from their attendance on Mr. Bishop’s church. Schools are established, of which there are now three for children under teaches from Lahainaluna. Mr. Bishop informed me that there was great difficulty in procuring suitable teachers, and a still greater difficulty in raising funds for their support. The teachers complain much of their inability to secure a regular attendance from their scholars, which is thought to result from a want of parental authority at home, and their leaving it optional with the children to attend school or not.
>
> This district contained in 1840 two thousand seven hundred and ninety-two inhabitants, and there is no satisfactory evidence of a decrease, although many speak of it a being great; but the latter opinion is formed from the census of 1836, which was on many accounts inaccurate, and ought not to be taken as authority on which to found such a statement.
>
> This is the best part of the island for raising cattle and sheep, which are seen here in great numbers than elsewhere. (Wilkes 1845:80-81)

During the early 19th century, the interior landscape of Honouliuli and the central ʻEwa plains was altered from the over-harvesting of *ʻiliahi* (sandalwood; *Santalum ellipticum*). The sandalwood trade, established by Euro-Americans in 1790, became a viable commercial enterprise by 1805 and was flourishing by 1810 (Oliver 1961). Prized in China for its unique fragrance and used to manufacture items such as incense, perfume, and medicine, Kamehameha I, before his death in 1819, seized control of the industry and ordered his lesser chiefs and the people to the mountains to harvest the prized wood (St. John 1947). Kamakau (1992:294) noted that sometime around 1829, "Manuia was cutting sandalwood at Puʻukuo [Puʻu Kuʻua; southwest of the project area, see Figure 13] in Honouliuli when Boki asked him to join them" in preparing for their trip to New Hebrides. Although the industry proved to be lucrative for the chiefs in control, it created a burden on the people and had a lasting impact on the environment. Farmers and fishermen were ordered to spend most of their time logging, resulting in food shortages and famine that led to a population decline. Kamakau (1992:204) indicates that "this rush of labor to the mountains brought about a scarcity of cultivated food … The people were forced to eat herbs and tree ferns, thus the famine [was] called Hi-laulele, Haha-pilau, Laulele, Pualele, ʻAmaʻu, or Hapuʻu, from the wild plants resorted to." Once Kamehameha realized that his people were suffering, he "declared all the sandalwood the property of the government and ordered the people to devote only part of their time to its cutting and return to the cultivation of the land" (Kamakau 1992:202). St. John (1947:20) deduced that "[t]he northern and southern slopes of the Schofield saddle apparently had much more extensive stands of sandalwood, from Waimano to Honouliuli, and from Pupukea to Makaleha." A historical account penned by ship surgeon and natural historian F. D. Bennett after an 1834 visit to Oʻahu and published in his book titled *Narrative of a Whaling Voyage Round the Globe* provides a succinct summary of land use practices and the economy at that time:

> The staple commodities of the [island] group are at present very few. Sandal-wood is the principal of these but the demands for it have been so urgent, and so much beyond the resources of the country, that nearly all the large trees have been destroyed, and for some time past the government has very prudently prohibited the cutting of young wood. The fossil salt of Oahu, and some hides, chiefly afforded by the wild cattle of Hawaii, are therefore the only available exports that remain; but the cultivation of sugar has been lately commenced under favourable [*sic*] auspices, and promises well for the commercial interests of the people. (Bennett 1840:237)

Sereno Bishop, one of the first generation missionaries provided the following description in which he details the changes in the natural environment to Oʻahuʻs central region in the 1830s:

> Our family made repeated trips to the home of Rev. John S. Emerson at Waialua during those years. There was then no road save a foot path across the generally smooth upland. We forded the streams. Beyond Kīpapa Gulch the upland was dotted with occasional groves of Koa trees. On the high plains the *ti* plant abounded, often so high as to intercept the view. No cattle then existed to destroy its succulent foliage. According to the statements of the natives, a forest formerly covered the whole of the then nearly naked plains. It was burned off by the natives in search of sandalwood, which they detected by its odor burning. (Bishop in Sterling and Summers 1978:89)

Māhele ʻĀina of 1848, Summary of Kuleana Claims

In 1795, the Hawaiʻi Island chief, Kamehameha, had completed his conquest against Kalanikūpule and the Maui forces that had seized Oʻahu just a short time prior. Kamehameha began dividing up the lands (*kālai ʻāina*) of Oʻahu amongst his chiefs and loyal supporters and gave Honouliuli to Kalanimoku as a *panalāʻau* (conquered territory), thus allowing him to pass the land to his heirs (Kameʻeleihiwa 1992). Kalanimoku then gave Honouliuli to his sister, Wahinepiʻo. However, by 1848 the land division known as the *Māhele ʻĀina* ushered in widespread change in land ownership across the archipelago. During the early part of the 19th-century, as Hawaiian political elites sought ways to modernize the Hawaiian Kingdom and as the population of Western settlers increased, major socioeconomic and political changes began to take place. By 1840, the Hawaiian Kingdom, through the formal adoption of a constitution, became a constitutional monarchy which was soon followed by a reformation of the traditional land tenure system. By 1848, King Kauikeaouli (Kamehameha III), the reigning monarch, and his chiefs came together for the final land division.

Kepā and Onaona Maly conducted a review of all the *Māhele* records for Honouliuli Ahupuaʻa recorded from 1847 through 1855 (Maly and Maly 2012a). The following discussion is taken from the paper in which they presented the results of their research, which included over 400 documents. According to Maly and Maly, "of the 106 native tenant claims and one chiefly claim identified from Honouliuli, 74 were awarded to the claimants or their heirs, and 33 were denied" (Maly and Maly 2012b:1). The sole chiefly or *aliʻi* claim (Land Commission Award No. 11216:8; Royal Patent No. 6971) was awarded to Mikahela Kekauʻonohi, (Kamehameha III's niece and Kamehameha I's granddaughter) who had inherited the *ahupuaʻa* from her late husband High Chief Aarona Keliʻiahonui after his death in 1849 (Maly and Maly 2012:7). The current project area falls within a portion of this *ali'i* award that comprises 43,250 acres of Honouliuli and originally included 2,610 acres of Pu'uloa, an *'ili* which Kekauonohi sold in 1849 to Issac Montgomery (Haun 1991; Kelly 1991). The 1920 map by W. E. Wall (Figure 17) shows Kekauonohi's land claim for Honouliuli Ahupua'a and the 1873 map of Honouliuli by W. D. Alexander (see Figure 14) situates the project area in the land area identified as Kupehau.

No *kuleana* awards were granted within the immediate project area vicinity. All *kuleana* awards that were granted in Honouliuli were clustered in an area located *makai* of the project area near the northwestern portion of Ka-ihu-o-Pala'ai (West Loch) along Honouliuli Stream. The distribution of the *kuleana* lands are shown in Hawai'i Registered Map No. 630 prepared in 1878 by M. D. Monsarrat (Figure 18). A second un-dated map obtained from the Department of Accounting and General Services miscellaneous map collection shows the location of the *kuleana* award and the associated *'ili* names (Figure 19).

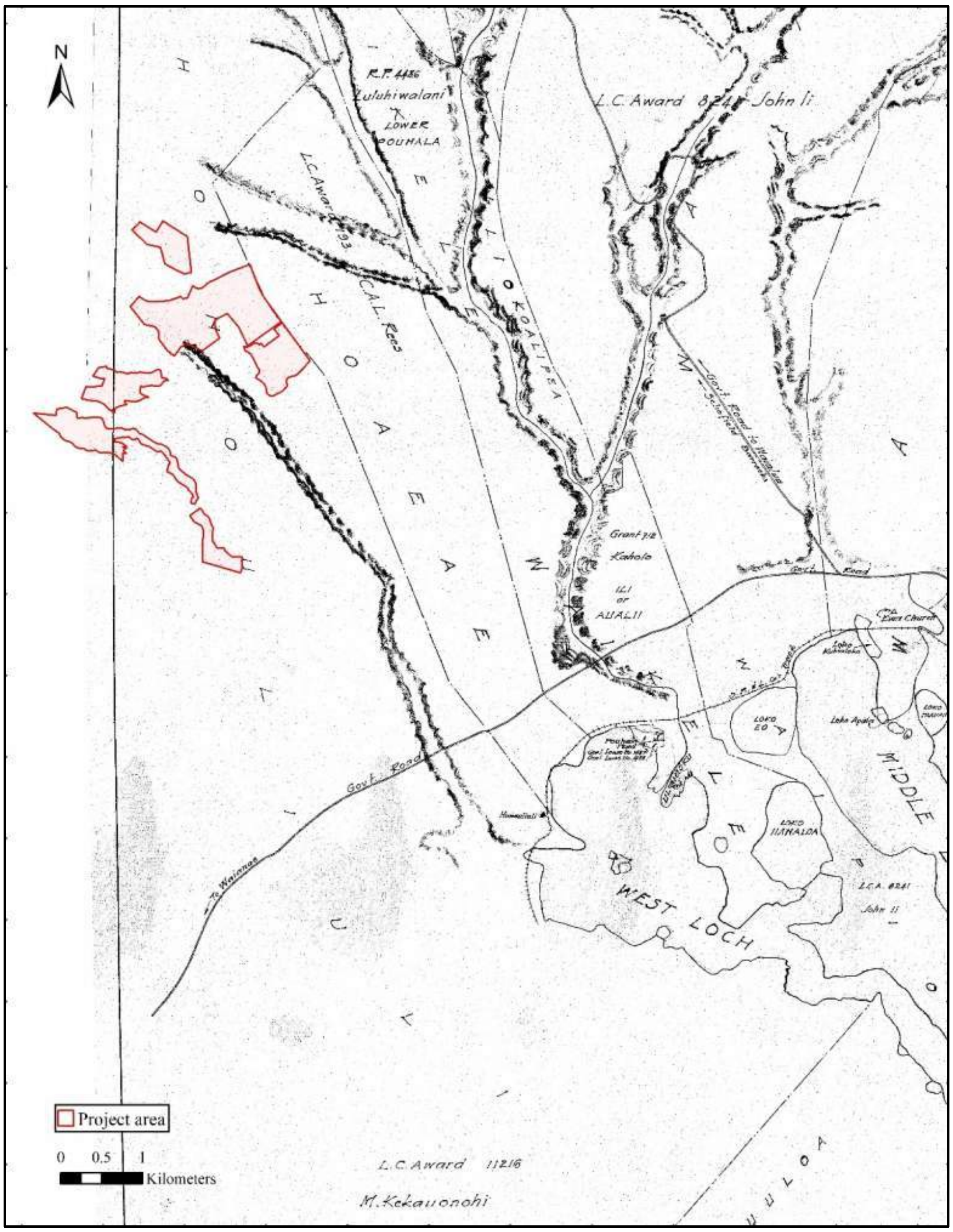


Figure 17. 1920 map of Pearl Harbor and adjacent lands by W. E. Wall showing LCAw 112616 to Kekauonohi (Department of Accounting and General Services).

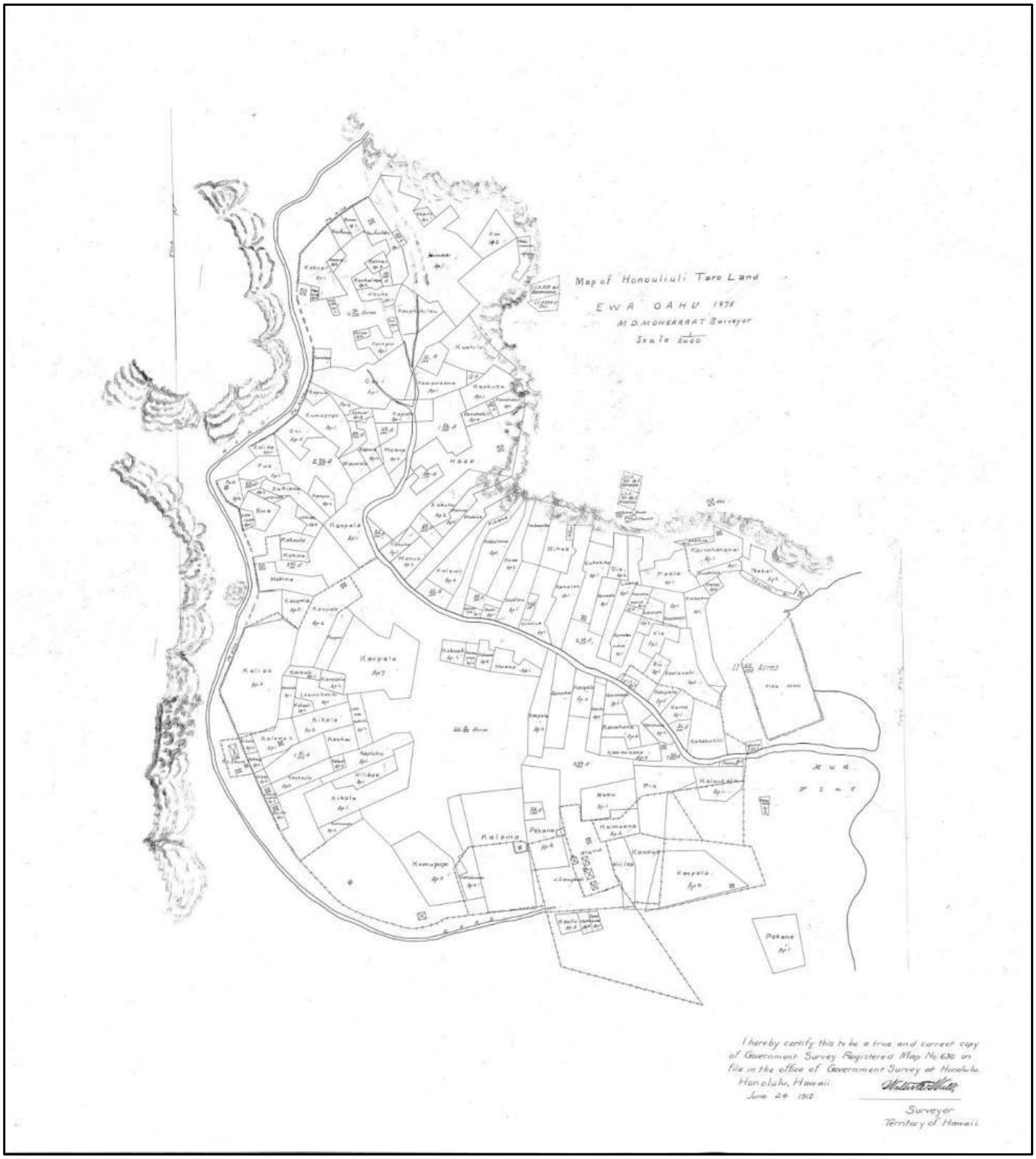


Figure 18. Hawai‘i Registered Map No. 630 by M. D. Monsarrat from 1878, project area not shown (Department of Accounting and General Services).

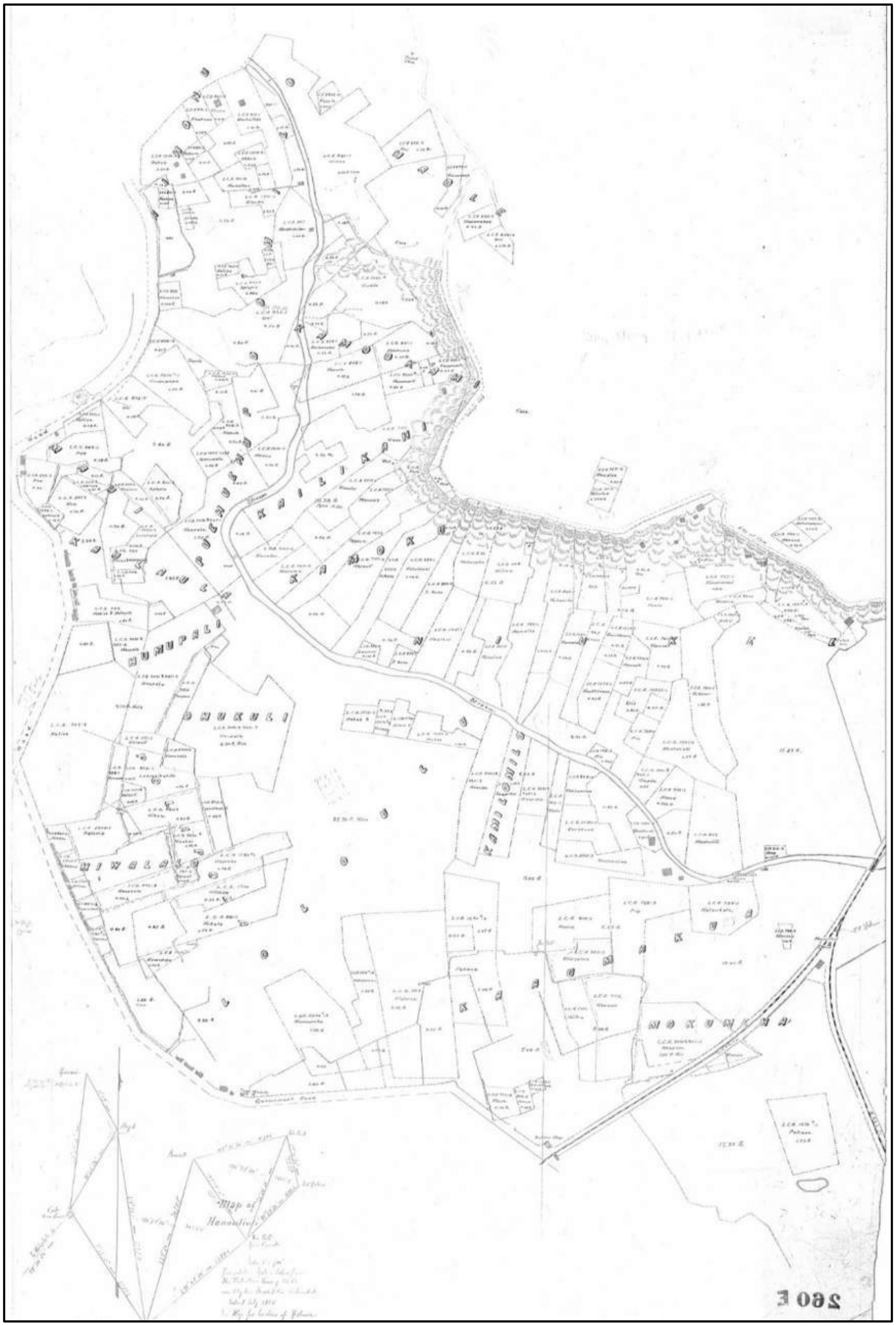


Figure 19. Undated map showing the location of *kuleana* in Honouliuli with associated *'ili* names, project area not shown (Department of Accounting and General Services).

Ranching and Rice Cultivation

By the 1840s, ranching operations began to develop in Honouliuli; soon foreigners such as John Meek, Isaac and Daniel Montgomery, James Dowsett, and James Campbell would control most of the acreage therein. In 1857, chief Levi Ha‘alele‘a deeded roughly 40,000 acres of Honouliuli Ahupua‘a, except for lands awarded to native tenants and the roughly 2,500 acres of Pu‘uloa previously conveyed to Isaac Montgomery, as a mortgage to Benjamin F. Snow. Upon his death, Ha‘alele‘a’s widow (Anaderia Amoe Ha‘alele‘a) conveyed Honouliuli, including “all the goods, lands and chattels” to John H. Coney in 1867 (Bureau of Conveyances Liber 23 May 11, 1867: 319). Shortly thereafter, Coney leased the lands to James Dowsett and John Meek for grazing. During the early to mid-20th-century, ranching continued across most of Honouliuli. Lifelong resident, Thelma Parish recalled that the *makai* flats of Honouliuli were used as rotating pasture for cattle by her ancestors and others (Maly and Maly 2012a).

In 1877, James Campbell purchased roughly 43,640 acres in Honouliuli Ahupua‘a for a total of $95,000 from John H. Coney and his wife Ami (Bureau of Conveyances Liber 52 September 11, 1877: 201-201). In October of 1877, Campbell married Abigail Kuaihelani Maipinepine, who was of Māui royal lineage (James Campbell Company 1978). In a *Statistical Directory of the Island of O‘ahu* published in 1880, James Campbell’s occupation is listed as “Landed Proprietor” and he appears as the owner of 43,250 acres of land cultivated for pasture; Campbell is also listed as the “Landowner of Kahuku Ranch” owning another 28,608 acres in pasture in Kahuku (Bowser 1880:298). Another entry for someone named Kaehuokalani lists his occupation as “Farmer” owning 4 acres of pastureland in Honouliuli (Bowser 1880:307). The third and final entry associated with Honouliuli is that of Lockgawk, a “Rice planter” by occupation who is listed as renting 140 acres in Honouliuli (Bowser 1880:314). Bowser (1880:409) states in a later entry found in the sugar plantations section of the same volume under the title “Honouliuli Estate” that the pastureland not only “affords grazing for much valuable stock,” but that its soils are “suitable for agriculture,” for “It is on this estate that Mr. Campbell’s successful artesian boring has been made.” He also adds “There are valuable fisheries attached to this estate,” the area of which he qualifies as follows “the length of this estate is no less than 18 miles. It extends to within less than a mile of the seacoast, to the westward of the Pearl River inlet” (Bowser 1880:409). The location of Campbell’s Honouliuli fisheries are shown in a 1913 map titled “No. 8 Oahu Fisheries Pearl Lochs Section” produced below as Figure 20. The success of Campbell’s well would later prompt ‘Ewa ranchers and plantation developers to drill numerous wells to search of the much needed water.

In a section titled “An Account of the Sugar Plantations and the Principal Stock Ranches on the Hawaiian Islands,” Bowser provides additional details regarding Campbell’s Honouliuli estate (Figures 21 and 22). The account, reproduced below, emphasizes the installation of the first successful artesian well in the islands and concludes with a brief description of a village in Honouliuli:

> The Honouliuli Ranch is an extensive property. The main road runs through it for about twelve miles, and the general breadth is seldom less than four miles. One large tract of this land is perfectly level, with the exception of a few acres near the centre, where there is a knoll of rising ground. . . . The soil at Honouliuli is good, and, with the aid of irrigation, will grow anything. In the mean time, it is wholly pasture land, but the means of irrigation have recently been secured by Mr. Campbell, who has sunk an artesian well to the depth of 273 feet. This well has delivered a continuous stream of water equal to 2,400 gallons per hour, ever since the supply from which the present flow comes, was struck on the 22d of September, 1879. Besides Mr. Campbell’s residence, which is pleasantly situated and surrounded with ornamental and shade trees, there are at Honouliuli two churches and a school house, with a little village of native huts. (Bowser 1880:495)

Figure 20. A 1913 O‘ahu Fisheries map by M. D Monsarrat, project area not shown.

Figure 21. Residence of James Campbell in Honouliuli (James Campbell Company 1978:10).

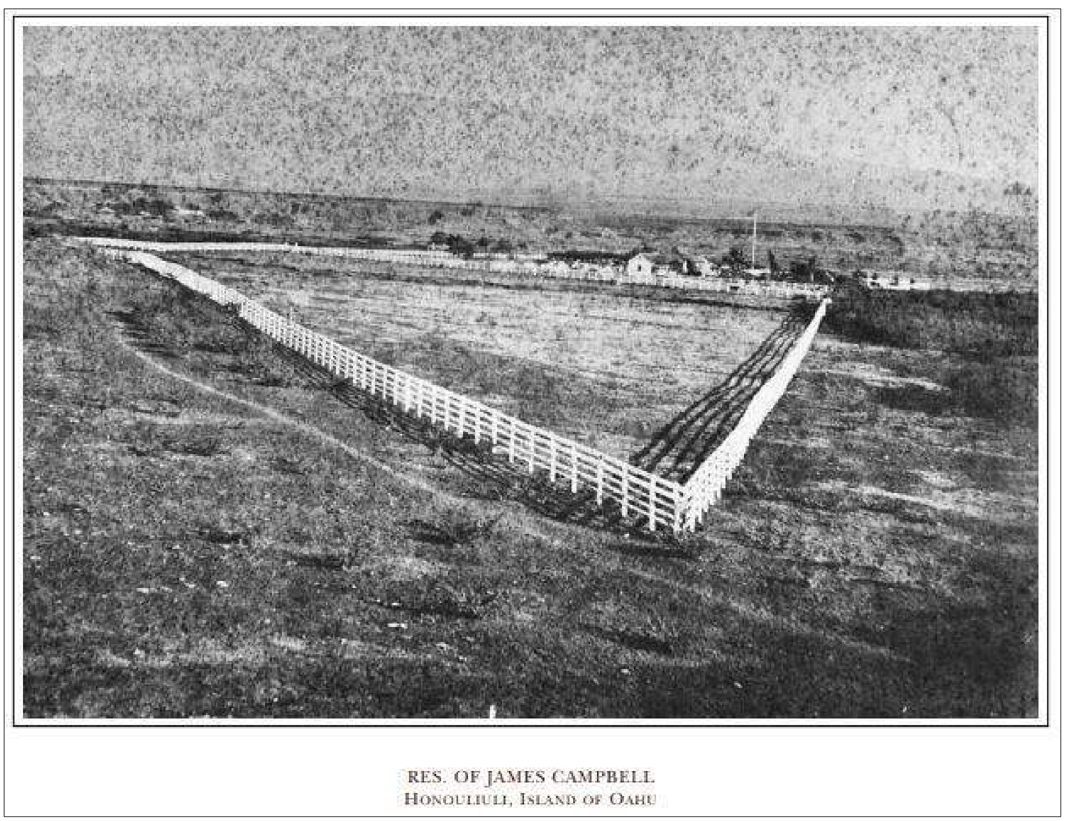


Figure 22. Residence of James Campbell in Honouliuli (James Campbell Company 1978:11).

In addition to ranching, during the second half of the 19th century as migrant contract sugar laborers from China settled in the islands to work on the sugar plantations, a local rice market began to develop. Although commercial sugar operations did not start in Honouliuli until 1890, by the 1880s and upon fulfillment of their contacts, Chinese laborer began leasing and buying taro lands from Hawaiians (Coulter and Chun 1937). Former taro lands located in the lowlands surrounding Pearl Harbor were converted from *lo'i* into rice paddies and by 1885, some 200 acres of Honouliuli prime taro lands were planted in rice (Cruz et al. 2011). In 1882, Frank Damon (1882:37) wrote the following description of rice cultivation in Honouliuli:

> Towards evening we reached Honouliuli, where the whole valley is leased to rice planters...This was one of the largest rice plantations we visited. Sometimes two or three men only, have a few fields which they cultivate for themselves, and we often too came upon houses where there were eight or ten men working their own land. But the larger plantations are owned by merchants in Honolulu, who have a manager acting for them.

In 1885, the first Japanese migrant laborer arrived and they soon joined the Chinese in rice farming. The Japanese farmers however, preferred short grain rice that was grown in California to the long grain variety grown locally by Chinese farmers. Although rice production was not a major economic contributor, it was an important industry for migrant laborers. By the early part of the 20th-century, the hand labor techniques employed by local rice farmers could not compete with the mechanized rice production in California. Despite efforts from the University of Hawai'i's agricultural extension to revive rice farming in 1906 and later in the early 1930, rice paddies were abandoned and the industry ceased (Haraguchi 1987).

Oahu Railway and Land Company and the Oahu Sugar Company

In 1889, B. F. Dilingham organized the Oahu Railway and Land Company (OR&L). The fate of the OR&L would prove to be inexorably linked to that of commercial sugar in 'Ewa and beyond. During the late 1880s, Dillingham promised investors that he would connect Honolulu with Pearl Harbor by means of a steam railroad. Although railroads largely associated with the sugar industry were already in operation on Hawai'i Island, O'ahu was undeveloped in comparison and the Pearl Harbor region was not yet known as a sugar production area (Yardley 1981). Furthermore, according to Dillingham's biographer Paul T. Yardley (1981:130), "the great dry plains of Ewa produced nothing but cattle and firewood." The main landholders of 'Ewa, including James Campbell, were all amenable to the planned railroad and the promise of increasing the value of their land holdings. On March 8, 1889, the formal groundbreaking for the railway took place at Moanalua near the intersection of Middle Street and Kamehameha Highway (Yardley 1981). By 1890 a route between Honolulu and Pearl City (Mānana) was laid and in 1895 the route into Wai'anae was set up. In 1898 and 1899 a connector line between Waialua Plantation and Kahuku and 'Ewa was put up (Kuykendall 1967). The complete OR&L railroad route is illustrated in Figure 23. The OR&L route appears to have followed the general alignment of earlier trails noted by John Papa 'Ī'ī (see Figure 16).

By July 1, 1890, the railroad reached Hō'ae'ae, east of the current project area (Yardley 1981). Later that same year, Dillingham shifted his focus to developing portions of Campbell's 60,000 acres in 'Ewa into sugar plantations and constructing a wharf in Honolulu Harbor that could accommodate ships loaded with sugar for export, as well as imports for transport by rail. Dillingham continued to run parts of the Campbell lands as ranches while renting out portions for other uses, which resulted in the establishment of Ewa Plantation Company in 1890. The Ewa Plantation cultivated the lower portions of Honouliuli and in 1897, Dillingham established the Oahu Sugar Company with its fields in the upper reaches of Honouliuli.

The development of sugar as an industry in the 'Ewa District was largely hampered by the arid condition and scant annual rainfall that was insufficient for producing profitable amounts of cane (Coulter 1933). However, the economic potential for developing a profitable sugar plantation was revealed in July 1879, when Campbell contracted John Ashley of California, who successfully drilled the first artesian well on Campbell's Honouliuli estate (see Figures 21 and 22), which Hawaiians had named Waianiani (Advertiser 1956b). Use of the well ceased in 1939, when the City and County of Honolulu sealed it (James Campbell Company 1978). By 1938, Oahu Sugar Company had sixty-three wells in operation (Advertiser 1956b). The availability of fresh water allowed for the expansion of commercial sugar into the 'Ewa District and the eventual establishment of several commercial sugar plantations in 'Ewa, two of which operated in Honouliuli, the Ewa Plantation Company and the Oahu Sugar Company. Having successfully promoted the Ewa Plantation, Dilingham turned his attention to developing sugar plantations in the upper portions of Honouliuli. The Oahu Sugar Company leased roughly 12,000 acres of land from the estates of John Papa 'Ī'ī, Bishop, and Robinson and constructed its mill in what is known today as Waipahu in Waikele Ahupua'a (Dorrance and Morgan 2000). In an editorial printed in *The Honolulu Advertiser* concerning the naming of Waipahu, Mr. Simeon Nawa'a opined that:

> "Waipahu" is not a tract of land, but another present-day manipulation and discordant of truth, and creating falsehood and confusion. The Oahu Railway and Land Co. is the culprit responsible for all confusions when it built its station at Kaohai, Waikele, and named it "Waipahu Station," and from that time it stuck. The Oahu Mill is located on "Keonekuilimalaulaoewa" (the arm-in-arm plateau of ewa). (Nawaa 1956:4)

To irrigate the upper fields, water was pumped to roughly the 500 foot elevation (Dorrance and Morgan 2000). However, moving water to even higher elevations led plantation managers and owners to propose constructing a system that would bring water from the Ko'olau mountains into the upper portions of 'Ewa. In 1913, Waiahole Water Company, a wholly-owned subsidiary of Oahu Sugar Co. was formed. The Waiahole Water Company led the construction of the massive Waiahole Ditch and upon its completion in 1916 included twenty-seven tunnels that connected to thirty-seven stream intakes on the Ko'olau mountains with the main bore through Waiāhole Valley. This system connected to fourteen tunnels on the south side of the Ko'olau mountains at Wai'awa thence by a westward ditch that brough water into Honouliuli. Upon its completion, the Waiahole Ditch extended for 21.9 miles, brought an estimated 32 million gallons of water daily to 'Ewa, and cost $2.3 million dollars to construct (Condé and Best 1973). The Waiahole Ditch, with some modifications, is still in used and has been listed on the State Inventory of Historic Places as Site 50-80-09-2268. While the 1913 Territory of Hawai'i survey map (Figure 24) does not depict the Waiahole Ditch in the project area vicinity, it does show the majority of the project area with the exception of a pie shaped section of land in the northeast corner to be mostly vegetated. A historic aerial taken thirty-eight years later between 1951-52 (Figure 25) shows that by this time, most of the project area had been cleared and planted in cane and the Waiahole Ditch is shown entering the project area from the east then meandering along the southern (*makai*) section of the fields. A 1953 USGS map (Figure 26) also shows the course of the Waiahole Ditch which matches the exact course shown in the 1951-52 aerial. In the immediate project area vicinity, a reservoir near the southern (*makai*) part of the project area is shown in both the 1951-52 aerial (see Figure 25) and the 1953 USGS map (see Figure 26. The 1953 USGS (see Figure 26) map also labels two water tanks, a flume, and two reservoirs along Kupehau Road, which is an access road leading from Kunia Road into the project area. In addition to showing the location of plantation infrastructure, the 1953 USGS (see Figure 26) map shows Pohakea trail extending in the vicinity of the northern section of the project area. Kluegel (1917:96) provides the following description of the Waiahole Ditch in the Honouliuli area:

> West of Waikakalaua Gulch, through Hoaeae and to the upper boundary of Oahu Plantation in Honouliuli, the conduit of 12,650 feet of cement-lined ditches, and three redwood pipes 5 feet in diameter, having an aggregate length of 2,830 feet.

When the United States entered World War II, "the Army took possession of over 500,000 acres of Ewa Plantation land" (Campbell 1994:2). The OR&L continued to flourish through the end of World War II and provided transport for millions of passengers and freight during the war, proving itself indispensable to the U.S. Army and Navy. However, after the war as infrastructure improvements to O'ahu roadways were implemented and a shift to automobiles, trucks, and buses for the transport of people and goods was underway, the OR&L could not compete. The year 1947 marked the close of the main line while limited operations between the docks and pineapple canneries continued before complete abandonment of the railway a few years later.

In contrast, "a good sugar crop and substantial investment in new equipment and development" were able to mitigate the effects of World War II on the sugar industry (ibid). Castle and Cooke Ltd. became the majority shareholder of Ewa Plantation Company in 1962; and by 1970, Ewa Plantation was unable to renew its lease for the Campbell Estate lands, and was forced to merge with Oahu Sugar Company, which had been acquired by AMFAC, Inc. roughly a decade prior to the merger (Yardley 1981). As a result of the merger, Oahu Sugar Company OSC became "the second largest sugar plantation in Hawaii and the third largest in the U.S." (Yamamoto et al. 2005:43). By 1982, Oahu Sugar Company covered fifty-five square miles of land with 15,488 cultivated acreage (ibid.). With a steady and reliable source of water, the Oahu Sugar Company was able to expand its operations into the interior parts of Honouliuli, and continued to produce high yields well into the 1980s.

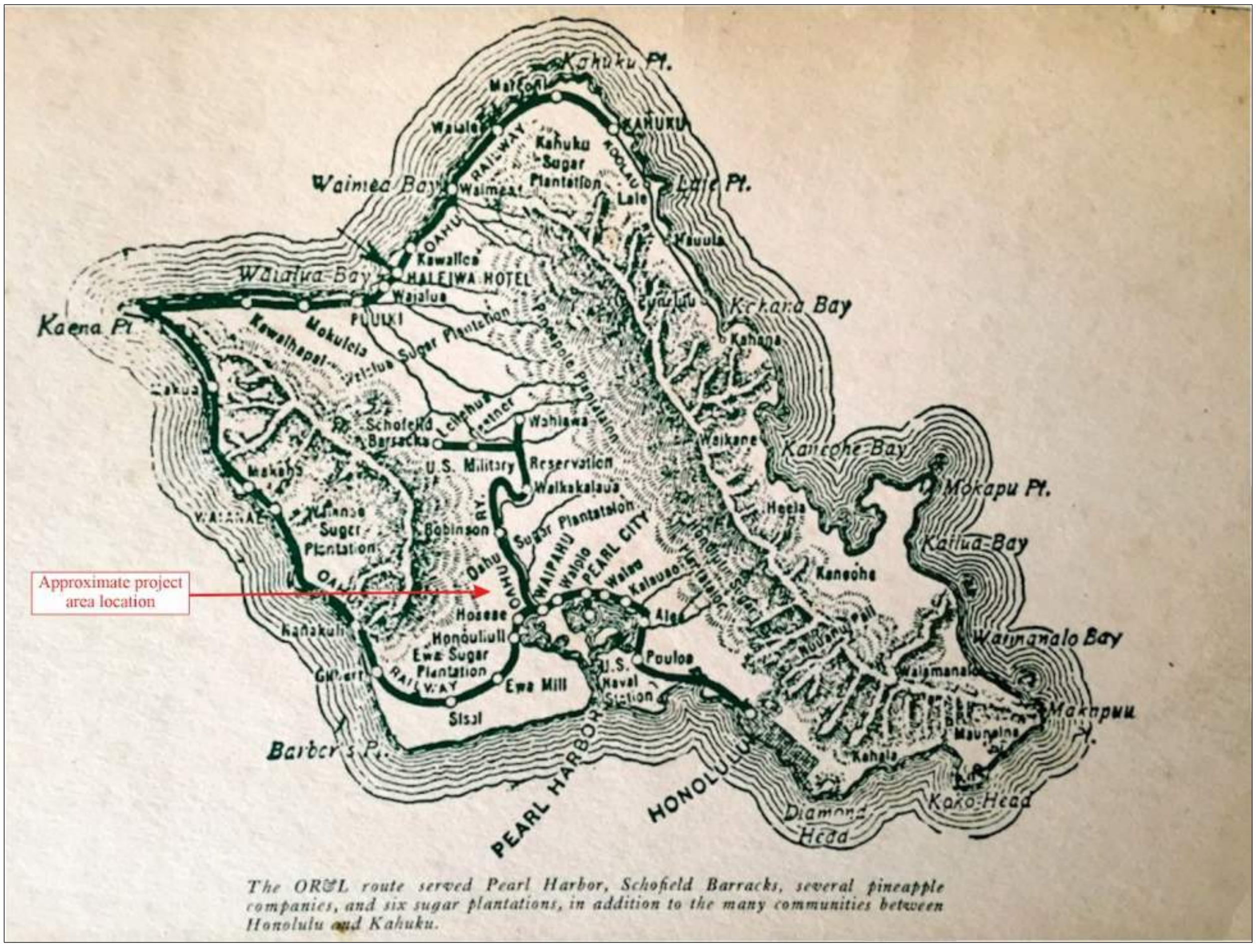


Figure 23. Map of completed OR&L railroad on O'ahu.

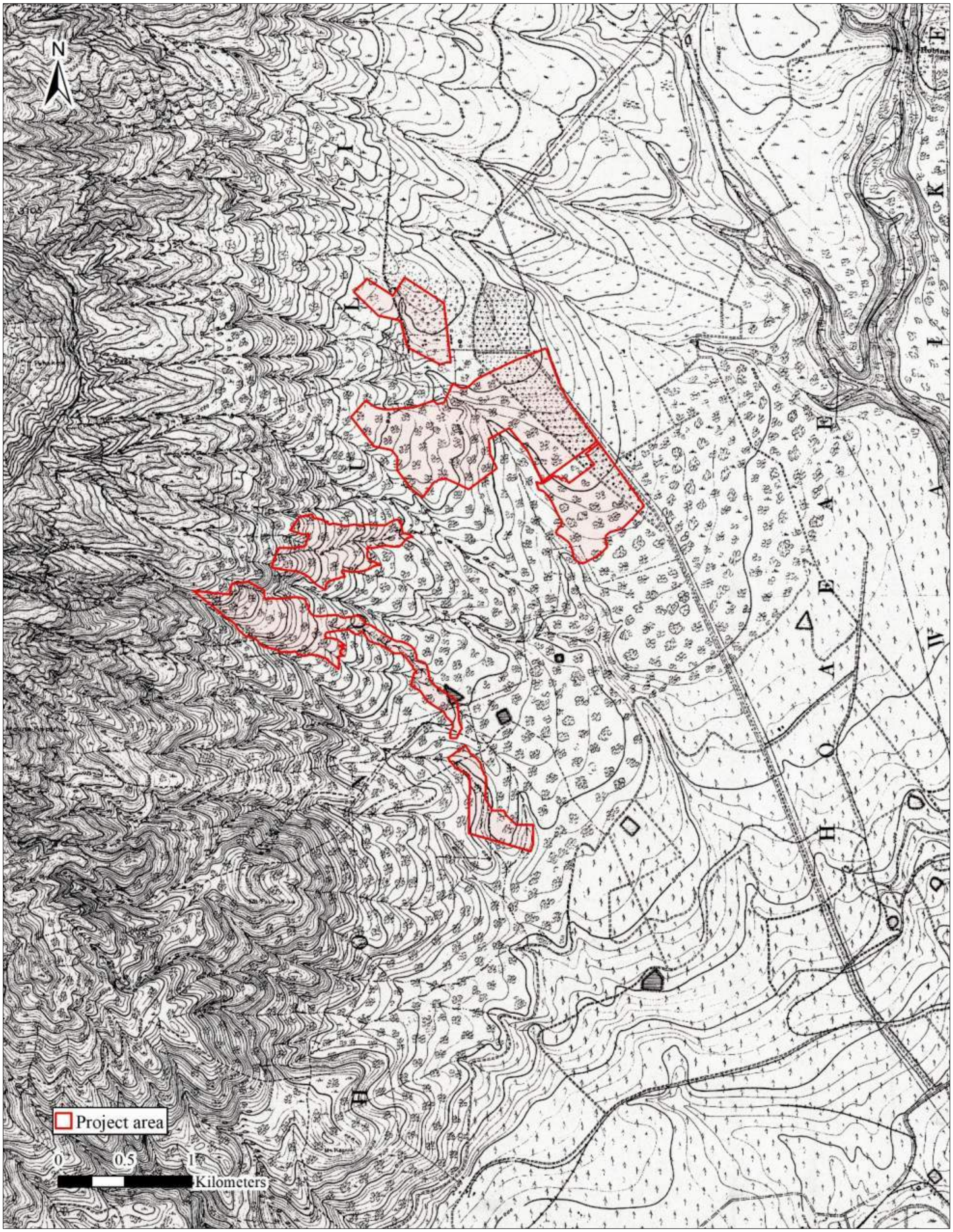


Figure 24. 1913 Terriitory of Hawai'i Survey map, Schofield Barracks Quadrant.

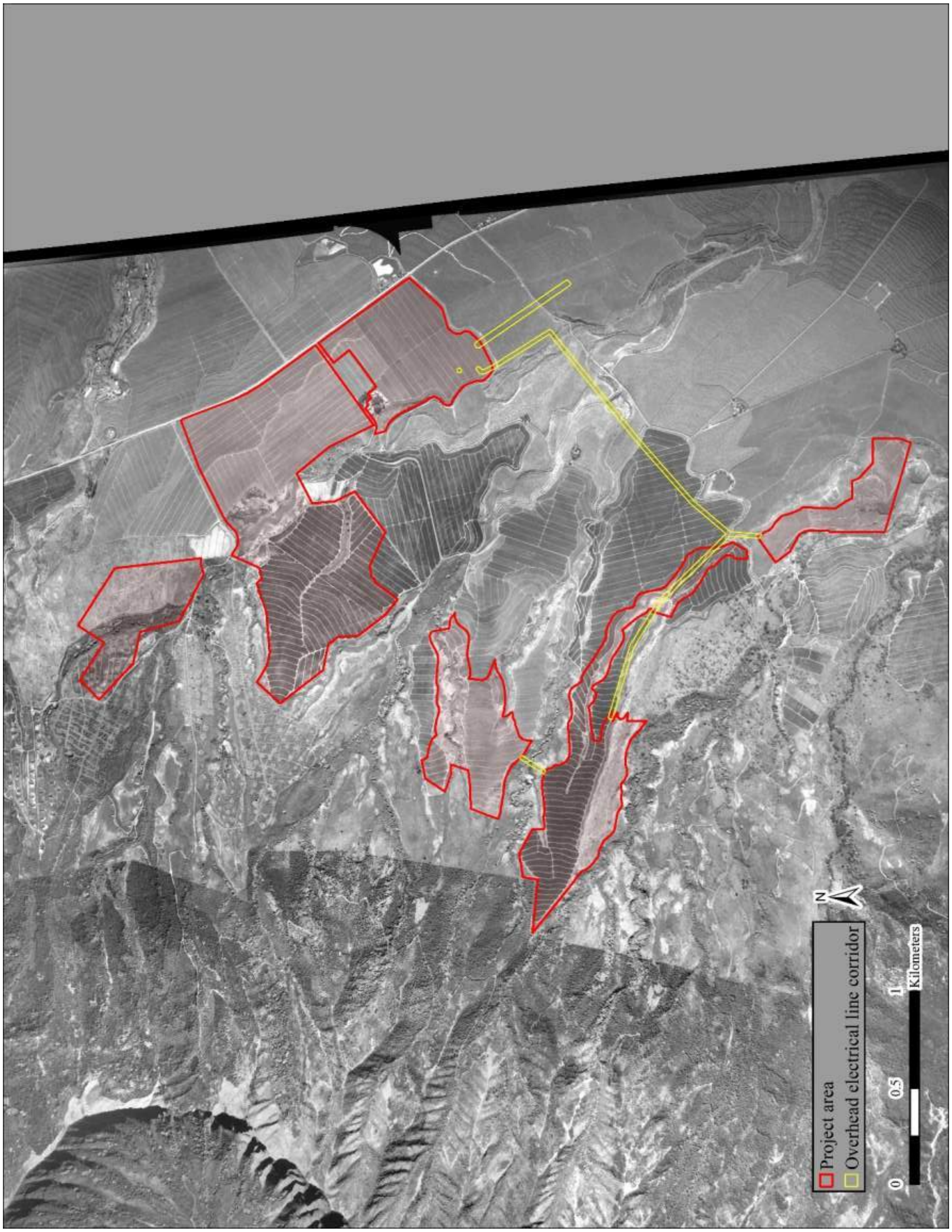


Figure 25. 1951-52 aerial photo of the project area showing Waiahole Ditch and associated reservoirs in the project area vicinity.

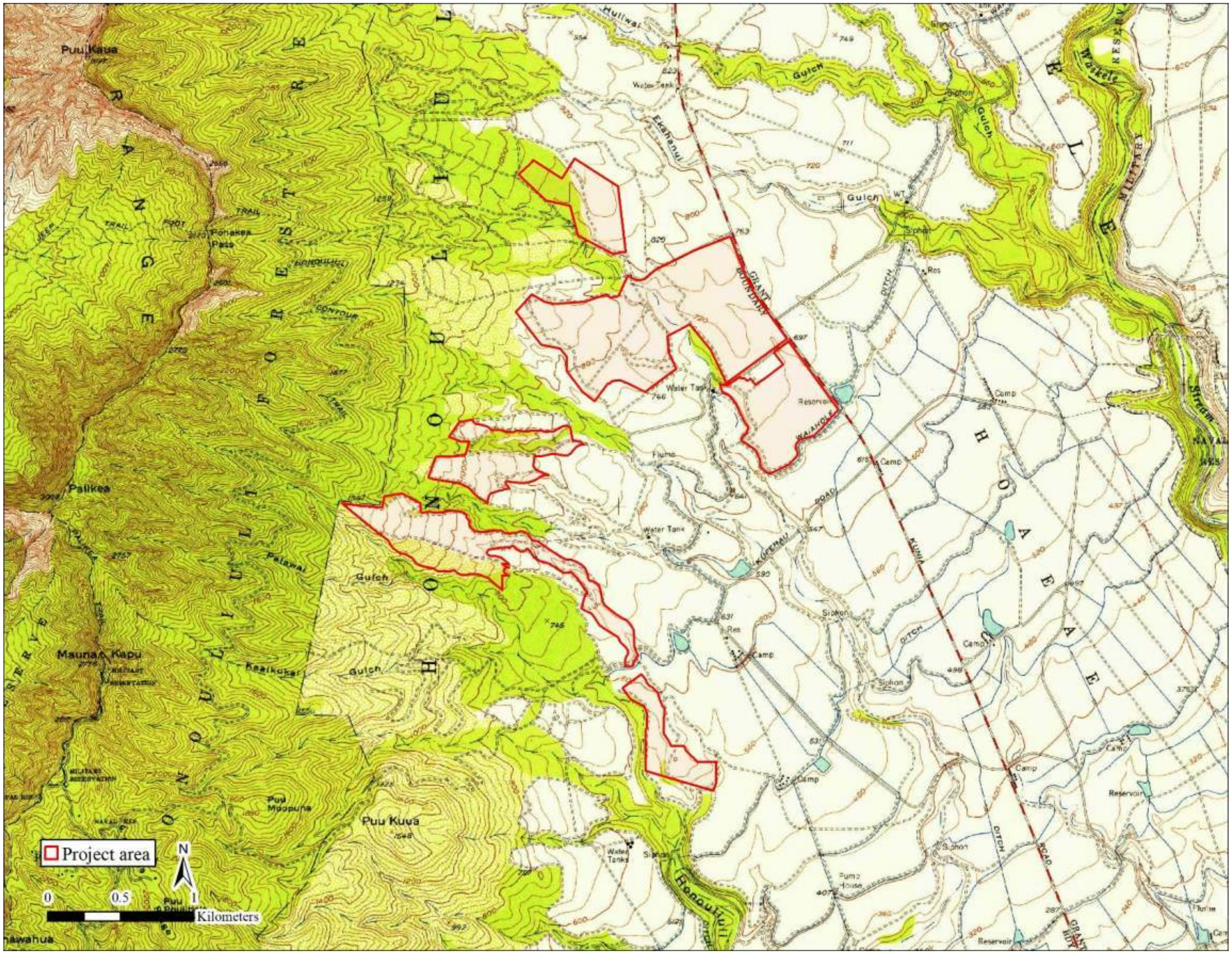


Figure 26. A portion of the 1953 USGS map, Schofield Barracks Quadrant showing project area and Waiahole Ditch and associated reservoirs.

Military Development

Pearl Harbor was used by foreigners as a military sea port in 1794 when John Kendrick used his ships to fire canon for several days at invading warriors from Kaua'i at the bequest of Chief Kalanikūpule of O'ahu during the "Battle of Kuki'iahu." Kotzbue (1821), a Russian sea captain, heard the name "Pearl Harbor" from Kamehameha I in 1816, and upon inspection of the port noted its depth and breadth, writing that it should be improved by Europeans. In 1824 an expedition was organized to take soundings of the depths of Pearl Harbor and the lochs by the HMS Blonde which arrived at Honolulu on May 3, 1825 (Byron 1826). In 1840 further survey of the harbor was conducted by Commodore Charles Wilkes of the U.S Exploring Expedition, who observed that:

> The inlet has somewhat the appearance of a lagoon that has been partly filled up by alluvial deposits. At the request of the king, we made a survey of it: the depth of water at its mouth was found to be only fifteen feet; but after passing this coral bar, which is four hundred feet wide, the depth of water becomes ample for large ships, and the basin is sufficiently extensive to accommodate any number of vessels. If the water upon the bar should be deepened, which I doubt not can be effected, it would afford the best and most capacious harbor in the Pacific. As yet there is no necessity for such an operation, for the port of Honolulu is sufficient for all the present wants of the islands, and the trade that frequents them (Wilkes 1845:79).

By the second half of the 19th century, U.S. nationals residing in Hawai'i began making serious efforts to secure Pu'uloa as an exclusive U.S. naval harbor (Kuykendall 1953). According to a newspaper article titled "Honolulu and Pearl Harbor Vital Centers of America's Power in Pacific," beginning in the 1840s, members of the U.S. government made it clear to all European countries who showed any interest in occupying the Hawaiian Islands that the U.S. would not allow it (Evening Bulletin 1908:9). After earlier failed attempts to secure a treaty with the U.S., in 1875, King Kalākaua signed the Treaty of Reciprocity, which established a free-trade agreement between the Hawaiian Kingdom and the U.S. (Kuykendall 1967). Despite U.S. attempts to gain control over Pearl Harbor in exchange for the free-trade agreement, King Kalākaua refused to surrender sovereign control. However, amendments were made and the treaty was renewed in 1887, which allowed the U.S. to enter a section of Pearl Harbor and create a naval coaling and repair station. Many Hawaiian nationals opposed the signing of a treaty and asserted that a treaty between the Hawaiian Kingdom and the U.S. would ultimately lead to cession or annexation (Kuykendall 1967). Then, as countries in Asia began to show interest, the U.S. shifted their focus to the east. As the Spanish-American war unfolded, the U.S. worked "to acquire the sovereignty of the Hawaiian Islands, both for the protection of the [U.S.] Pacific coast and in order to make it possible to maintain any naval base in the Far East" (Evening Bulletin 1908:9). The need for a mid-Pacific base highlighted the importance of Pearl Harbor and Hawai'i. In 1898, under the administration of President William McKinley, the U.S. government approved a joint resolution of annexation that purportedly established the Republic of Hawai'i as a U.S. Territory (Sai 2011). On April 30, 1900, President McKinley had signed the Organic Act which organized the Territory of Hawai'i and defined the political structure of the newly established government (An Act to Provide for a Government for the Territory of Hawaii (Organic Act), 31 Stat. 141, 56th Cong. Sess. 1 (April 30, 1900)) in Justice 2000).

These events led to sweeping and long-lasting changes that altered the political, economic, and socio-cultural fabric of these islands. In light of this massive political transformation, in 1899, President McKinley issued the first of severeal executive orders that set aside 15,000 acres of O'ahu's public lands for military use. By 1908, the U.S. began its process of transforming Ke-awa-lau-o-Pu'uloa into a military installation through dredging, construting a dry dock, barracks, warehouses, submarine base, radio center, and a hospital. By the 1930s, the harbor had become a mjor industrial base for the U.S. Pacific Fleet and other parts of O'ahu were developed as Army bases including Schofield Barracks located upland of Honouliuli in Wai'anae Uka (Justice 2000). In 1931 on a 213-acre parcel, the Navy constructed an ammunition depot at West Loch (Cruz et al. 2011). Throughout the remainder of the 1930s, the U.S. Navy expanded its operations in Honouliuli to include the construction of the 'Ewa Field, installation of roads in the coastal area, and purchased 3,500 acres of land to construct Barbers Point Naval Air Station (ibid.). A 1944 aerial photo (Figure 27) of the project area shows continued agriculture while a 1959 map obtained at the collections of the University of Hawai'i at Mānoa library shows the military expansion around O'ahu and extensive naval operations in the 'Ewa region (Figure 28).

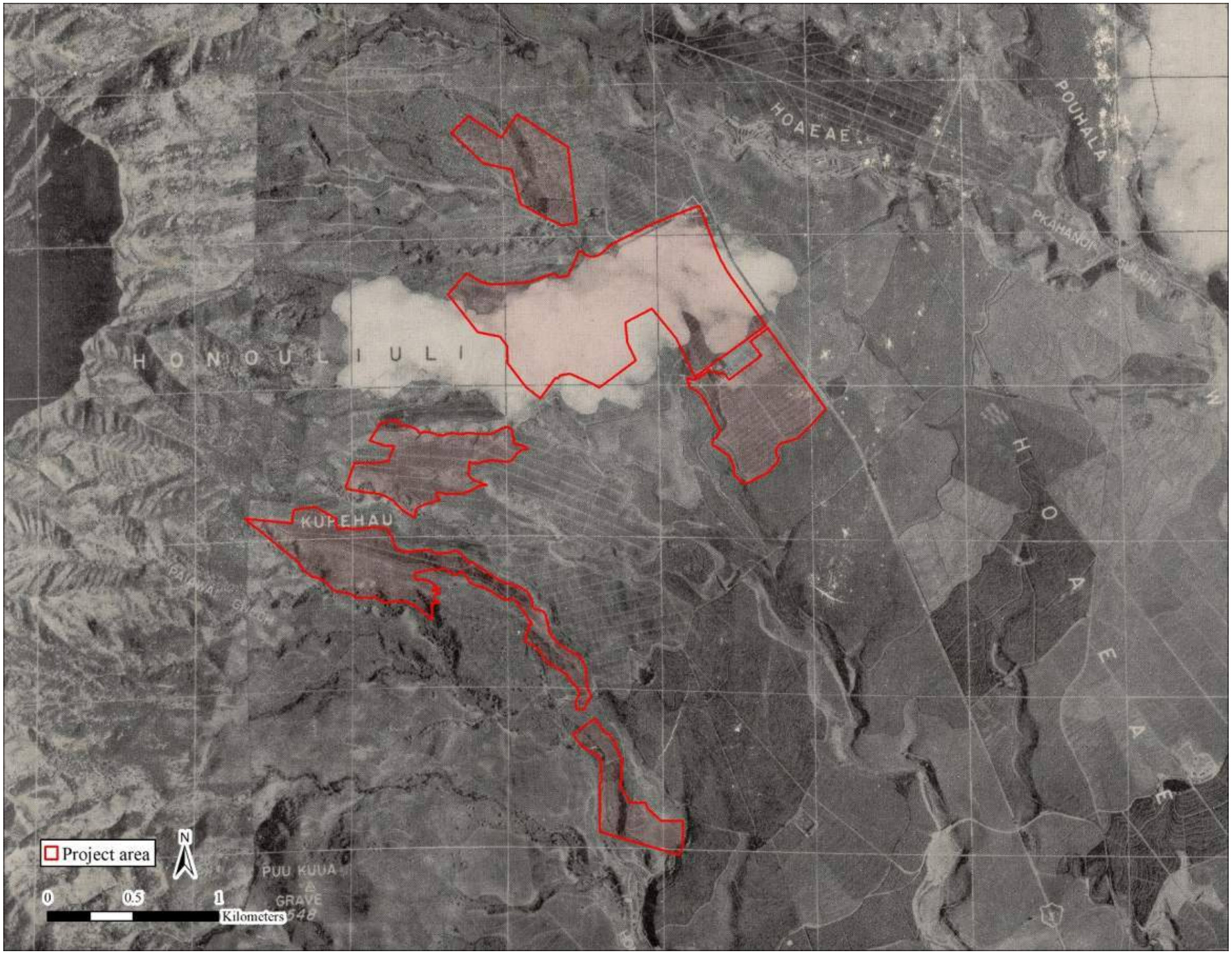


Figure 27. 1944 aerial of the project area showing continued agriculture.

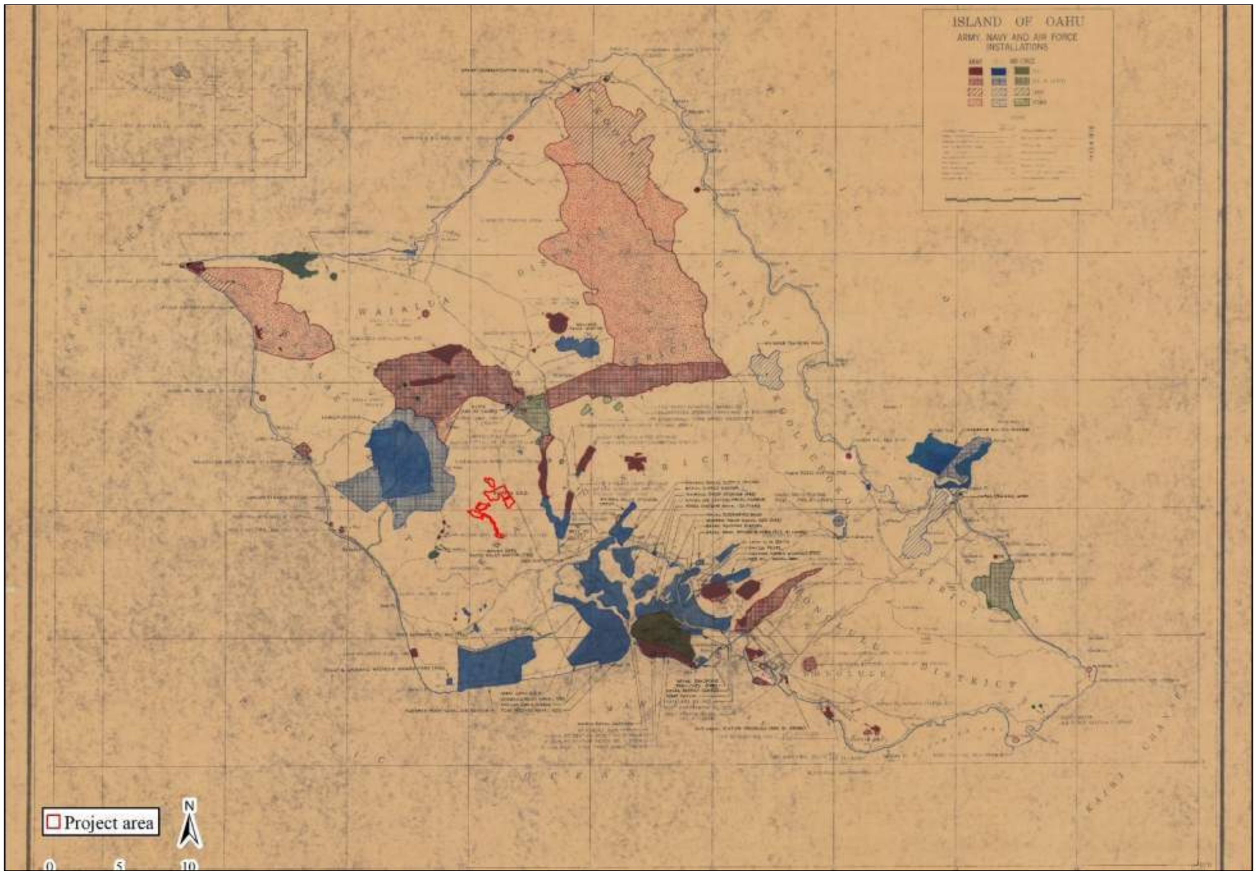


Figure 28. 1959 O‘ahu military installations map.

World War II and the Establishment of the Honouliuli Internment Camp

On the morning of December 7, 1941, the United States entered into World War II (WWII) after Japan launched an attack on U.S. Naval base in Pearl Harbor. By the afternoon, the Terrirotial Governor, Joseph B. Poindexter had declared martial law and hundreds of civilian arrest were made by the Federal Bureau of Investigation (FBI) and the U.S. Army. After the initial arrests were made, the FBI transfered the prisoners to the military police and prisoners were detained at several facilities in Honolulu. By March of 1942, internees and Prisoners of War (POW), the majority of which were of Japanese ancesty, were relocated from Sand Island to the Honouliuli Internment Camp.

The camp was built by the U.S. military and was set up along the floodplains of Honouliuli Gulch, just south of the project area (Figure 29) on land leased by the Oahu Sugar Company from Campbell Estate (Burton and Farrell 2011). The camp “was designed to encompass up to 160 acres, with facilities for approximately 3,000 prisoners of war and civilian internees” and the “Army cleared trees and grass in the densely vegetated valley at Honouliuli to enhance security” (Burton and Farrell 2011:46). Honouliuli served as a base camp and a point of transfer for POW. The camp was also known by other names including Alien Internment Camp and later POW Compound Number 6, however, internees referred to it as *Jigoku-Dani* (“Hell Valley”) because of its secluded location and often intense heat (Farrell 2017). “Honouliuli was divided into several compounds, so that prisoners of war and civilian internees were separated, and civilian Japanese Americans were separated from German Americans” (Nye in Farrell 2017:25). While there are no clear record of the number of individuals that were housed at the camp, it has been estimated that by 1945, the “prisoner population at Honouliuli may have reached 4,000 or more” thus exceeding the planned capacity (Falgout in Farrell 2017).

Figure 29. Honouliuli Internment and POW camp ca. 1945 (from Hawaiʻi Plantation Village, Waipahu in Burton and Farrell 2011:26).

According to Burton and Farrell (2011:47), archaeological and archival research inidicates that the "...Honouliuli internment camp was expanded at some point in its occupation..." With the lifting of martial law on October 24, 1944, there was no legal basis for detaining citizens and by December of 1945, the repatriation of prisoners began. Sometime before 1948, the camp was abandoned and demolished by the U.S. Army Corps of Engineers (Figure 30). By 1958, the land was leased by Mr. Rodney Santiago for ranching which lasted until 2000 (Farrell 2017).

Archaeological investigations conducted between 2006 and 2017 resulted in the identification of 215 features, 175 of which are directly associated with WWII camp. The forty remaining features not associated with the camp includes two ditch systems that pre-date the camp as well as post-war agricultural features (Farrell 2017). In 2009, Burton and Farrell prepared a National Register nomination and three years later on February 21, 2012, the site was was assigned SIHP Site 50-80-08-9068 and listed on the National Register of Historic Places. In 2015, under the administration of President Barak Obama, the Honouliuli Internment Camp was established as a national monument (Figure 31) (Secretary 2015). The northern most section of the Honouliuli National Historic Site is situated just beyond the project area's southern boundary (see Figure 31).

The Honouliuli National Historic Site is currently managed by the National Park Service (NPS) and is closed to the public until all of the NPS planning requirements have been completed. NPS along with various community stakeholders including The Japanese Cultural Center of Hawaiʻi, Pacific Historic Parks, and the University of Hawaiʻi West Oʻahu are currently in the strategic planning phase, which is necessary for the establishment of any national park.

Figure 30. Abandoned Honouliuli Internment Camp with the Waiahole Ditch in foreground (Hashimoto Collection in Farrell 2017:31).

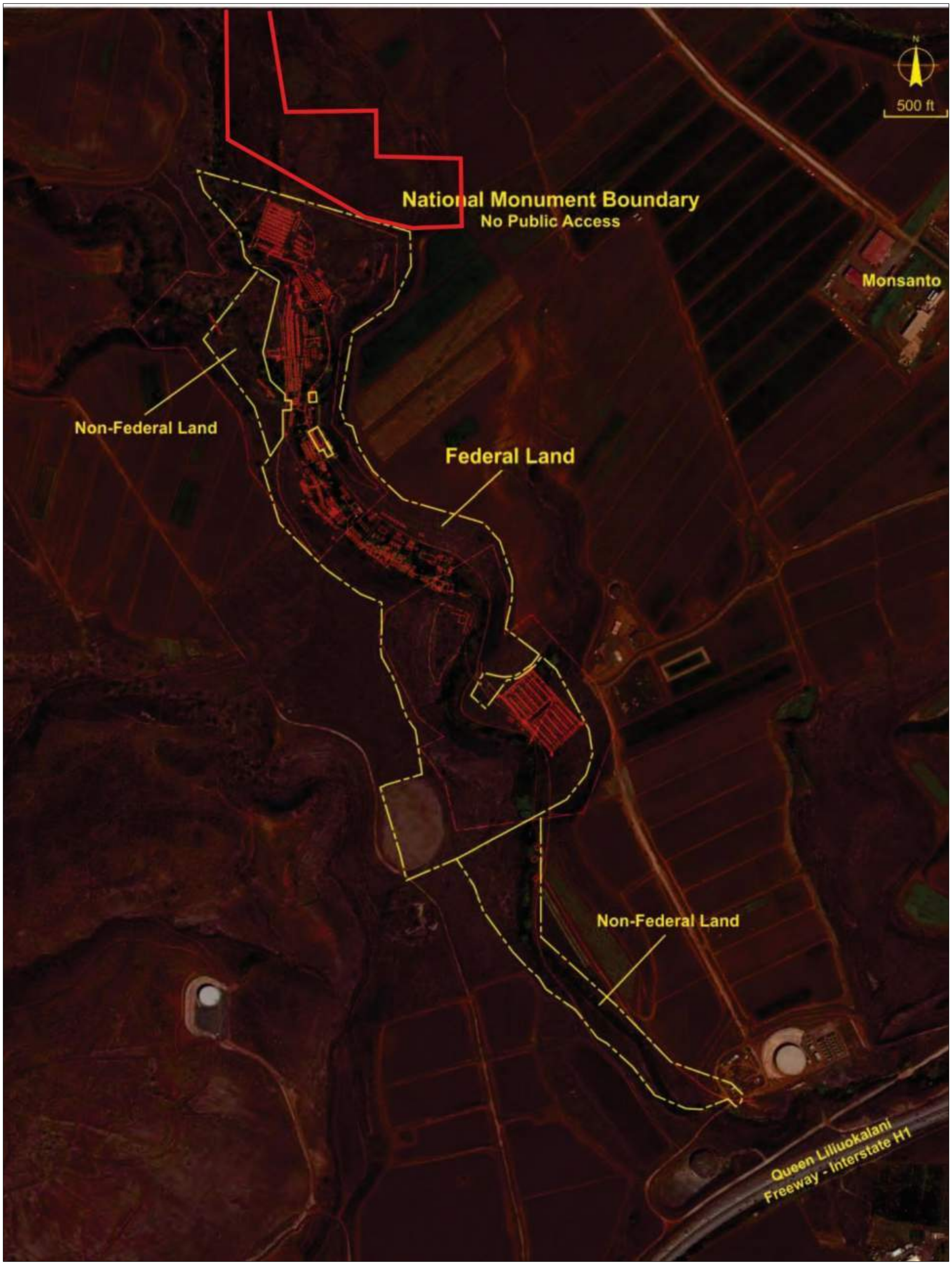


Figure 31. Honouliuli National Monument (from Farrell 2017:268), with southern section of current project area (Solar Array Area 5) outlined in red.

Residential and Commercial Development

O'ahu Sugar Co. continued commercial sugar cultivation throughout the second half of the 20th century before it closed its operations in 1995. An aerial photo taken in 1962 (Figure 32) shows the project area under commercial sugar cultivation. The land then returned to the estate of James Campbell who then leased the property to Del Monte Fresh Produce, Inc. for pineapple cultivation. With respect to the current Hartung property which comprises the majority of the project area with the exception of the northern and southern most section, in 2008, Syngenta Hawaii, LLC a subsidiary of Syngenta Seeds, Inc. (an indirect subsidiary of Syngenta AG, a Switzerland-based multinational agricultural company) utilized the majority of the property for agricultural research, development, and seed corn production. In 2017, the Wisconsin corporation, Hartung Brothers Inc. purchased the property where they have continued to expand its agricultural operations for the cultivation of various food crops including beet, carrots, cucumbers, lima beans, peas, snapbeans, sweet corn, and seed corn (PBR Hawaii 2018).

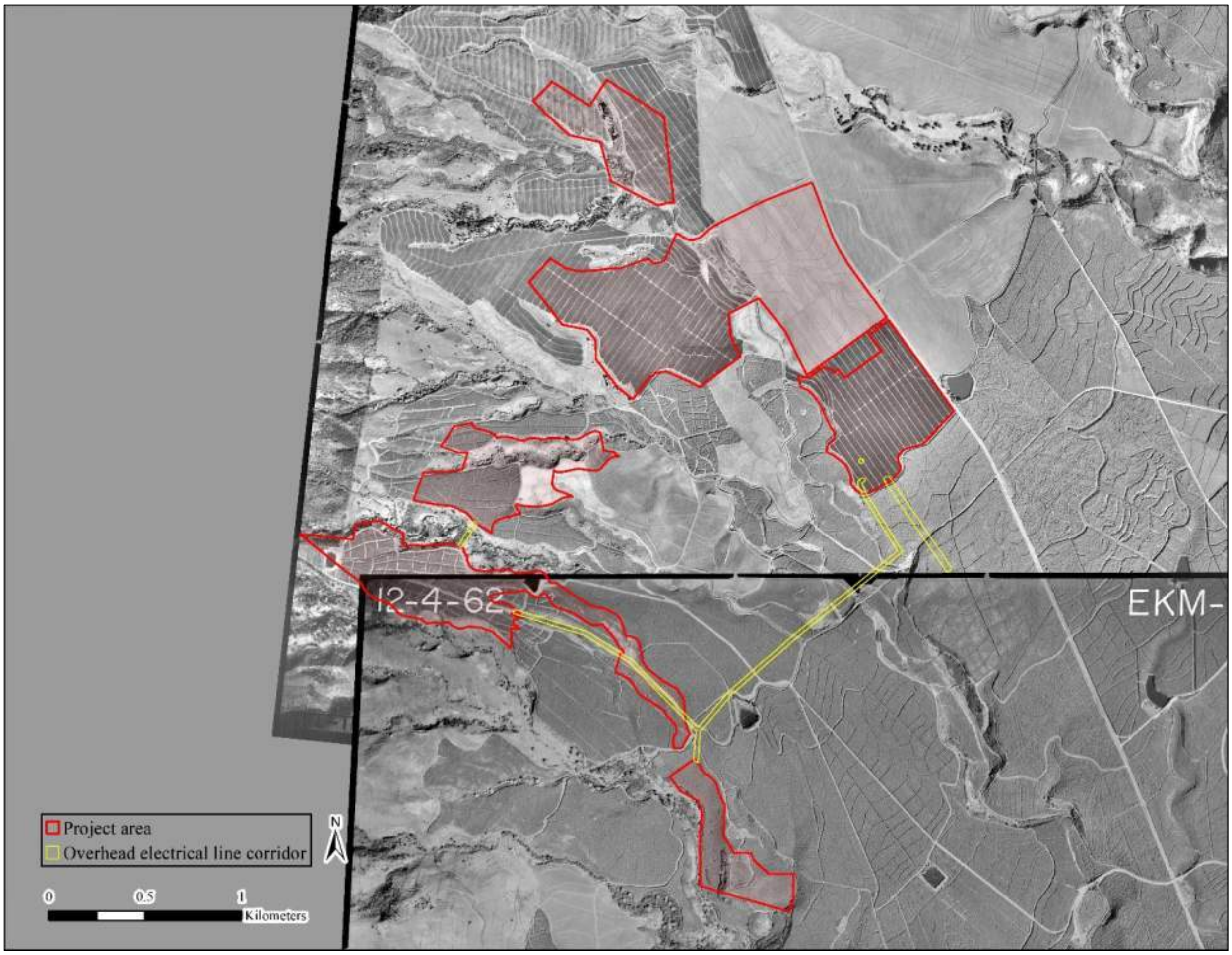


Figure 32. 1962 aerial images (2, registered) with the current project area outlined in red.

PRIOR ARCHAEOLOGICAL STUDIES

During his 1906 seminal work, Thos. G. Thrum (1906) only references one *heiau* in this general region of the 'Ewa District. No name is provided for a former *heiau* located on "Kapolei hill, Ewa.—Size and class unknown." Other early archaeological work conducted by J. Gilbert McAllister in 1930 and published three years later (McAllister 1933) as *Archaeology of Oahu*, identified three sites (Sites 134, 135, and 137) in the general vicinity (to the west and south) of the current project area (see Figure 13). Site 134, Puu Kuina Heiau, destroyed by the time of McAllister's fieldwork in 1930 was located in Kaaikukai/Kaaikukui gulch. McAllister (1933:107) reported that "[t]he suggestion of a terrace is about all that remains, and no idea of the size of the heiau or the number of terraces can be obtained." Site 135, a series of stone enclosures, was interpreted by McAllister (ibid.) to have been "kuleana sites," likely inferring a residential function. Site 137, also destroyed by the time of McAllister's 1930 fieldwork, was identified as "Puu Kuua Heiau" (McAllister 1933:108). McAllister (ibid.) related, "The heiau was located on the ridge overlooking Nanakuli, as well as Honouliuli, at the approximate height of 1800 feet. Most of the stones of the heiau were used for a cattle pen located on the sea side of the site. That portion of the heiau which has not been cleared for pineapples has been planted in ironwoods."

McAllister's (1933) work was recompiled and augmented, first in 1962 and then again in 1978, by Elspeth Sterling and Catherine Summers. With respect to the current project area vicinity, Sterling and Summers (1978) added results of fieldwork reported by Elspeth Sterling and Yosihiko Sinoto in 1960 to the north of the current study area at Ekahi Nui Gulch. Sterling and Summer (1978:37) related:

> Ekahi Nui Gulch is situated between Puu Kaua and Puu Kanehoa. Up to about the 1200-foot elevation the valley's sides are not too steep. Around this elevation, along the sides of the stream, were remains of many terraces and some house sites. There are enormous boulders scattered around the valley and under their shelter was found paving and in some cases a small platform or terrace in front. Under one large boulder there was paving as well as many basalt spawls, indicating some kind of 'workshop' perhaps A burial platform was also seen, of fairly recent construction.
>
> To the north, on the ridge above, on fairly level land just mauka of a fence there was a stone platform approximately 9 feet x 15 feet which was in a poor state of preservation. This may possibly have been a small heiau hoʻouluʻai for the agricultural activity in the valley.

A review of the records on file at the DLNR-SHPD revealed that numerous archaeological studies have been conducted in Honouliuli Ahupuaʻa beginning in the 1970s with the advent of the Cultural Resources Management industry to comply with both federal and state laws and regulation. The vast majority of these studies were conducted in the coastal areas and areas *makai* of Farrington Highway where military and residential and commercial development activities were occurring. The following discussion focuses on those studies that are more proximate to the current project area.

Beginning in 2002 there were a series of archaeological studies (Perzinski et al. 2003; Pammer et al. 2010; Tulchin and Monahan 2011; Monahan and Thurman 2013; McMahon and Tolleson 2014) with overlapping boundaries conducted adjacent to the western boundaries of the current project area (Table 2; Figure 33).

In 2002, Cultural Surveys Hawaiʻi, Inc. (CSH) conducted an Archaeological Inventory Survey (AIS) of roughly 250 acres (see Figure 33) for the proposed Kunia Landfill project (Perzinski et al. 2003). As a result of the AIS fieldwork, Perzinski et al. (2003) recorded six sites (SIHP Sites 50-80-12-6456 through -6461) containing thirty-two features. Site 6456 was described as "a temporary habitation terrace, an agricultural clearing mound and a trail segment" (ibid.:50). Site 6457 was described as "a large walled enclosure, connected terraces and a clearing mound and located in the central gulch leading to Pōhākea Pass. The enclosure contains a small terrace within the interior, a ramp on the outside wall and three soil retaining terraces directly below the ramp feature" (ibid.). Interpreted as a *heiau*, this site yielded radiocarbon dates indicating occupation during both Precontact and early Historic times. Site 6458 was described as two (Features A and B) filled crevices possibly used for temporary habitation as the "leveled surface of Feature B has an area of approximately 4 m^2 with the southeast portion of the surface flush with the surrounding topography and the northwest side elevated 63 cm above the ground surface. The feature appears to have been deliberately leveled and raised off the ground and would have offered ample space for a small shelter or temporary habitation." (ibid.). Sites 6459 and 6460 were described as remnant Historically constructed stone boulder features near existing roadways, and both were left as functionally "indeterminate" (ibid.) Site 6461 "consists of historic roads, cuts and culverts" (ibid.) All six were assessed as significant under Criterion d and Site 6456, interpreted to be a *heiau*, was assessed as significant under Criteria c and e as well. This site was recommended for preservation while Sites 6458 and 6461 were recommended for data recovery. Sites 6456, 6459, and 6460 were considered fully documented requiring no further work.

In 2009, CSH (Pammer et al. 2010) conducted an AIS for the proposed Kunia Loa Ridge Farmlands Project on approximately 294 acres (see Figure 33); which subsumed the Perzinski et al. (2003) project area. Pammer et al. (2010) identified eight historic properties, inclusive of the six sites recorded earlier by Perzinski et al. (2003). The two additional sites were SIHP Sites 50-80-12-7125, a possible anthropomorphic Historic Period petroglyph; and Site 7126, a relatively large (10 square meters) rock mound of indeterminate age and function (Pammer et al. 2010). All eight sites were assessed as significant under Criterion d, with Site 7125 also assessed as significant under Criterion e. Pammer et al. (2010) recommended treatments consistent with the Perzinski et al. (2003) study, adding a preservation treatment for Site 7125 and a no further work treatment for Site 7126.

Table 2. Prior archaeological studies conducted in the vicinity of the current project area.

Year	*Author(s)*	*Type of Study*	*Location*
2003	Perzinski et al.	AIS	Northwest of current project area
2010	Pammer et al.	AIS	West of project area
2011	Tulchin and Monahan	Recon	West of project area
2013	Monahan and Thurman	AIS	West of project area
2014	McMahon and Tolleson	AIS	Northwest of current project area
2017	Farrell	Research/UH Field Schools	South of current project area

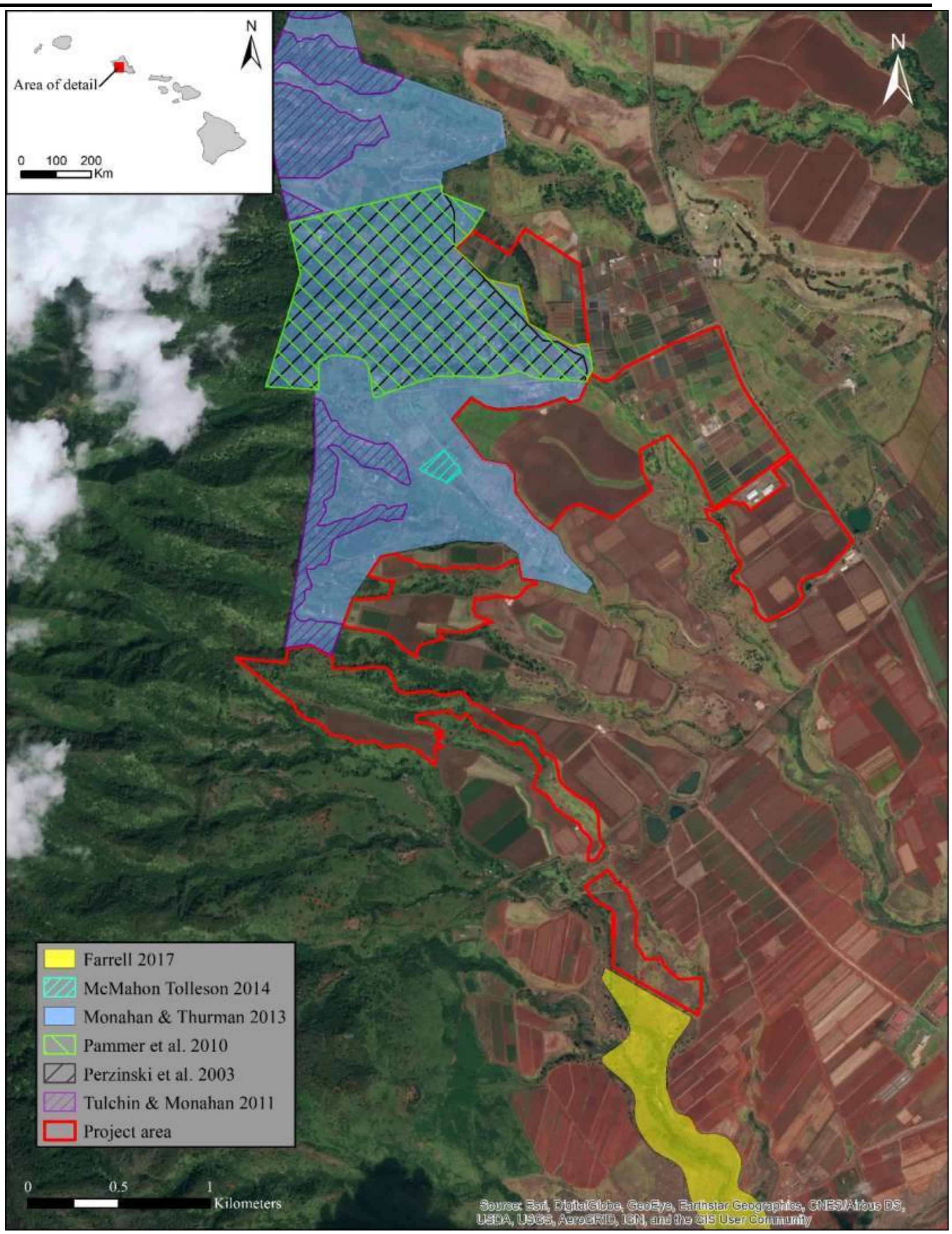


Figure 33. Locations of relevant prior studies.

In 2011, CSH expanded on their earlier (Pammer et al. 2010) AIS with an Archaeological Reconnaissance Survey (Tulchin and Monahan 2011) of an expanded Kunia Mauka Loa Ridge Farmlands Project (see Figure 33). The reconnaissance focused on gulch and drainage areas, rather than plateaus and level raised areas that had been subject to heavy commercial agriculture. Tulchin and Monahan (2011) identified twenty-nine additional sites, several newly identified possible burial feature (SIHP Sites 50-80-12-7341 and two newly discovered features at Site 6459). The complete results of the Tulchin and Monahan (2011) reconnaissance were included in a subsequent AIS conducted by TCP Hawai‘i, LLC (Monahan and Thurman 2013).

In the meantime, during October of 2012, Exploration Associates, Ltd. (McMahon and Tolleson 2014) conducted an Archaeological Assessment of a 5.295 -acre parcel (Lot 23) within the Kunia Mauka Loa Ridge Farmlands Project area (see Figure 33); on a lot not specifically investigated during any of the earlier conducted CSH studies. McMahon and Tolleson (2014:18) reported that “[n]o archaeological sites or artifacts, either surface or subsurface were identified within the parcel.”

Starting in December of 2012 and lasting until March of 2013, TCP Hawai‘i, LLC completed fieldwork for an AIS (Monahan and Thurman 2013) for the approximately 854 acre Kunia Mauka Loa Ridge C&C Farmlands Project area (see Figure 33). This study encompassed the areas that were the focus of the four above-discussed studies. Monahan and Thurman (2013) recorded sixty sites (Figure 34), and provided the following summary of their findings:

> . . . 60 historic properties have been identified. This includes 14 sites that can be loosely categorized as Plantation infrastructure: nine of these (7346, 7442, 7443, 7444, 7445, 7446, 7450, 7452 and 7453) are flumes, siphon/pipes, concrete and mortar-and-rock retention basins, and sluice gates; four of these (7333, 7338, 7441 and 7451) are road-related and include unimproved roads, culverts and retaining terraces beneath roads; finally, one of these (7455) is a truly impressive field-clearing pile of boulders approximately one acre in size. . . . The range of dates for these plantation sites is probably around 100 years ago at the oldest and extending into the 1960s in some cases (e.g., the concrete flumes).
>
> Eleven sites appear to be related to ranching activities in Historic times: seven of these (7323, 7324, 7330, 7332, 7347, 7349 and 7458) are walls, short remnants of walls and rock fence line bases, which look like short walls but likely functioned along with fence posts and wire as fences; two of these (7334 and 7440) are bulldozed road segments in an area (upper ‘Ēkaha Nui Gulch) that plantation activities did not impact; one of these (7348) is a mound cleared to make way for a dirt road; and one of these (7329), also in the non-plantation-activity area of upper ‘Ēkaha Nui Gulch, is some bulldozer push and probably hand-piled boulder alignments and piles.
>
> The most interesting sites, from the perspective of chronicling traditional Hawaiian use of the landscape, are those which retain traditional-style structures and which are either attributed to pre-Contact times or to “pre-Contact to early Historic.” . . . Sixteen sites have been interpreted as either pre-Contact or “pre-Contact to early Historic” with one (7343) having a mix of features from different time periods. The 16 pre-Contact/pre-Contact to early Historic sites include: two heiau complexes (6457 and 7447), one formal enclosure complex within which a burial was documented (7331), a very large and impressive terraced agricultural and habitation complex with a petroglyph in ‘Ēkaha Nui Gulch (7326), habitations and possible habitations (6456, 6458, 7325, 7340 and 7454) and several possible burial sites . . .
>
> Other notable sites include two extensive military (ca. 1940s) road complexes (6461 and 7335) and two petroglyph boulders (7125 and 7337) . . .
>
> A newly-discovered heiau (7447) is truly remarkable in terms of its good preservation, lack of Historic-era impact, and impressive structures and features—including an altar stone and a slab-lined hearth. . .
>
> Another impressive, newly-discovered site is a large, relatively undisturbed landscape of naturally-occurring boulder outcrops in the upper reaches of the project area—right at the boundary with the forest reserve in Lot 1—that have been modified by piling, stacking and leveling of cobbles and pebbles. This large (approximately 2-acre) site complex appears to represent a burial ground. (Monahan and Thurman 2013:30)

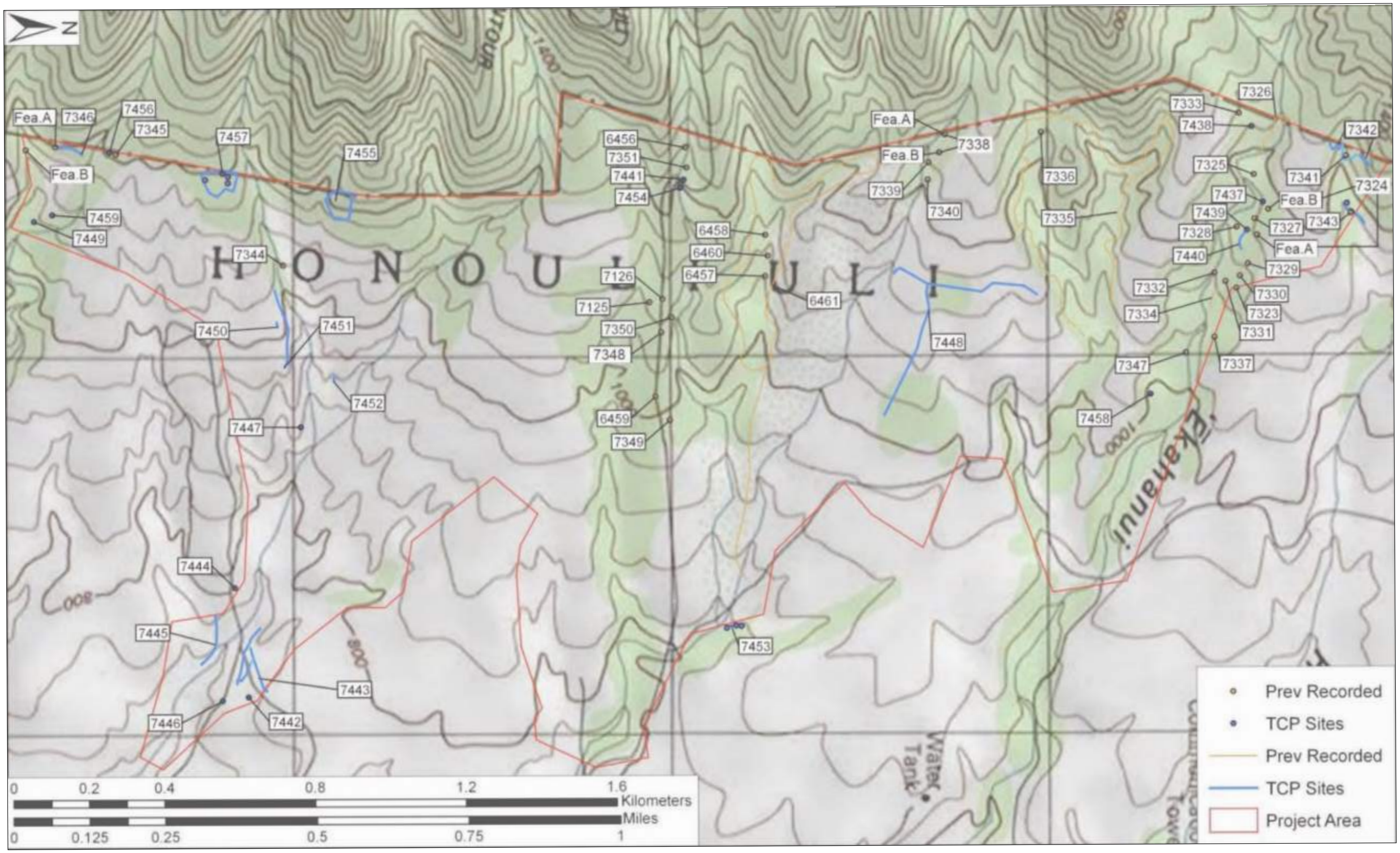


Figure 34. Locations of sites recorded rby Monahan and Thurman (2013:33).

In the evaluation of site significance, Monahan and Thurman (2013) seems to have conflated HRS Chapter 6E (HAR §13-284) assessments with HAR §13-198 (Hawai'i Register of Historic Places) evaluations. In any case, of the sixty sites recorded, Monahan and Thurman (2013) assessed six as "not significant," all associated with twentieth century plantation infrastructure. Thirty-nine sites were assessed as significant under Criterion d only, eight under Criteria d and e, one under Criteria c and d, and six under Criteria c, d, and e.

The following is Monahan and Thurman's summary of the site treatment recommendations:

> Thirty-two (32) sites are recommended for "no further work" (NFW). These NFW sites include the six that were evaluated as "not significant" . . .The rest of these NFW sites—with two possible exceptions—are Historic-era sites attributed to ranching or plantation activities, or indeterminate sites that do not appear to be Hawaiian constructions. For these sites, they have yielded their informational and research value, and no additional relevant information could be gained by either further work or preservation of these. One of the NFW sites is a small lithic scatter (7439). The other is a clearing mound that could be either/or pre-Contact to early Historic in age (7459). At both of these sites, there is no additional information that could be gained by further work or by preserving them.
>
> Twenty (20) sites are recommended for "Preservation" because they retain high cultural, emotional and/or sentimental value to some Native Hawaiians and/or because they have potential for yielding additional relevant data to historical or prehistoric research in the future.
>
> Finally, eight (8) sites are recommended for "Preservation and Burial Treatment Plan" (BTP) because they either have yielded human skeletal remains (7331) or because they resemble possible burials and probably contain human skeletal remains. (Monahan and Thurman 2013:380)

Except for two modified outcrops (Sites 7449 and 7459), all of the sites (n=9) described within or in close proximity to the current project area (see Figure 34) are related to Historic Period plantation infrastructure. Also, all nine of these sites were assessed as significant under Criterion d only and eight were recommended for no further work. Site 7449, a modified outcrop interpreted to be an excellent example of a traditional agricultural site was recommended for preservation. Monahan and Thurman (2013) clearly adopted a "splitter" approach when defining what features comprise an individual site, particularly with their segregation of Historic Period plantation infrastructure sites (n=14). As one of these site (Site 7346) appears to extend into the current project area, this site number (SIHP Sites 50-80-12-7346) will be applied to the grouping of functionally and temporally related Historic Period plantation features recorded during the current study.

In December of 2017, Mary Farrell completed a report (Farrell 2017) describing the archaeological investigations conducted over an eleven-year period (2006-2017) at the Honouliuli POW and Internment Camp (*Jigoku-Dani*). This work was started as a volunteer effort by the Japanese Cultural Center of Hawai'i and as it gained momentum, expanded to a University of Hawai'i field school opportunity. This work led to the listing of the Honouliuli Internment and Prisoner of War Camp Site (SIHP Site 50-80-08-9068) on the National Register of Historic Places in 2012, and the designation in 2015 of the Honouliuli National Monument. It is important to note that the boundaries of the National Register site and the National Monument are not the same; and with respect to the current project area, Figure 35 shows this relationship relative to the southern boundary of Solar Array Area 5. Of relevance to the current study, within the northern portion of Site 9068, identified as Compound I of the prisoner of war camp on U.S. Army maps (Figure 36), Farrell (2017:57) reported that "[a]ccording to Lodge (Gordon 1981), the far north end of this compound consisted of cane fields before the war, and the 1951 aerial photograph (as well as irrigation troughs found in the area) indicates it was cultivated after the war, too." Within in the extreme northern portion of their study area, several section of "Waialua flumes," referred to by Farrell (2017:58) as "concrete troughs," were recorded. No features seem to have been documented in the area between the National Monument boundary and the National Register site boundary.

Figure 35. Northern boundaries of Honouliuli National Monument (black line), National Register site (yellow line, and southern boundary of current project area (red line).

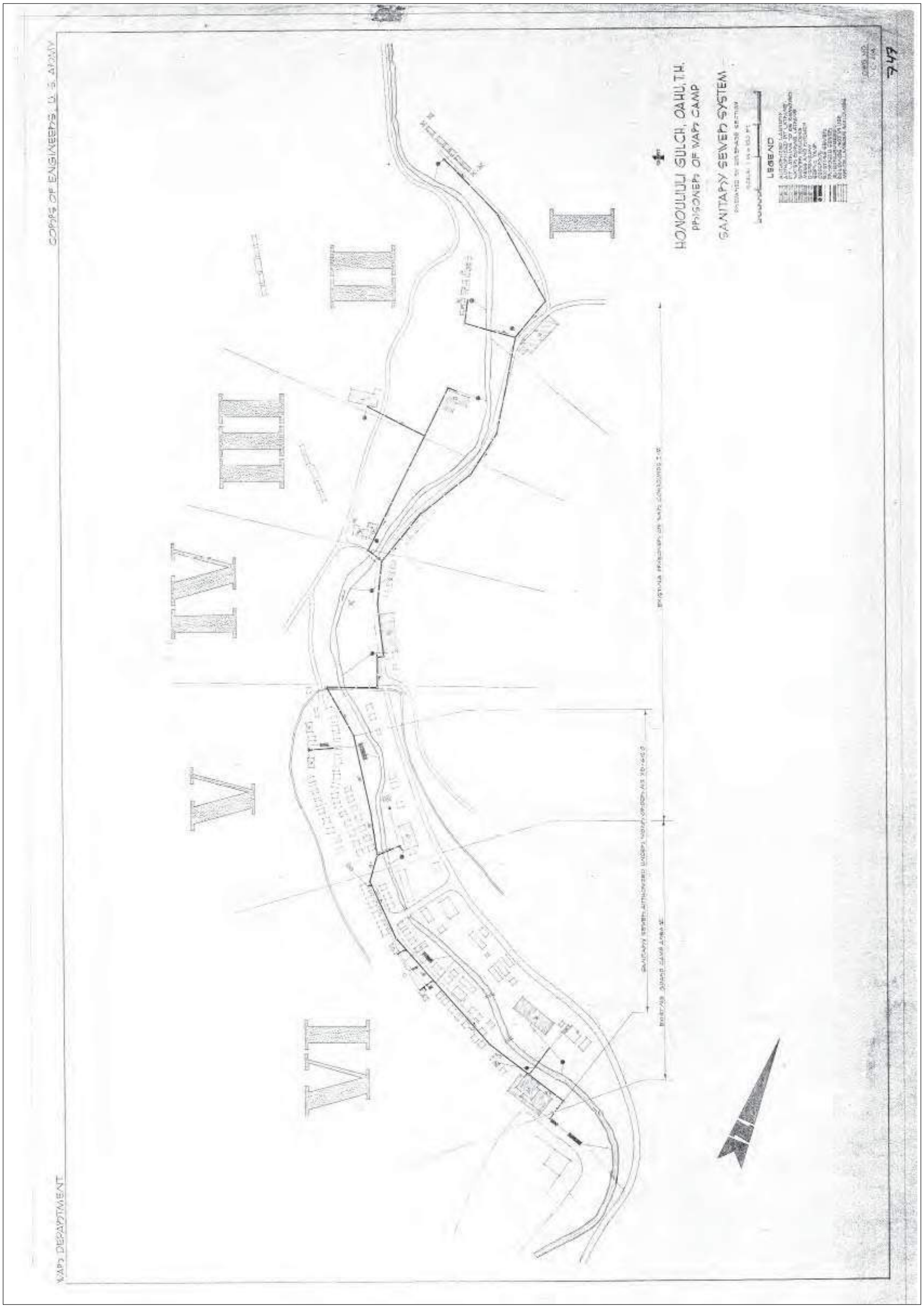


Figure 36. Honouliuli Gulch, O‘ ahu, T.H. Prisoner of War Camp Sanitary Sewer System, sheet 1 (from Farrell 2017:294).

3. PROJECT AREA EXPECTATIONS

A set of project area expectation is derived from the results of prior archaeological research coupled with the background research presented above. Archival maps (see Figures 13 and 16) indicate that the Pohakea Trail extending eastward from Pohakea Pass in the Waianae Range may traverse near or within the current project area. The prior Monahan and Thurman (2013) AIS located between the current project area and the Honouliuli Forest Reserve, from where the Pohakea Trail emerges did not find any physical evidence of the Pohakea Trail but did record features along Pohakea Road that may indicate the road superseded the trail in both that and the current project areas. Additional evidence for the supersession is seen on a 1936 US Army terrain map (Figure 37) showing the Pohakea Trail as a dotted line terminating into double red lines indicating the new Pohakea Road (perhaps built by the Army Corp of engineers) extending to Kunia Road. This alignment of Pohakea Trail/Road passes along and outside the southern boundary of Solar Array Area 4c and along and outside the northern boundary of Solar Array Area 4b.

Historic sugar plantation-related features have been recorded near the current project area boundaries; SIHP Site 50-80-12-7346, a water siphon/aqueduct feature was recorded by Monahan and Thurman (2013) as entering the current project from the north into Solar Array Area 1, Farrell (2017) noted concrete sectional troughs (Waialua flumes) in the area just south of Solar Array Area 5. It is expected that additional plantation infrastructure related to irrigation within the Oahu Sugar Company fields (Figure 38), including a portion of the Waiāhole Ditch (Site 2268) will be present within portions of the current project area. While Figure 41, which is undated, does not show operational Oahu Sugar Company fields where Solar Array Areas 3, 4a, 4b, and 4c, aerial imagery dating from 1944 (see Figure 27), 1951-2 (see Figure 25), and 1962 (see Figure 32) shows these areas under active cultivation. In fact, the proposed solar project area is situated almost entirely within lands that have been subject to intensive cultivation since at least 1916. Except for one proposed overhead electrical line that crosses a short shallow gulch area (connecting Areas 1 and 2), the development site does not include areas of high probability for Precontact or early Historic traditional archaeological resources. The prior research conducted to the north and west of the current study area indicates that the more prominent gulches and drainages were modified with terracing associated with traditional taro cultivation. It is, however, highly unlikely that anything other than twentieth century plantation-related features will be encountered within the current project area.

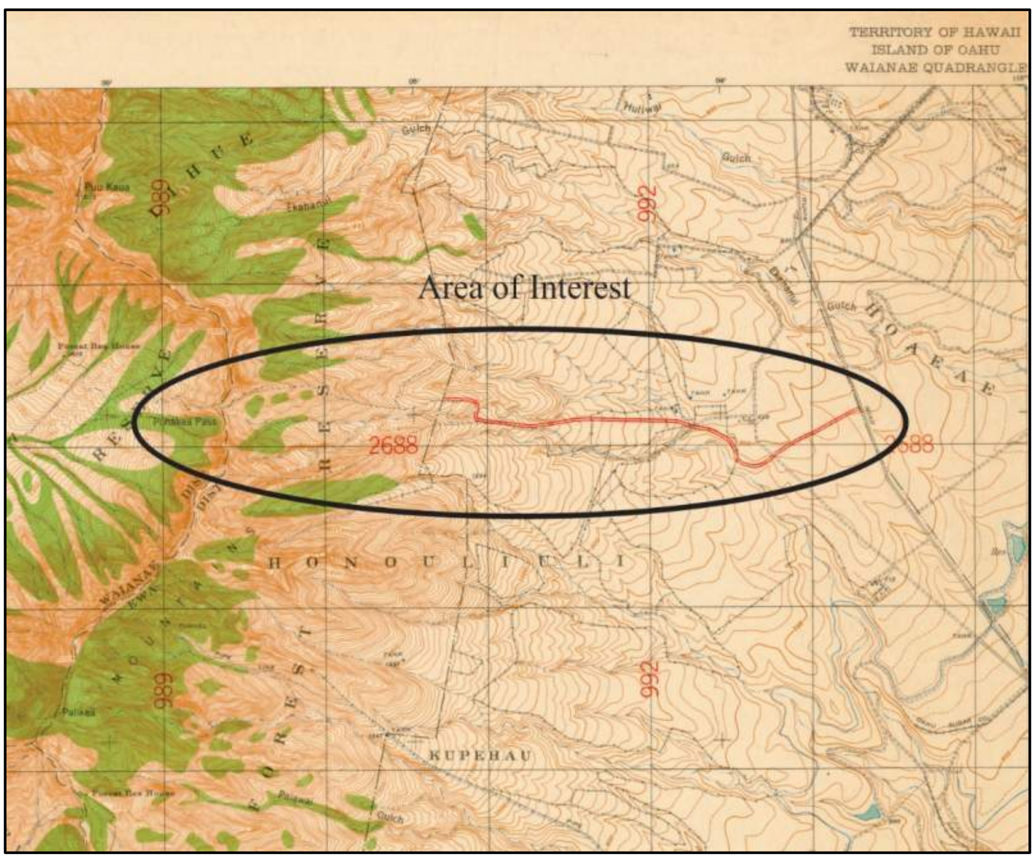


Figure 37. Portion of 1936 US Army Corp of Engineers terrain map.

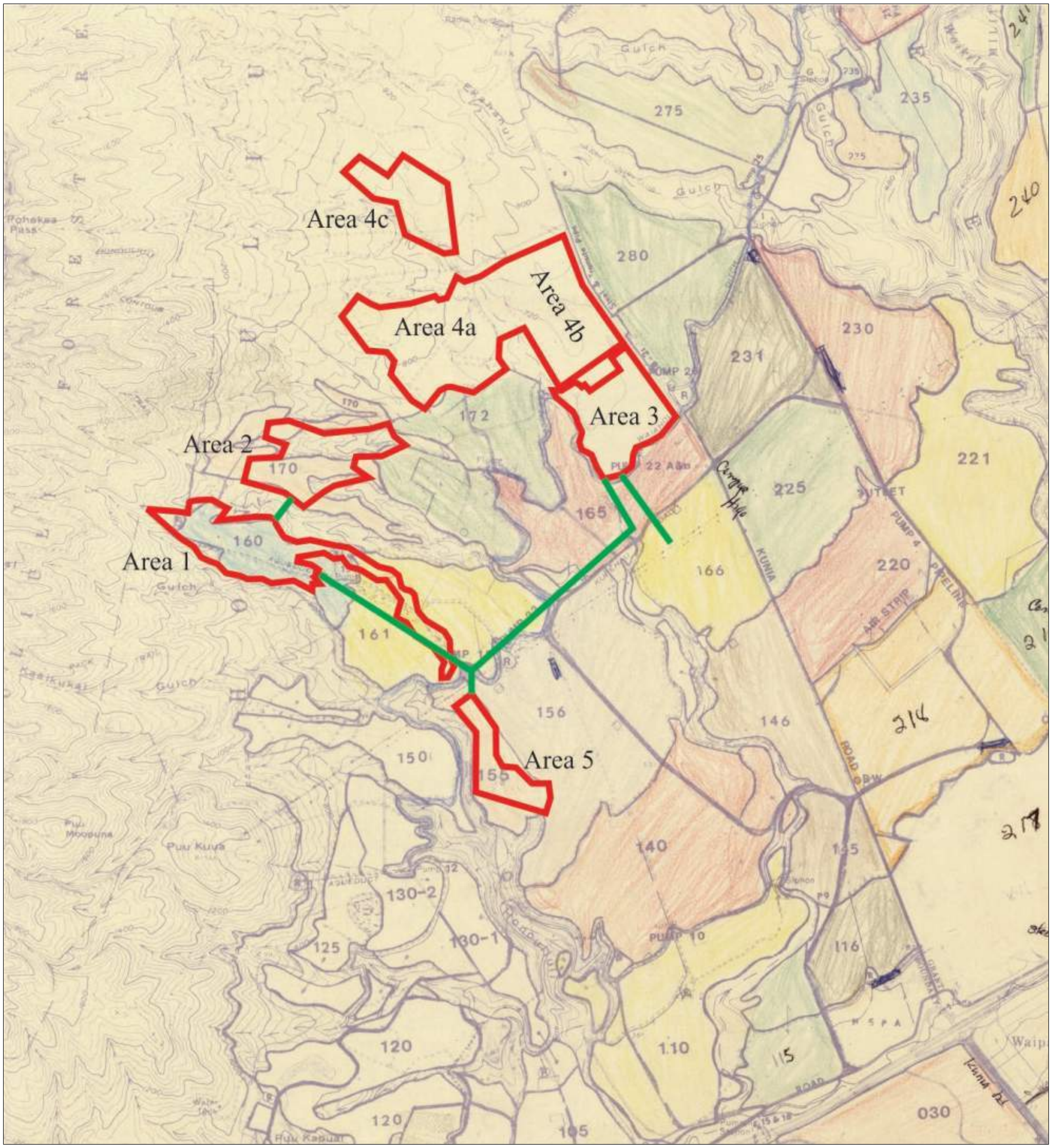


Figure 38. Portion of an undated (possibly 1950) Oahu Sugar Company field map with current project area outlined in red and proposed overhead electrical line corridor in green.

4. FIELDWORK

In March of 2018, ASM Principal Investigator Robert B. Rechtman, Ph.D. and Senior Archaeologist Teresa Gotay, M.A. conducted an initial site inspection to review the boundaries of the project area and develop a comprehensive fieldwork strategy to identify and document the historic properties contained therein. The survey fieldwork, site identification, and documentation were conducted between August 8 and 22, 2020 and from January 25 to 27, 2021 by Matthew Clark, M.A. (Principal Investigator), Teresa Gotay, M.A., Kimberly Lauko, B.A., Deidra Moore, B.A., and Daina Avila, B.A. A total of 185 person-hours was expended during the fieldwork.

METHODS

The entire project area was subject to intensive pedestrian transect survey. Transects spacing varied based on terrain and vegetation; in gently sloped areas with little to no vegetation and within cultivated fields, spacing could be as much as 20 meters apart, whereas in moderately sloped vegetated areas and in the one gulch area, transect spacing was reduced to 5 meters. Transect direction was chosen to take advantage of existing roads and field boundaries. Ground surface visibility was excellent over roughly 70% of the project area, good over roughly 20% of the project area, and poor over roughly 10% of the project area.

When potential archaeological features were encountered, the survey crew cleared vegetation and examined them more thoroughly. Those features determined to be historic properties were then documented and each feature was assigned a temporary site number sequentially as it was recorded (T-1, T-2, T-3, etc.), and a precise location for each of the recorded features was collected using a handheld tablet computer running ESRI's Collector application connected to an EOS Arrow 100 GNSS receiver with sub-meter accuracy (set to the UTM NAD 83 datum, Zone 4 North). It was decided that subsurface testing was not necessary as the project area had been subject to intensive commercial cultivation for over 100 years; no Precontact or traditional Hawaiian features were encountered and there was no cartographic information suggesting the existence of such former land use; and the identification, dating, and functional interpretations of the Historic Period plantation infrastructure features could be accomplished without such testing.

Given that the current study uses an existing SIHP number (SIHP Site 50-80-12-7346) to describe all of the newly identified features encountered during the current fieldwork, a short methodological discussion regarding site definition is appropriate. As mentioned earlier, Monahan and Thurman (2013) during the study of an adjacent property identified at least fourteen Historic plantation-related features. They chose to adopt a "splitter" approach to defining sites and assigned fourteen different site numbers. One of their sites (Site 7346) was recorded to extend into the current study area. This site is an irrigation feature used, in conjunction with numerous other irrigation features, to provide water to this portion of the Oahu Sugar Company's greater Waipahu region fields. The current study takes a "lumper" approach in defining this site by expanding it to include all of the newly identified plantation-related irrigation features encountered. Methodology, the archaeological "site" is the common analytical unit for undertaking comparative analyses. Sites are also the administrative unit for describing and defining archaeological resources, as mandated by the DLNR-SHPD. However, sites are not absolute quantifiable entities that are simply waiting to be discovered by archaeologists; rather, sites are defined through the interpretation of features and associations, both spatial and temporal. It is features that are absolute entities waiting to be discovered and described. It is features that archaeologists encounter in the field, not sites; and it is the associations of features in space and time that facilitate interpretation. Sites are defined once the features are recorded and the associations studied within the context of an entire landscape. Thus, a feature can be said to have formal attributes and a site to be a functional interpretation of formal, spatial, and temporal associations. In the case of the current study, an Oahu Sugar Plantation map (see Figure 38) provides a basis for associating features functionally with the understanding that the site developed over time begin after 1916 after the Waiāhole Ditch (also describe below as a separate site) brought the needed irrigation water the area. The discussion of Site 7346 below is organized by field number and feature type.

FINDINGS

As a result of the current fieldwork effort two sites (Table 3 and Figure 40) were defined, Site 2268 (Waiāhole Ditch) and Site 7346 (Oahu Sugar Company Irrigation features). The Waiāhole Ditch has been previously documented in other portions of O'ahu, and was built between 1913 and 1916 by the Waiahole Water Company a subsidiary of the Oahu Sugar Company. Site 7346, a feature of which was previously recorded to the west of the current project area, is here described as a collection of Plantation-era irrigation infrastructure features associated with commercial cultivation of the project area likely beginning after 1916, a date marking the availability of water in the project brought by the Waiāhole Ditch. Each of these sites within the current project area is described below.

Table 3. Historic sites identified within the current project area.

SIHP Site No.	*Formal Type*	*Function*	*Temporal Affiliation*
50-80-09-2268	Concrete/Earthen Ditch	Plantation Irrigation	Historic (post 1916)
50-80-12-7346	Earthen Ditches, Concrete Flumes, Water Siphons, Pumps, Sluice Gates, Metal Aqueducts, Reservoir and Masonry Retention Basin	Plantation Irrigation	Historic (post 1916)

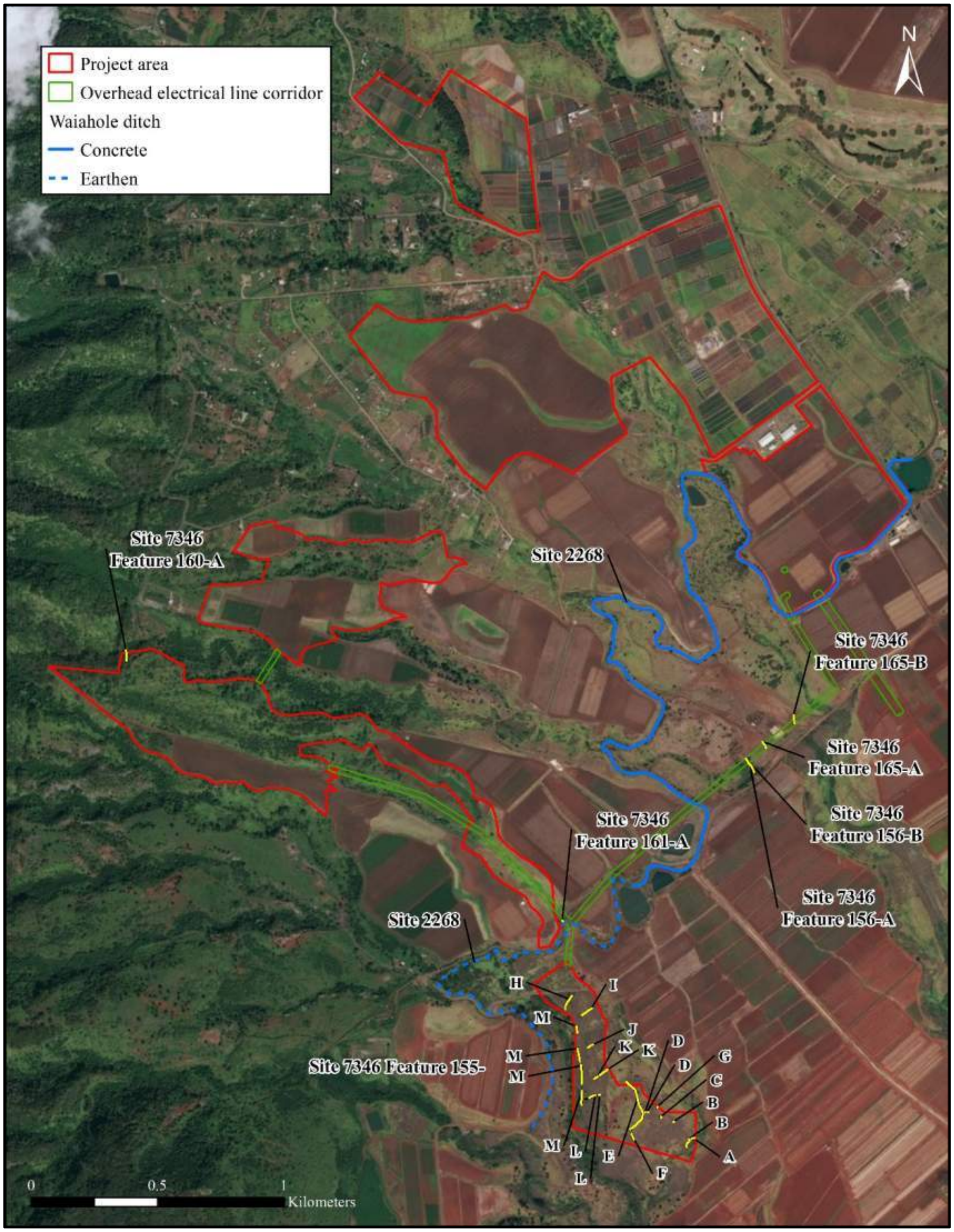


Figure 39. Locations of historic sites recorded within the current project area.

Waiāhole Ditch (SHIP Site 50-80-09-2268)

As previously stated, Site 2268 is not within any of the Solar Array footprint area but is crossed at two locations by the Overhead Electrical Line Corridor (see Figure 39). In the vicinity of the current project area, the Waiāhole Ditch is shown on a 1936 map (Figure 40) as terminating at a reservoir to the northeast of the proposed Solar Array Area 5. This terminus point represents the 1916 westward extent of the ditch. The 1916 version is a relatively wide concreted channel (Figure 41). Sometime after 1936, the Waiāhole Ditch was extended further to the west as an earthen ditch only reinforced with concrete where necessary for outflow features. This site continues to function as an irrigation feature and retains its historical integrity to be considered significant under HRS Chapter significance Criteria a and c.

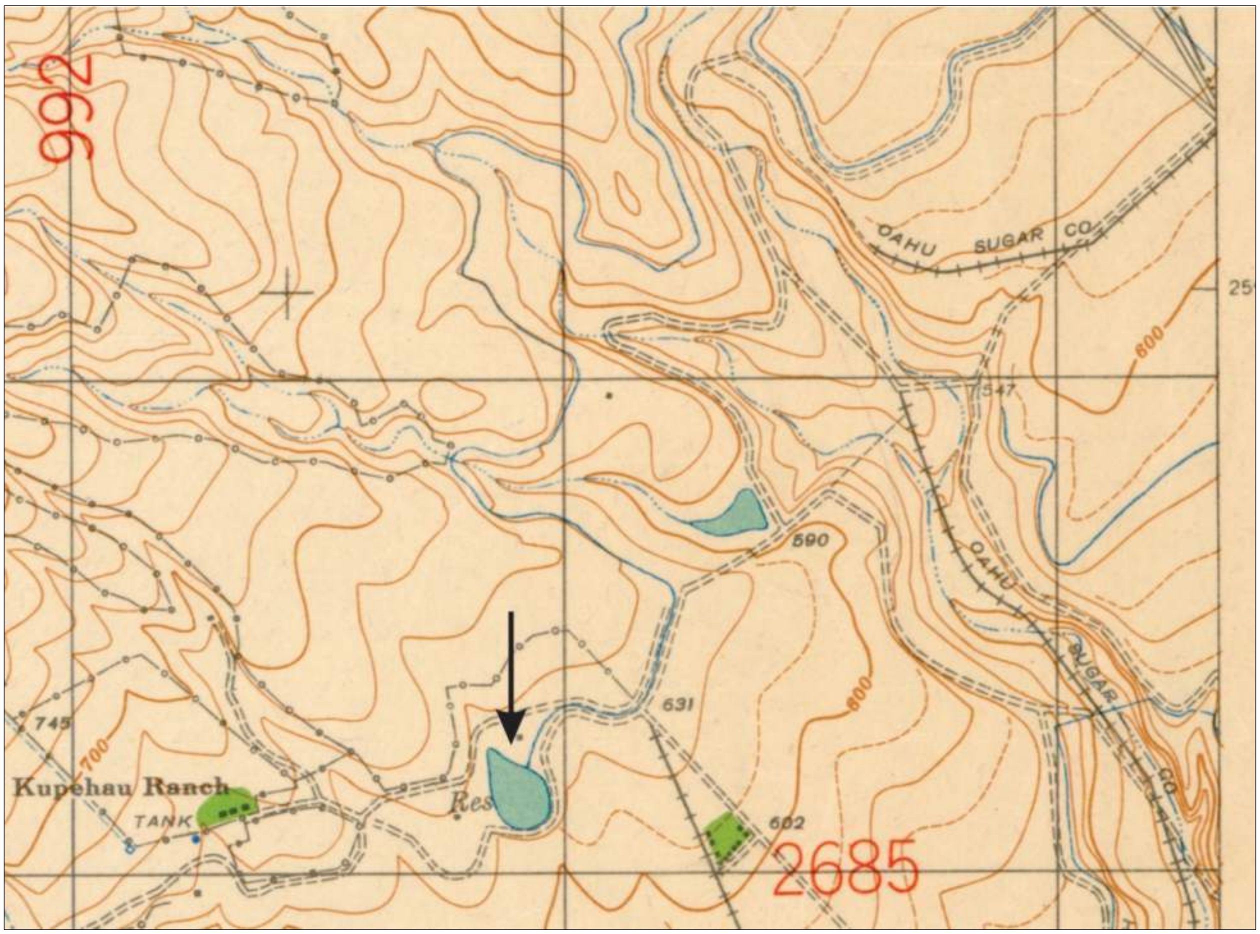


Figure 40. Portion of 1936 US Army Corps of Engineers terrain map.

Figure 41. 1916 concreted section of the Waiāhole Ditch.

Oahu Sugar Company Irrigation System (SIHP Site 50-80-12-7346)

Plantation irrigation infrastructure was recorded in Solar Array Areas 1 and 5 and along the proposed overhead electrical line corridor extending to the east from Solar Array Area 5 toward Solar Array Area 3 (see Figure 39). The Oahu Sugar Company field map (see Figure 38) provides the organizational basis for describing these irrigation features relative to numbered fields. Two primary types of irrigation features were identified within the project area: earthen ditches and sectional concrete flumes (commonly referred to as "Waialua" flumes). Earthen ditches consist of trenches that were mechanically excavated following specific elevation contours to carry water down slope to the fields. Earthen ditches are typically excavated out of a slope, with the upslope side of the ditch left as a natural cut and the excavated soil used to berm and reinforce the down slope edge. The ditches are the main water channels of the plantation. The fields themselves were watered using smaller portable flumes that drew from the main ditches. "Waialua" flumes, as the name implies were first invented by the Waialua Agricultural Company (WAC) to irrigate their fields on the north shore of O'ahu (Wilcox 1996). These sectional concrete flumes consist of mass produced, square sided, U-shaped, concrete channels that were placed end to end in a line to carry water in a downslope direction and made watertight at the seams with a black tarlike material. Each flume section had outflow openings (blocked by small tin gates) that could be pulled up to allow for water flow into the fields, where it flowed down slope through furrows between the rows of sugarcane and saturated the ground (Wilcox 1996). The success that the WAC had irrigating their fields with these types of pre-cast concrete flumes led other plantations, such as the Oahu Sugar Company to follow suit. While the integrity of the irrigation infrastructure has suffered the ravages of time, as an archaeological site it retains sufficient integrity to be considered significant under HRS Chapter 6E significance Criteria a and d.

Features in Field 155

The irrigation system recorded within former Oahu Sugar Company Field 155 (Solar Array Area 5; see Figure 39) includes a main earthen ditch (Feature 155-E) that once carried water south from the Waiāhole Ditch (SHIP Site 50-80-09-2268) to Field 155, as well as 12 remnant alignments of concrete sectional flumes (Features 155-A to 155-D and 155-F to 155-N) that fed off of that main ditch to provide water to the field itself (Figure 42). These irrigation features were the most recent irrigation features installed by the Oahu Sugar Company (perhaps during the late 1940s or early 1950s) and were likely in use until the middle 1990s when the plantation shut down. Although currently fallow, the lands encompassed by Field 155 were most recently used for ranching purposes and the grubbing of vegetation for pasture improvement in more recent years has negatively impacted all of the irrigation features within the project area. The entire field, which was once planted in sugarcane, is now covered with a thick growth of vegetation consisting primarily of *koa haole* and Guinea grass. Only remnant portions of the former irrigation features remain. Each feature identified within the project area is described in further detail below.

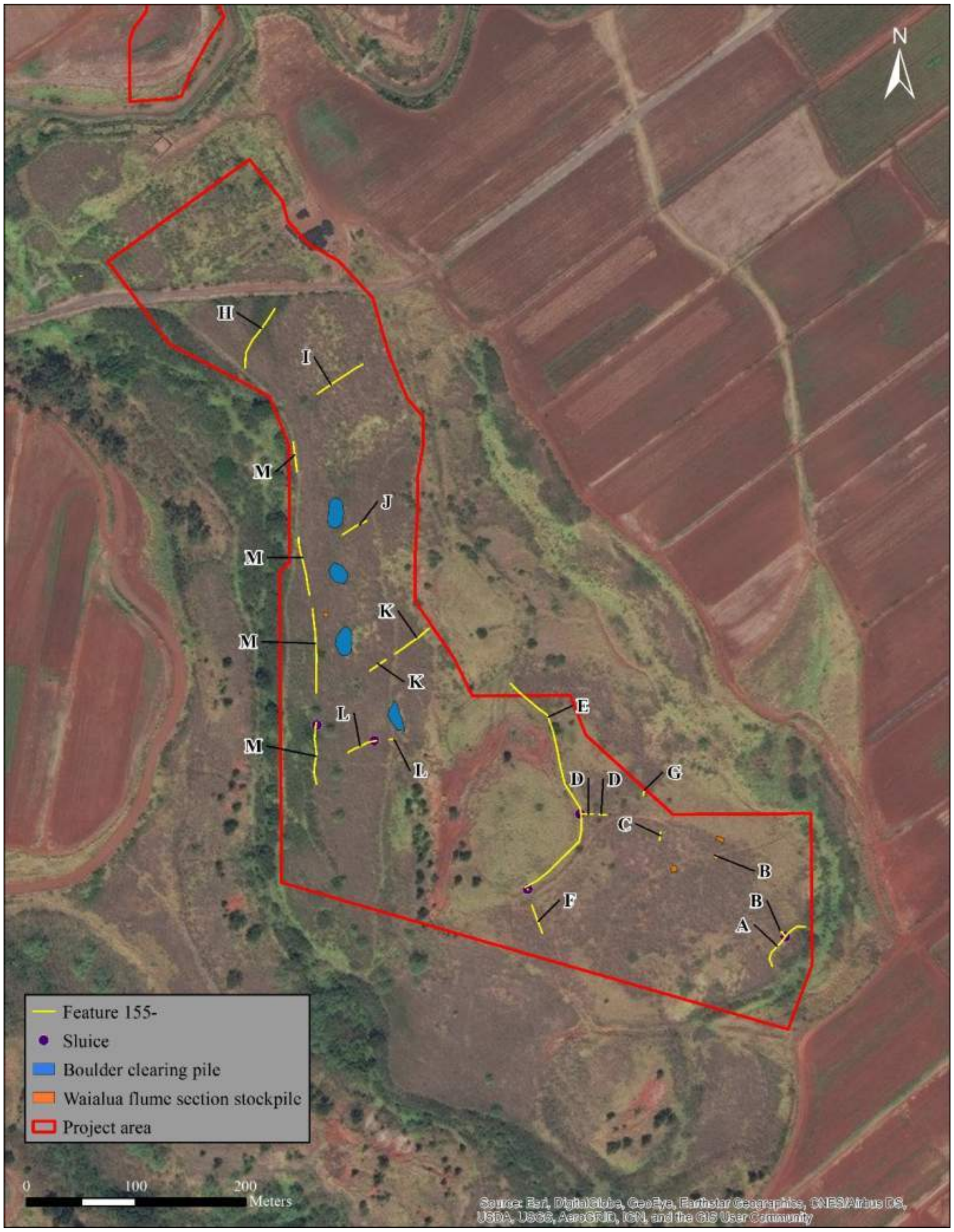


Figure 42. Site 7346 Feature 155 plan view.

Feature 155-A

Feature 155-A consists of an intact portion of a Waialua flume alignment that is located in the southeast corner of Area 5 (see Figure 42). This irrigation flume, which once carried water to the southeast around both sides of a topographic high point, was once fed water from the main Field 155 earthen ditch by way of Feature 155-B. Feature 155-A measures 60 meters long overall and is comprised of pre-cast concrete flume sections that each measure 93 centimeters long by 40 centimeters wide by 23 centimeters tall (Figures 43 and 44). The flume sections that form Feature 155-A have been placed in a U-shaped alignment around the base of the topographic high point, and both ends of the U-shape terminate at bulldozing to the southeast. At the apex of the U-shape flume alignment is an old sluice gate where Feature 155-B joins Feature 155-A (Figure 45). The pre-cast concrete flume sections at the junction between these features are taller and wider than those that form the rest of the alignment, measuring 60 centimeters wide and nearly a meter tall. Two sluice gates would have formerly been present at this junction that could be opened or closed to direct the water flow from Feature 155-B either to the northeast or to the southwest through Feature 155-A.

Figure 43. Site 7346 Feature 155-A, view to the southwest.

Figure 44. Site 7346 Feature 155-A, view to the northwest.

Figure 45. Site 7346 Feature 155-A, sluice at the intersection with Feature 155-B, view to the southeast.

Feature 155-B

Feature 155-B consists of an intact portion of Waialua flume that intersects with Feature 155-A in the southeastern corner of Area 5 (see Figure 42). This sectional flume once carried water down slope to the southeast from the main earthen ditch to Feature 155-A, providing water to the adjacent sugarcane fields on along the way (see Figure 42). Two intact portions of this flume are present within the project area. The first intact portion extends northwest from the sluice gate at its intersection with Feature 155-A for 7.3 meters (Figure 46). The pre-cast concrete flume sections that make up this portion of Feature 155-B each measure 93 centimeters long by 40 centimeters wide by 23 centimeters tall. A second intact portion of the Feature 155-B flume occurs 88 meters to the northwest (up slope) of the first (Figure 47). This section of Feature 155-B measures 3 meters long and is comprised of concrete Waialua flume sections that measure 76 centimeters long by 16.5 centimeters wide by 28 centimeters tall. The portions of the flume that once connected the two intact sections of Feature 155-B, and continued northwest from the more upslope (northwestern) intact section, have been bulldozed into a pile located 18 meters northeast of the northwestern portion of the feature (Figure 48). A stockpile of unused Waialua flume sections is present on an old wood pallet located 37.5 meters southwest of the more upslope (northwestern) intact portion (Figure 49).

Figure 46. Site 7346 Feature 155-B, view to the northeast from the sluice at the intersection with Site 7346 Feature 155-A.

Figure 47. Site 7346 Feature 155-B, northwestern intact section, view to the northeast.

Figure 48. Site 7346 Feature 155-B, push pile of flume sections located northeast of the more northwestern intact portion, view to the northwest.

Figure 49. Site 7346 Feature 155-B, stockpile of unused Waialua flume sections on a wooden pallet, view to the north.

Feature 155-C

Feature 155-C consists of a partially intact Waialua flume alignment located 53 meters northwest of Feature 155-B and 53 meters southeast of Feature 155-D (see Figure 42). Feature 155-C measures 7.7 meters long and is comprised of flume sections that each measure 93 centimeters long by 63 centimeters wide by 28 centimeters tall (Figure 50). This flume once carried water down slope to the south from either the Feature 155-B or Feature 155-D alignments, both of which have been bulldozed away in the vicinity of Feature 155-C. Both ends of Feature 155-C have been destroyed by bulldozing.

Figure 50. Site 7346 Feature 155-C, view to the south.

Feature 155-D

Feature 155-D consists of a partially intact Waialua flume alignment located 53 meters northwest of Feature 155-C adjacent to Feature 155-E (see Figure 42). This flume alignment extends west from Feature 155-E (the main earthen ditch that once fed water to Field 155) for 22 meters. It is comprised of flume sections that each measure 93 centimeters long by 63 centimeters wide by 28 centimeters tall (Figure 51). A wooden sluice gate is present at the western end of Feature 155-D where it joins Feature 155-E (Figure 52). The edges of Feature 155-E have been reinforced with cobbles and concrete at this location, and a cobble to the north of the gate is marked with the number “20,” while a cobble to the south of the gate is marked with the number “23,” perhaps indicating field sections within the overall Field 155.

Feature 155-E

Feature 155-E consists of an earthen irrigation ditch that crosses the southeastern portion of Area 5 and once carried water from the Waiāhole Ditch (SHIP Site 50-80-09-2268) south to Field 155 (see Figure 42). A roughly 230-meter-long section of ditch that wraps around the eastern edge of a topographic high point is present within the project area (Figure 53). Feature 155-E appears to have been mechanically excavated, with the soil that was removed from the ditch excavation used to create an earthen berm along the eastern (down slope) edge. The ditch itself measures roughly 1 meter wide by 60 centimeters deep (when measured below the interior edge of the earthen berm). The cut bank along the western edge of the ditch is generally 1 to 2 meters tall. Two sluice openings to Waialua flume alignments are present along the length of the earthen ditch within the current project area. One allowing water to flow into Feature 155-D (see above), and the other allowing water to flow into Feature 155-F. The outlet to Feature 155-F is similar to the outlet to Feature 155-D, but the wooden sluice gate is no longer present, and most of the flume alignment immediately adjacent to the ditch has been bulldozed away (Figure 54). To the southwest of the outlet to Feature 155-F, the Feature 155-E earthen ditch has also been bulldozed and is no longer present.

Figure 51. Site 7346 Feature 155-D, western portion of intact flume alignment, view to the west.

Figure 52. Site 7346 Feature 155-D, sluice gate at Feature 155-E, view to the west.

Figure 53. Site 7346 Feature 155-E, earthen ditch, view to the south.

Figure 54. Site 7346 Feature 155-E, sluice outlet that formerly released water into Feature 155-F, view to the northwest.

Feature 155-F

Feature 155-F consists of a partially intact Waialua flume alignment that begins 14 meters southeast of the sluice opening at the southwestern end of Feature 155-E near the southern boundary of Area 5 (see Figure 42). Feature 155-F measures 29.8 meters long and is comprised of flume sections that each measure 93 centimeters long by 63 centimeters wide by 28 centimeters tall (Figure 55). This flume once carried water down slope to the southeast from Feature 155-E. Both ends of Feature 155-F have been destroyed by bulldozing.

Feature 155-G

Feature 155-G consists of a partially intact Waialua flume alignment located 40 meters northwest of Feature 155-C and 37 meters northeast of Feature 155-D (see Figure 42). Feature 155-C measures 5.9 meters long and is comprised of flume sections that each measure 93 centimeters long by 63 centimeters wide by 28 centimeters tall (Figure 56). This flume once carried water down slope to the north from either the Feature 155-B or Feature 155-D alignments, both of which have been bulldozed away in the vicinity of Feature 155-G. Both ends of Feature 155-G have also been destroyed by bulldozing.

Feature 155-H

Feature 155-H consists of a partially intact Waialua flume alignment located near the northern boundary of Area 5 (see Figure 42). Feature 155-H measures 66.5 meters long overall and is comprised of flume sections that each measure 93 centimeters long by 63 centimeters wide by 28 centimeters tall, but many of the sections have been displaced and are scattered about in a rough line that extends in a northeast/southwest direction (Figure 57). This flume likely once carried water down slope to the southwest from the Feature 155-E earthen ditch, but both ends of Feature 155-H have been destroyed by bulldozing.


Figure 55. Site 7346 Feature 155-F, view to the northwest.


Figure 56. Site 7346 Feature 155-G, view to the north.

Figure 57. Site 7346 Feature 155-H, view to the northeast.

Feature 155-I

Feature 155-I consists of a partially intact Waialua flume alignment located 85 meters southeast of Feature 155-H that extends southwest from the eastern boundary of Area 5 (see Figure 42). Feature 155-I measures 53.2 meters long overall and is comprised of flume sections that each measure 93 centimeters long by 63 centimeters wide by 28 centimeters tall (Figure 58). This irrigation flume once carried water down slope to the southwest from the Feature 155-E earthen ditch. Both ends of Feature 155-I have been destroyed by bulldozing.

Figure 58. Site 7346 Feature 155-I, view to the west.

Feature 155-J

Feature 155-J consists of a partially intact Waialua flume alignment that extends southwest from near the eastern boundary of Area 5 roughly 142 meters south of Feature 155-I (see Figure 42). Feature 155-J measures 27.8 meters long overall and is comprised of flume sections that each measure 93 centimeters long by 63 centimeters wide by 28 centimeters tall (Figure 59). This irrigation flume once carried water down slope to the southwest from the Feature 155-E earthen ditch, but it is currently in poor condition and both ends have been destroyed by bulldozing. Piles of large boulders cleared from Field 155 are present to the northwest and northeast of Feature 155-J (Figure 60).

Feature 155-K

Feature 155-K consists of a partially intact Waialua flume alignment that extends southwest from the eastern boundary of Area 5 roughly 123 meters south of Feature 155-J (see Figure 42). A roughly 48-meter long section of Feature 155-K, bisected midway along its length by a bulldozed road, is present within the project area. It is comprised of flume sections that each measure 93 centimeters long by 63 centimeters wide by 28 centimeters tall (Figure 61). This irrigation flume once carried water down slope to the southwest from the Feature 155-E earthen ditch, but both ends have been destroyed by bulldozing. A pile of large boulders cleared from Field 155 is present to the northwest of Feature 155-K (Figure 62).

Figure 59. Site 7346 Feature 155-J, view to the northeast.

Figure 60. Clearing pile of large boulders located within Field 155 to the northwest of Site 7346 Feature 155-J, view to the north.

Figure 61. Site 7346 Feature 155-K, view to the southwest.

Figure 62. Clearing pile of large boulders located within Field 155 to the northwest of Site 7346 Feature 155-K, view to the southwest.

Feature 155-L

Feature 155-L consists of a partially intact Waialua flume alignment that extends southwest from near the eastern boundary of Area 5 roughly 68 meters south of Feature 155-K (see Figure 42). A roughly 45-meter-long section of Feature 155-K, bisected midway along its length by a bulldozed road, is present within the project area. It is comprised of flume sections that each measure 93 centimeters long by 63 centimeters wide by 28 centimeters tall (Figure 63). This irrigation flume once carried water down slope to the southwest from the Feature 155-E earthen ditch, but both ends have been destroyed by bulldozing. A former sluice gate is present at the northeastern end of the southwestern section of Feature 155-L near where the feature has been bisected by bulldozing (Figure 64). At this location, cement grooves are visible in the flume walls, but no wooden sluice gate is present. At the southwestern end of the southwestern section of Feature 155-L, the irrigation flume turns 90-degrees to the south begore terminating at bulldozing (Figure 65). A pile of large boulders cleared from Field 155 is present to the north of Feature 155-L, near its northeastern end.

Figure 63. Site 7346 Feature 155-L, northeastern end, view to the southwest.

Figure 64. Site 7346 Feature 155-L, former sluice gate location, view to the southwest.

Figure 65. Site 7346 Feature 155-L, 90-degree turn at southwestern end of the flume alignment, view to the north.

Feature 155-M

Feature 155-M consists of a partially intact Waialua flume alignment that extends north/south through the project area along the western boundary of Area 5 (see Figure 42). A roughly 320-meter-long section of Feature 155-M, bisected by bulldozing into four sections, is present within the project area. It is comprised of flume sections that each measure 93 centimeters long by 63 centimeters wide by 28 centimeters tall. This irrigation flume once carried water down slope to the south from the Feature 155-H following the eastern edge of a small stream drainage. The intact sections of Feature 155-M, from north to south, measure 29.5 meters (Figure 66), 57.6 meters (Figure 67), 83.2 meters (Figure 68), and 61.1 meters (Figure 69) long respectively. It appears that the flume used to branch to the west at the northern end of the southernmost section of Feature 155-M where an old sluice is located (Figure 70), but the western branch has been destroyed by bulldozing and no evidence of it was found. Both ends of Feature 155-M have also been destroyed by bulldozing.

Figure 66. Site 7346 Feature 155-M, northernmost intact section, view to the south.

Figure 67. Site 7346 Feature 155-M, north-central intact section, view to the north.

Figure 68. Site 7346 Feature 155-M, south-central intact section, view to the north.

Figure 69. Site 7346 Feature 155-M, southernmost intact section, view to the northwest.

Figure 70. Site 7346 Feature 155-M, sluice gate indicating the presence of a former western flume branch at the northern end of the southernmost section, view to the southwest.

Feature in Field 156

Within the northern extension of Field 156 (see Figure 38), and within the proposed overhead electrical line corridor extending between Solar Array Areas 5 and 3 (see Figure 39), one feature (Feature 156-A) was observed. Feature 156-A (Figure 71) is a curvilinear cobble reinforced slope that represents the northeastern side of a former reservoir, which has been filled in. This reservoir is shown on a 1936 topographic map (Figure 72) and it appears to be out of use by the time of a 1951-52 aerial image (see Figure 25). Clues to the date of construction of this reservoir might be found etched in the concrete of a related retention basin with water control valve construction located to the east of Feature 156-A. This related feature (Feature 156-B) appears to be the control mechanism for water release of the reservoir to irrigate Oahu Sugar Company Field 156. Feature 156-B, although outside of the survey corridor for the overhead electrical lines, was documented (Figure 73) during the current study as it appears related to Feature 156-A located within the survey corridor. Feature 156-B is a piped outlet with metal control valve (Figure 74) leading into a basalt and concrete retention basin (Figure 75). The outflow from this basin was through a concrete sluice gate (Figure 76) into an earthen ditch. A date of “1928” is etched into concrete of the sluice gate (Figure 40) suggesting a construction date for both this feature and the reservoir.

Figure 71. Site 7346 Feature 156-A.

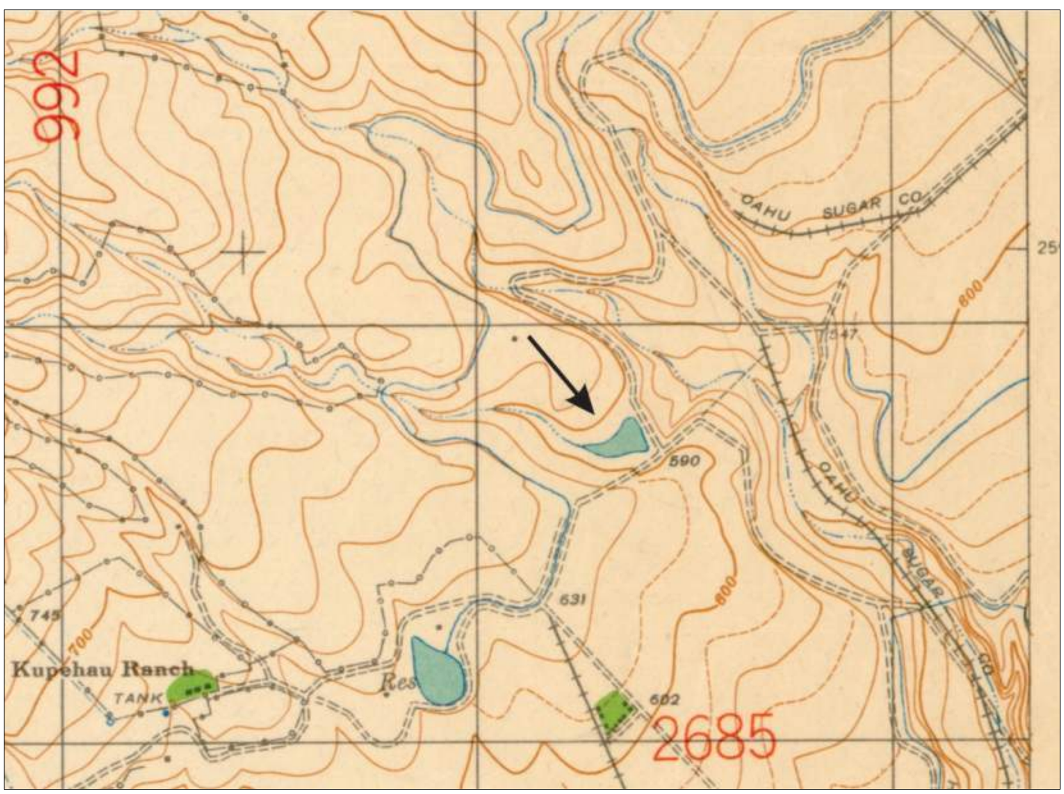


Figure 72. Portion of 1936 US Army Corp of Engineers terrain map showing reservoir (black arrow).

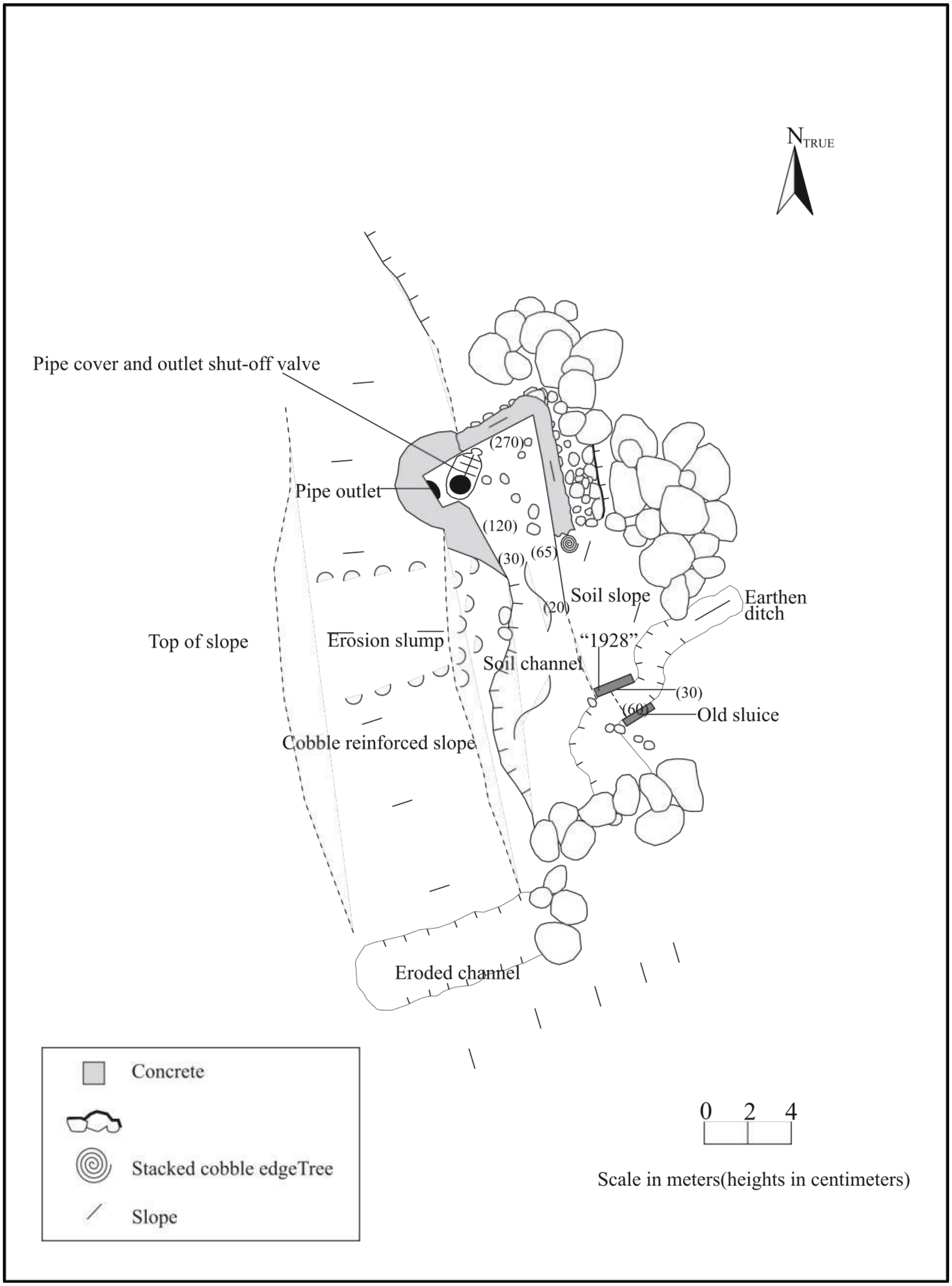


Figure 73. Site 7346 Feature 156-B plan view.

Figure 74. Site 7346 Feature 156-B water control valve.

Figure 75. Site 7346 Feature 156-B basalt and concrete retention basin.

Figure 76. Site 7346 Feature 156-B outflow sluice.

Figure 77. Date (1928) etched in to concrete on Site 7346 Feature 156-B outflow sluice.

Features in Fields 160 and 161

In Solar Array Area 1, one feature (Feature 160-A), a metal aqueduct pipe siphon (Figure 78) was observed in the extreme northwestern corner of this area (see Figure 40). The aqueduct pipe extends to the north, outside of the current project area, and terminates at a concrete outlet that feeds an earthen ditch. The aqueduct pipe, concrete outlet, and earthen ditch (Figure 79 and 80) were documented by Monahan and Thurman (2017). As shown on an enlargement of the Oahu Sugar Company field map (Figure 81) this aqueduct siphon feature is fed via an underground continuation of the aqueduct pipe, a section of which is exposed (Figure 82) within the project area. This pipe extended in a southeasterly direction to a pump house (Figure 83) located south of the project area that in turn received water from an underground aqueduct connected to another pump (see Figure 81) that drew water from the Waiāhole Ditch. At the point along the ditch connected to this water delivery system, and within Field 161 (see Figure 81), one feature (Feature 161-A), a metal water control valve (Figure 40) that operated a sluice gate was observed. The Waiāhole Ditch at this location is an earthen construction (Suggesting a post 1936 date) and Feature 161-1 is in the survey corridor for the proposed overhead electrical lines.

Figure 78. Site 7346 Feature 160-A siphon invert.

Figure 79. Site 7346 metal aqueduct pipe recorded by Monahan and Thurman (2017:247).

Figure 80. Site 7346 concrete outlet and earthen ditch recorded by Monahan and Thurman (2017:246).

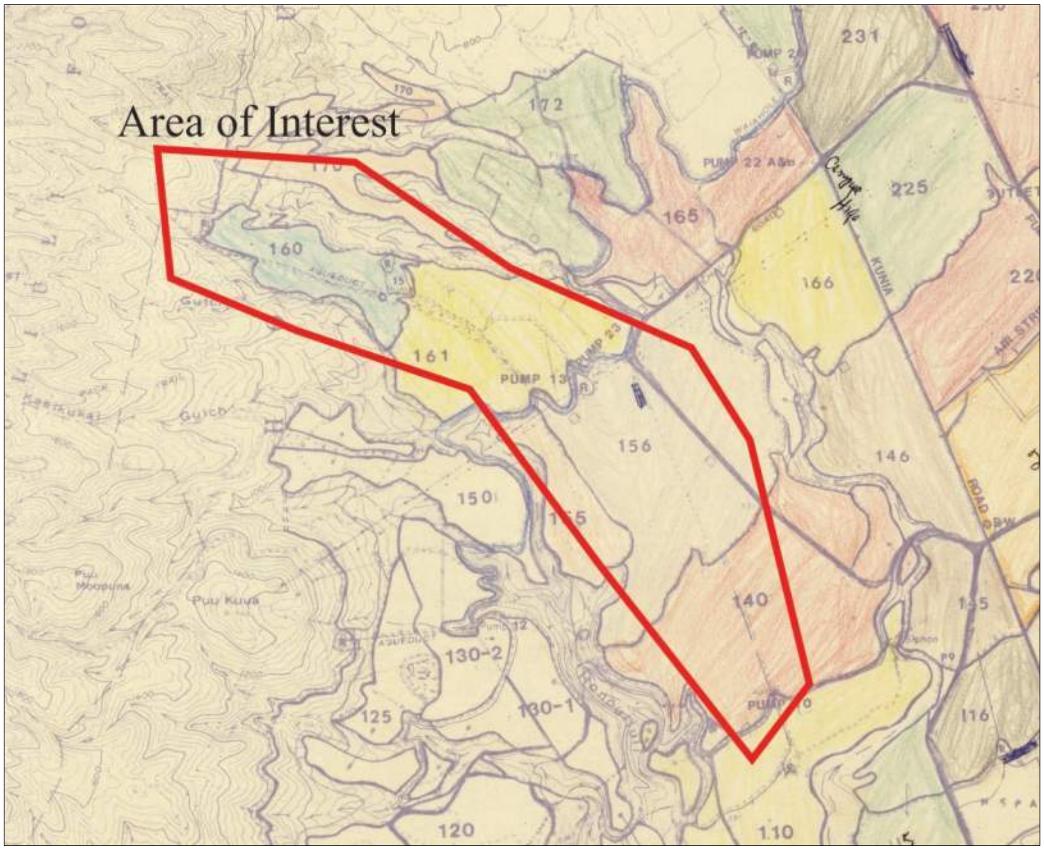


Figure 81. Enlargement of a portion of undated Oahu Sugar Company field map.

Figure 82. Exposed metal aqueduct pipe.

Figure 83. Pump house and siphon.

Figure 84. Site 7436 Feature 161-A sluice apparatus.

Features in Field 165

In the proposed overhead electrical line corridor extending between Solar Array Areas 5 and 3 (see Figure 40), two features (Features 165-A and 165-B), both remnant sections of concrete “Waialua Flumes,” were observed extending in a roughly north/south direction. Features 165-A and 165-B are separated by roughly 150 meters. This area has been subject to extensive grubbing and tilling in the past. Feature 165-A (Figure 85) extends in a curvilinear fashion for a distance of roughly 31 meters. This remnant concrete flume is made up of connected sections, each measuring 93 centimeters long, 63 centimeters wide, and 28 centimeters tall. Feature 165-B (Figure 86) is a highly fragmented linear section of similar sized concrete sectional flume that extends for roughly 36.5 meters. At the northern end of this remnant concrete flume is a larger (measuring 60 centimeters wide and nearly a meter tall) fragmented concrete right angle connector section indicating that there was once a more extensive network of concrete flumes bringing water to Oahu Sugar Company Field 165, which is clearly seen on an enlarged portion of a 1977 aerial image (Figure 40) showing the current project area.

Figure 85. Site 7436 Feature 165-A.

Figure 86. Site 7436 Feature 165-B.

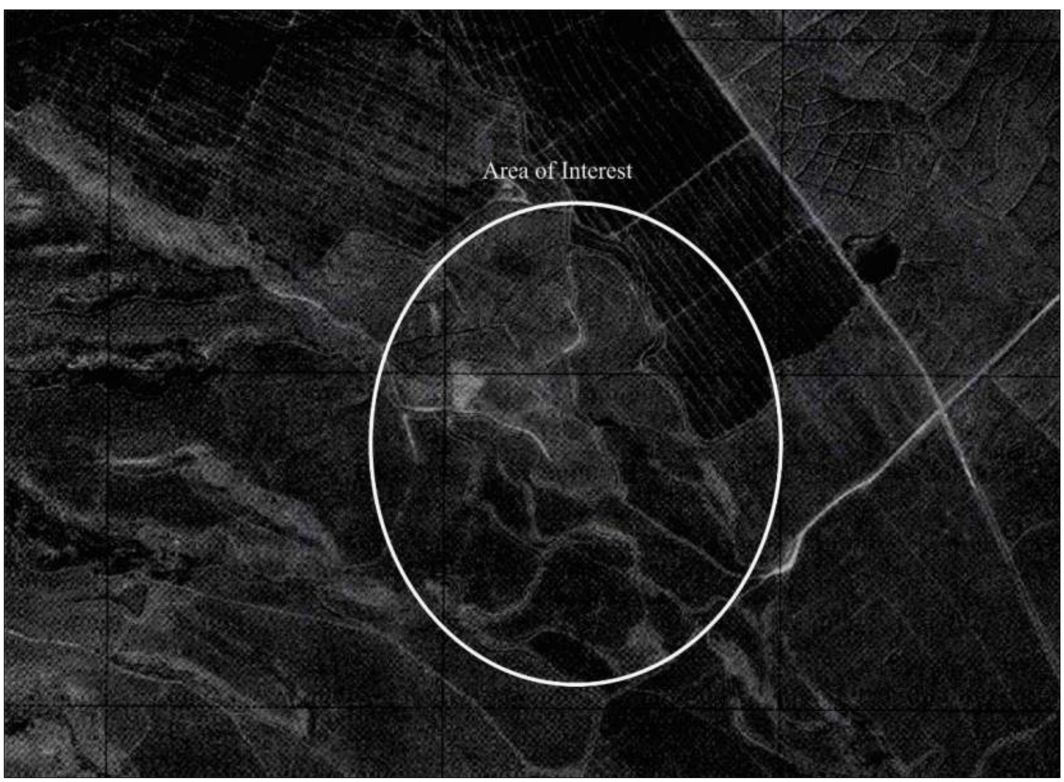


Figure 87. Enlargement of 1977 aerial image showing location of concrete flumes.

SUMMARY AND DISCUSSION

The were no resources dating from the Precontact Period encountered during the fieldwork conducted for this project. This is somewhat understandable given that the current project area is within both former and current intensively used agricultural fields. The current inventory survey fieldwork resulted in the documentation of early to middle twentieth century sugar plantation irrigation infrastructure. Using historic map sources, the irrigation features identified in the field are understood within the context of their interrelated functions. Portions of four former irrigation systems deriving their water from the same source, the Waiāhole Ditch, were identified and ascribed to the numbered Oahu Sugar Company fields within which they were found. The features described for Field 155 were part of a water delivery system that fed Field 155. As this area (Solar Array Area 5) has been fallow and apparently only used for ranching since the closure of the Oahu Sugar Company operation, the surface irrigation features are more intact than in other portions of the plantation that has seen recent cultivation. The features described for Field 156 are remnants of a former reservoir that retained and distributed water to Field 156. The features described for Fields 160 and 161 transported water to irrigation features (earthen ditches and flumes) that fed field to the north of the current project area, which were documented in a study conducted by Monahan and Thurman (2014). The features described for Field 165 are remnants of a much more extensive irrigation system utilizing sectional concrete flumes that have since been bulldozed. The complete lack of features in the recently and actively cultivated area (Solar Array Areas 2a, 2b, 2c, 3, 4a, 4b, and 4c) is a testament to the intensity of modern cultivation practices and the effect such practices have on historic resources, and also perhaps a reflection of the nature of historic cultivation activities conducted by entities other than the Oahu Sugar Company.

5. SIGNIFICANCE ASSESSMENTS AND RECOMMENDATIONS

The recorded historic properties are assessed for their significance based on criteria established and promoted by the DLNR-SHPD and contained in the Hawai‘i Administrative Rules 13§13-284-6. For a resource to be considered significant it must possess integrity of location, design, setting, materials, workmanship, feeling, and association and meet one or more of the following criteria:

- a Be associated with events that have made an important contribution to the broad patterns of our history;
- b Be associated with the lives of persons important in our past;
- c Embody the distinctive characteristics of a type, period, or method of construction; represent the work of a master; or possess high artistic value;
- d Have yielded, or is likely to yield, information important for research on prehistory or history;
- e Have an important traditional cultural value to the native Hawaiian people or to another ethnic group of the state due to associations with traditional cultural practices once carried out, or still carried out, at the property or due to associations with traditional beliefs, events or oral accounts—these associations being important to the group’s history and cultural identity.

The significance assessments and treatment recommended for the two sites documented in the current project area are presented in Table 4 and discussed below.

Table 4. Site significance and treatment recommendations.

SIHP Site No.	*Site Type*	*Temporal Affiliation*	*Significance*	*Recommended Treatment*
50-80-09-2268	Waiāhole Ditch	Historic (post 1916)	a and c	Avoidance and protection
50-80-12-7346	Sugar Plantation Irrigation Infrastructure	Historic (twentieth century)	a and d	Monitoring

SHIP SITE 2268

A section of the Waiāhole Ditch (SHIP Site 50-80-09-2268) was identified meandering along the southern and western boundaries of Solar Array Area 3 and extending in a southerly direction past Solar Array Area 5 (see Figure 39). The construction of the massive Waiahole Ditch project, which included twenty-seven tunnels that connected to thirty-seven stream intakes on the Ko‘olau mountains with the main tunnel reaching Waiāhole Valley, was completed in 1916 by the Waiahole Water Company, a subsidiary of Oahu Sugar Company. The significance of this site with respect to both its engineering aspects and its effects on O‘ahu’s physical and political landscapes cannot be overstated; thus, this site is considered significant under Criterion a and Criterion c. As the Waiāhole Ditch continues to be a functioning water source for irrigation and other purposes, and as it will remain beyond the footprint of any Mahi Solar ground lease areas, per HAR §13-284-8 (a)(1)(A) the recommended treatment for this site with respect to the current project is “avoidance and protection” during development activities.

SIHP SITE 7346

Collectively, the features of Site 7346 represent the Oahu Sugar Company irrigation infrastructure that provided water to former cultivated fields within the project area. This infrastructure is no longer functional and has either deteriorated in place or has been bulldozed into refuse piles. Infrastructural elements include earthen ditches, reservoirs, metal aqueduct pipes and siphons, concrete reinforced masonry structures and pumps, and concrete sectional flumes (known as “Waialua Flumes”). As the agricultural fields this infrastructure supported were significant in Hawaii’s plantation history, Site 7346 is considered significant under Criterion a; and as the study of this site (both archaeologically and cartographically) has yield information on twentieth century land use practices, Site 7436 is also considered significant under Criterion d. While it is the contention of the current study that the archaeological research potential for Site 7436 within the current project area has likely been exhausted, the possibility (albeit remote) remains that as of yet significant undiscovered aspects of this site, or archaeological resources that predate this site, could be encountered within the current project area; therefore, per HAR §13-284-8 (a)(1)(C) the recommended treatment for this site with respect to the current project is “monitoring” during development activities.

6. DETERMINATION OF EFFECT

The Waiāhole Ditch (Site 2268) lies outside of the footprint of the ground lease of the proposed Mahi Solar Project but may be traversed during the installation of overhead electrical transmission lines. As such, there is the potential to inadvertently impact this historic property during construction. With respect to Site 7346 (Oahu Sugar Company irrigation infrastructure), as described above, there is a remote possibility that significant undiscovered archaeological resources could be encountered during mass grading and trenching activities. Therefore, the HRS Chapter 6E-42 determination of effect for the proposed Mahi Solar Project is “effect with agreed upon mitigation.” As mitigation for this effect, per HAR §13-279-3, archaeological monitoring will occur during ground-disturbing activities pursuant to an archaeological monitoring plan that will be prepared in accordance with HAR §13-279-4 and submitted to the DLNR-SHPD for review and acceptance prior to initiating any ground-disturbing activity. Per HAR §13-279-4(a)(1), the archaeological monitoring plan will describe Waiāhole Ditch (Site 2268) as a site requiring protection during construction and will contain protocols for the temporary protection of this historic resources during development activities.

REFERENCES CITED

Abbott, I. A.

1992 *Lāʻau Hawaiʻi, Traditional Hawaiian Uses of Plants*. Bishop Museum Press, Honolulu.

Advertiser, T. H.

1956a Pearl Harbor Rich In Legend. *The Honolulu Advertiser* [Honolulu]. May 27, 1956, accessed October 19, 2020.

1956b Story of Water Is Story of Sugar. *The Honolulu Advertiser* [Honolulu]. July 03, 1956: 44, accessed October 19, 2020.

Beckwith, M. W.

1951 *The Kumulipo A Hawaiian Creation Chant*. University of Hawaii Press, Honolulu.

1970 *Hawaiian Mythology*. University of Hawai'i Press, Honolulu.

Bennett, F.

1840 *Narrative of a Whaling Voyage Round the Globe*. R. Bentley, London.

Bingham, H.

1848 *A Residence of Twenty-One Years in the Sandwich Islands*. First ed. Sherman Converse, New York.

Bowser, G.

1880 *The Hawaiian Kingdom Statistical and Commercial Directory and Tourists Guide*. George Bowser and Co., Honolulu.

Breeden, J., A. Lau, and A. Ehrenkrantz

2020 Mahi Solar Project Biological Resources Report. SWCA Environmental Consultants SWCA Project No. 61736. Prepared for Longroad Energy Management, LLC, Honolulu.

Burton, J. F. and M. M. Farrell

2011 National Register of Historic Places Registration Form Honouliuli Internment Camp, Honolulu County, Hawaii. Trans-Sierran Archaeological Research. Prepared for National Register of Historic Places, California.

Byron, G.

1826 *Voyage of the H.M.S. Blonde to the Sandwich Islands, in the Years 1824-1825*. John Murray, London.

Campbell, A.

1817 *A Voyage Round the World, from 1806 to 1812, In Which Japan, Kamschatka, The Aleutian Islands, and The Sandwich Islands Were Visited*. Van Wrinkle, Wiley & Co., Printers, New York.

1967 *A Voyage Around the World from 1806 to 1812*. University of Hawai'i Press, Honolulu.

Campbell, S.

1994 Register of the Ewa Plantation Company. Ewa, Oahu 1891-1960. Hawaiian Sugar Planter's Association Plantation Archives.

Condé, J. C. and G. Best

1973 *Sugar Trains: Narrow Gauge Rails of Hawaii*. Glenwood Publishers, Felton, California.

Cordy, R.

2002 *The Rise and Fall of the Oʻahu Kingdom*. Mutual Publishing, Honolulu.

Coulter, J. W.

1933 The Oahu Sugar Cane Plantation, Waipahu. *Economic Geography* 9(1 (Jan)):60-71.

Coulter, J. W. and C. K. Chun

1937 *Chinese Rice Farmers in Hawaii*. University of Hawaiʻi Research Publication, vol. Number 16. University of Hawaiʻi, Honolulu.

Cruz, B., C. O'Hare, D. Shideler, and H. H. Hammatt

2011 Cultural Impact Assessment for the Honouliuli/Waipahu/Pearl City Wastewater Facilities, Honouliuli, Hōʻaeʻae, Waikele, Waipiʻo, Waiawa, and Mānana, and Hālawa Ahupuaʻa, ʻEwa District, Oʻahu Island, TMK: [1] 9-1, 9-2, 9-4, 9-5, 9-6, 9-7, 9-8, 9-9 (Various Plats and Parcels). Cultural Surveys Hawaiʻi, Inc., Kailua, HI Job Code: HONOULIULI 35. Prepared for AECOM Pacific, Inc.

Damon, F.

1882 Tours Among the Chinese, No. 1. *The Friend* [Honolulu]. April 1882, accessed 10/27/2020.

Dorrance, W. and F. Morgan

2000 *Sugar Islands: The 165-Year Story of Sugar in Hawaii*. Mutual Publishing, Honolulu.

Ellis, W.

1963 *Journal of William Ellis, Narrative of a Tour of Hawaii, or Owhyee; with remarks on the History, Traditions, Manners, Customs and Language of the Inhabitants of the Sandwich Islands*. Advertiser Publishing Co., Ltd., Honolulu.

Emerson, N. B.

1893 The Long Voyages of the Ancient Hawaiians. *Papers of the Hawaiian Historical Society Number Five*.

Evening Bulletin

1908 Honolulu and Pearl Harbor Vital Centers of America's Power in Pacific. *Evening Bulletin* [Honolulu]. 16 July: 39. Electronic document, https://chroniclingamerica.loc.gov/lccn/sn82016413/1908-07-16/ed-1/seq-9/.

Farrell, M. M.

2017 Honouliuli POW and Internment Camp Archaeological Investigations at Jigoku-Dani 2006-2017. Japanese Cultural Center of Hawaiʻi. Prepared for National Park Service, Honolulu.

Fornander, A.

1880 *An Account of the Polynesian Race: Its Origins and Migrations, and the Ancient History of the Hawaiian People to the Times of Kamehameha I*, vol. II. Trübner & Co., London.

1916-1917 *Fornander Collection of Hawaiian Antiquities and Folk-lore*. Memoirs of the Bernice Pauahi Bishop Museum, vol. IV. Bishop Museum Press, Honolulu.

1918-1919 *Fornander Collection of Hawaiian Antiquities and Folk-lore. The Hawaiians' Account of the Formation of their Islands and Origin of their Race, with the Traditions of their Migrations, etc., as Gathered from Original Sources.* Memoirs of the Bernice Pauahi Bishop Museum Volume V. Bishop Museum Press, Honolulu.

Handy, E. S. C. and E. G. Handy

1972 *Native Planters in Old Hawaii: Their Life, Lore, and Environment*. Bernice P. Bishop Museum Bulletin 233. Bishop Museum Press, Honolulu.

Handy, E. S. C., E. G. Handy, and M. K. Pukui

1991 *Native Planters in Old Hawaii: Their Life, Lore, and Environment*. Bernice P. Bishop Museum Bulletin 233. Bishop Museum Press, Honolulu.

Haraguchi, K.

1987 *Rice in Hawaii A Guide to Historical Resources*. Humanities Program of the State Foundation on Culture and the Arts and the Hawaiian Historical Society, Honolulu.

Haun, A. E.

1991 An Archaeological Survey of the Naval Air Station, Barber's Point, Oʻahu, Hawaiʻi. Prepared for Applied Research Group of Bishop Musum, Honolulu.

Hillebrand, W.
1888 *Flora of the Hawaiian Islands: A Description of their Phanerograms and Vascular Chryptograms*. Hafner Publication Company, New York.

Hoʻoulumāhiehie
2006a *The Epic tale of Hiʻiakaikapoliopele*. Translated by M. P. Nogelmeier. Awaiaulu, Honolulu.

2006b *Ka Mo'olelo o Hiʻiakaikapoliopele*. Awaiaulu, Honolulu.

Ii, J. P. (John Papa ʻĪʻī)
1993 *Fragments of Hawaiian History*. 2nd revised ed. Originally published 1959. Edited by D. Barrère. Translated by M. K. Pukui. B.P. Bishop Museum Special Publication 70. Bishop Museum Press, Honolulu.

James Campbell Company, LLC.
1978 *James Campbell ESQ*. 7th ed. Estate of James Campbell, Kapolei, HI.

Judd, C. S.
1936 Sandalwood, Once the Gold Mine of Hawaii, is Coming Back. *Honolulu Star-Bulletin* [Honolulu]. 8 February: 46, 52. Electronic document, https://www.newspapers.com/, accessed October 19, 2020.

Justice, DOI and DOJ
2000 From Mauka to Makai: The River of Justice Must Flow Freely. Department of the Interior and Department of Justice, Washington, D.C.

Ka Loea Kalaiaina
1900 He Moolelo nona Wahi Pana o Ewa I Huna Keleloaia me ka nalowale loa a hiki ole ke ikeia. *Ka Loea Kalaiaina* [Honolulu]. 13 Januari: 4. Electronic document, www.papakilodatabase.com, accessed 10/13/2020.

Kaaiakamanu, D. M. and J. K. Akina
1922 *Hawaiian Herbs of Medicinal Value: Found Among the Mountains and Elsewhere in the Hawaiian Islands, and Known to the Hawaiians to Possess Curative and Palliative Properties Most Effective in Removing Physical Ailments*. Board of Health of the Territory of Hawaii.

Kamakau, S. M.
1869 Ka Moolelo Hawaii, helu 181, No ka Noho Alii ana o Kauikeaouli Maluna o ke Aupuni, a Ua Kapaia o Kamehameha III. *Ka Nupepa Kuokoa* [Honolulu]. 30 September: 4. Electronic document, https://www.papakilodatabase.com, accessed 12/10/2020.

Kamakau, S. M.
1964 *Ka Poʻe Kahiko: The People of Old*. B.P. Bishop Museum Special Publication 51. Bishop Museum Press, Honolulu.

1991 *Tales and Traditions of the People of Old, Nā Moʻolelo a ka Poʻe Kahiko*. Bishop Museum Press, Honolulu.

1992 *Ruling Chiefs of Hawaii*. Revised ed. Kamehameha Schools Press, Honolulu.

Kameʻeleihiwa, L.
1992 *Native Land and Foreign Desires: Ko Hawaii ʻĀina a Me Nā Koi Puʻumake a Ka Poʻe Haole, Pehea lā e Pono ai? How Shall We Live in Harmony?* Bishop Museum Press, Honolulu.

1996 *He Moʻolelo Kaʻao O Kamapuaʻa An Annotated Translation of a Hawaiian Epic from Ka Leo O Ka Lāhui June 22, 1891-July 23, 1891*. Bishop Museum Press, Honolulu.

Kapena, B.
1862 He Inoa No Ailuene. *Ka Hoku O Ka Pakipika* [Honolulu]. 27 March: 4. Electronic document, https://www.papakilodatabase.com, accessed 12/10/2020.

Kapihenui, M. J.
1862a He Moolelo no Hiiakaikapoliopele. *Ka Hoku O Ka Pakipika* [Honolulu]. 20 March: 4. Electronic document, https://www.papakilodatabase.com, accessed 12/10/2020.

1862b He Moolelo no Hiiakaikapoliopele, Helu 11. *Ka Hoku O Ka Pakipika* [Honolulu]. 3 April: 4. Electronic document, https://www.papakilodatabase.com, accessed 12/10/2020.

Kaualilinoe, J. W. K.
1870 Ka Moolelo o Kalelealuaka. Ka Ihu Kae-a-e-a o Lihue, Kauai, Ka Olali Hoi O Kona Mau La U-i. *Ka Nupepa Kuokoa* [Honolulu]. 14 September: 4. Electronic document, https://www.papakilodatabase.com, accessed 10/28/2020.

Kelly, M.
1991 Notes on the History of Honouliuli Appendix A. Department of Anthropology, Bernice P. Bishop Museum *An Archaeological Inventory Survey of the Naval Air Station, Barber's Point O'ahu, Hawai'i*. Prepared for Naval Facilities Engineering Command, Honolulu.

Kikiloi, S. K.
2010 Rebirth of an Archipelago: Sustaining a Hawaiian Cultural Identity for People and Homeland. *Hūlili: Multidisciplinary Research on Hawaiian Well-Being* 6:73-115.

Kluegel, C. H.
1917 Engineering Features of the Water Project of the Waiahole Water Company. In *Hawaiian Almanac and Annual for 1916*, pp. 93-109. edited by T. G. Thrum. Thos G. Thrum, Honolulu.

Kotzbue, O. v.
1821 *A Voyage of Discovery into the South Seas and the Bering Straits in Search of a North-East Passage Undertaken in the Years 1815, 16, 17, and 1818, in the ship Rurick*. Richard Philips and Co., London.

Krauss, B. H.
1993 *Plants in Hawaiian Culture*. A Kolowalu Book. University of Hawaii Press, Honolulu.

Kuokoa, K. N.
1877 He Moolelo no Aahoaka ke Koa a me Kona Hanau Kupanaha Ana, He Moolelo Kahiko no Kauaia, Helu 6. *Ka Nupepa Kuokoa* [Honolulu]. 24 February: 4. Electronic document, https://www.papakilodatabase.com, accessed 10/27/2020.

Kuykendall, R.
1953 *The Hawaiian Kingdom Volume II 1854-1874. Twenty Critical Years*, vol. 2. 3 vols. University Press of Hawaii, Honolulu.

1967 *The Hawaiian Kingdom: Volume III: 1874-1893. The Kalakaua Dynasty*, vol. 3. 3 vols. University of Hawaii Press, Honolulu.

Macrae, J.
1922 *With Lord Byron at the Sandwich Islands in 1825. Being Extracts from the Diary of James Macrae, Scottish Botanist*. Edited by W. Wilson, Honolulu.

Maly, K. and O. Maly
2012a He Moʻolelo ʻĀina– Traditions and Storied Places in the District of ʻEwa and Moanalua (in the District of Kona), Island of Oʻahu : A Traditional Cultural Properties Study – Technical Report TMK Overview Sheets Zone 9-1 To 9 (Various Parcels); and Zone 1-1 (Various Parcels). Kumu Pono Associates, LLC Study No. 131 (April 21, 2012). Prepared for SRI Foundation, Rio Rancho, New Mexico.

2012b Honouliuli Land Tenure in the Māhele ʻĀina (1847-1855): A Study Prepared for the Hoakalei Foundation. Kumu Pono Associates, LLC. Prepared for Hoakalei Foundation. L. Kumu Pono Associates, Hilo.

Manu, M.
2002 *Keaomelemele: "He Moolelo Kaao no Keaomelemele"*. Edited by M. P. Nogelmeier. Translated by M. K. Pukui. Bishop Museum Press, Honolulu.

McAllister, J. G.
1933 *Archaeology of Oahu*. Bernice P. Bishop Museum Bulletin 104. Published by the Museum, Honolulu, Hawaii.

McElroy, W. K., M. Elison, and D. Duhaylonsod
2013 FINAL—Cultural Impact Assessment for a Proposed Solar Farm in Kalaeloa, Honouliuli Ahupua‘a, ‘Ewa District, Island of O‘ahu. Keala Pono Archaeological Consulting, LLC. Prepared for Mana Elua, Honolulu, Honolulu.

McMahon, N. and W. Tolleson
2014 An Archaeological Assessment of Lot 23, a 5.295 Acre Parcel within the Kunia Loa Ridge Farm Lots Project Honouliuli Ahupua‘a, ‘Ewa District, Island of O‘ahu, TMK: [1] 9-2-004:005. Explorations Associates Ltd. Report. Prepared for David Sunagawa.

Meyen, F.
1981 *A Botanist's Visit to Oahu in 1831. Being the Journal of Dr. F.J.F. Meyen's Travels and Observations about the Island of Oahu*. Edited by M. A. Pultz. Translated by A. Jackson. Press Pacifica, Ltd., Honolulu.

Monahan, C. and D. Thurman
2013 Archaeological Inventory Survey Kunia Mauka Loa Ridge C&C Farmlands Project, Honouliuli Ahupua‘a, ‘Ewa District, O‘ahu Island, Hawai‘i, TMK (1) 9-2-004. TCP Hawai‘i, LLC Report. Prepared for C7C Farmlands, LLC, Honolulu.

Nakuina, E.
1904 *Hawaii, Its People. Their Legends*. The Hawaii Promotion Committee, Honolulu.

Nawaa, S. K.
1956 Hawaiiana Note. *The Honolulu Advertiser* [Honolulu]. October 20, 1956: 18, accessed October 19, 2020.

Oliveira, K.-A.
2014 *Ancestral Places: Understanding Kanaka Geographies*. Oregon State University Press, Corvallis.

Oliver, D.
1961 *The Pacific Islands*. University of Hawaii Press, Honolulu.

Pammer, M., D. Perzinski, D. Shideler, and H. Hammatt
2010 Archaeological Inventory Survey of an Approximate 294-acre Parcel for the Proposed Kunia Loa Ridge Farmlands Project Honouliuli Ahupua‘a, ‘Ewa District, Island of O‘ahu TMK: [1] 9-2-004:005 por. Cultural Surveys Hawai‘i, Kailua, Hawai‘i.

PBR Hawaii
2018 Agricultural Land Assessment for Hartung Brothers Hawaii, LLC's Proposed Important Agricultural Land, Island of O‘ahu. PBR Hawaii. Prepared for Hartung Brothers Hawaii, LLC, Honolulu.

Perzinski, D., D. Shideler, and H. Hammatt
2003 Archaeological Inventory Survey of an Approximate 250-acre Parcel for the Proposed Kunia Lan Fill Project, Honouliuli Ahupua‘a, ‘Ewa District, Island of O‘ahu TMK: 9-2-00: por 5. Cultural Surveys Hawai‘i Report. Prepared for URS Corporation.

Pukui, M. K. (editor)
1983 *‘Ōlelo No‘eau: Hawaiian proverbs & poetical sayings*. Bishop Museum Press, Honolulu.

Pukui, M. K., S. H. Elbert, and E. Mo‘okini
1974 *Place Names of Hawaii*. Revised and Expanded ed. University of Hawaii Press, Honolulu.

Pukui, M. K. and L. Green
1995 *Folktales of Hawai'i: He mau Ka'ao Hawai'i*. B. P. Bishop Museum Press, Honolulu.

Sai, D. K.
2011 *Ua Mau Ke Ea Sovereignty Endures: An Overview of the Political and Legal History of the Hawaiian Islands*. Pūʻā Foundation, Honolulu.

Secretary, O. o. t. P.
2015 Presidential Proclamation Establishment of the Honouliuli National Monument. The White House, Washington, D.C.

Soehren, L.
2010 Hawaiian Place Names. *Ulukau: The Hawaiian Electronic Library*. Electronic document, http://ulukau.org/cgi-bin/hpn? , accessed September 14, 2016.

St. John, H.
1947 The History, Present Distribution, and Abundance of Sandalwood on Oahu, Hawaiian Islands. *Pacific Science* 1(1):5-20.

Sterling, E. and C. Summers
1978 *Sites of Oahu*. Bishop Museum Press, Honolulu.

Tulchin, J. and C. Monahan
2011 Archaeological Reconnaissance Survey for the Kunia Mauka Loa Ridge Farmlands Project, Honouliuli Ahupuaʻa, ʻEwa District, Island of Oʻahu, TMK: [1] 9-2-004: 013 por. Cultural; Surveys Hawaii, Inc., Kailua, Hawaiʻi.

Thrum, T.
1906 Heiaus and Heiau Sites Throughout the Hawaiian Islands, IN Thos. G. Thrum, compiler, *Hawaiian Almanac and Annual for 1907*, pp. 38-47, Honolulu, HI.

Vancouver, G.
1801 *A Voyage of Discovery to the North Pacific Ocean and Round the World*, vol. III. John Stockdale, London.

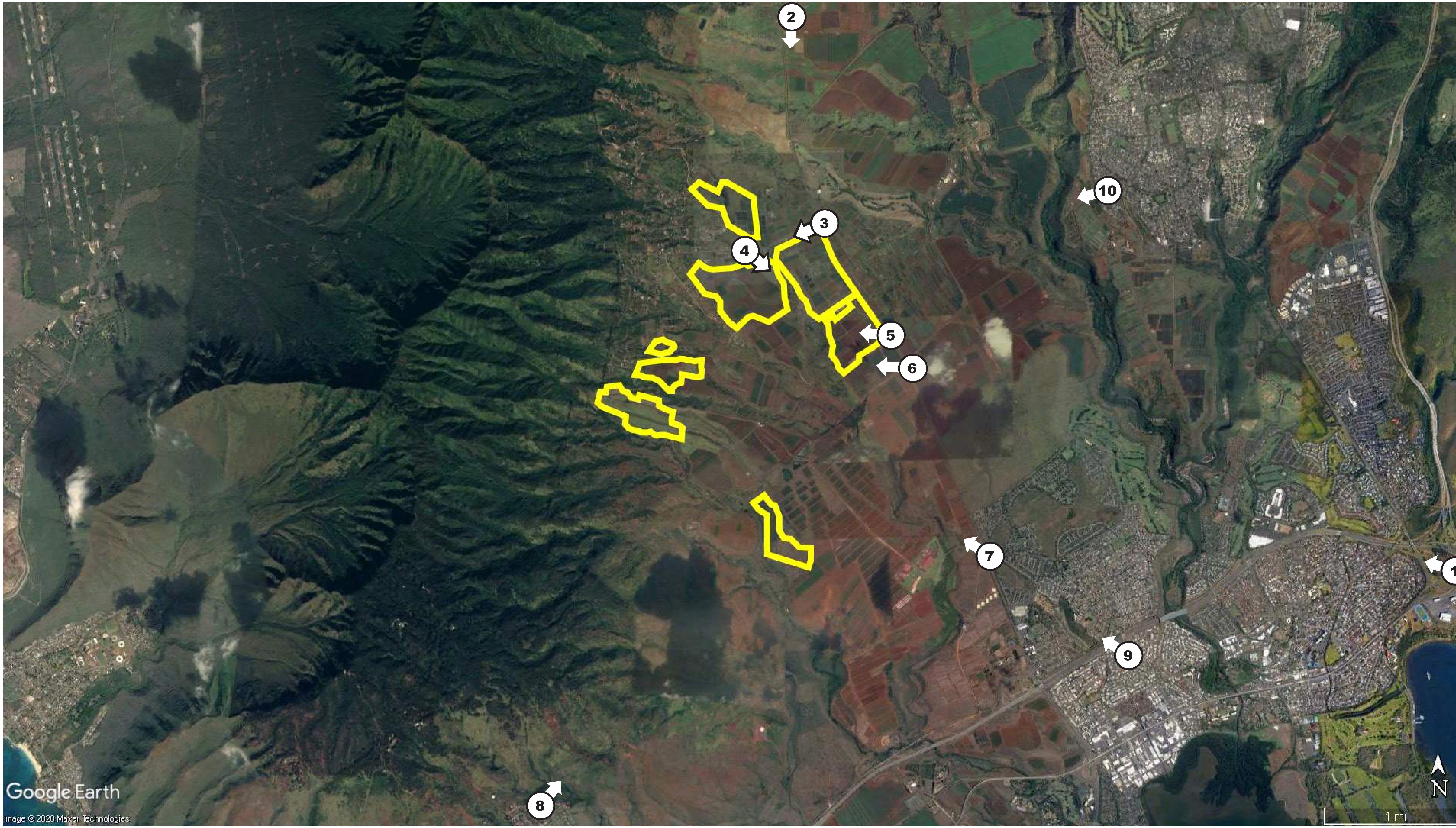
Wilcox, C.
1996 Sugar Water: Hawaii's Plantation Ditches. University of Hawai'i Press, Honolulu.

Wilkes, C.
1845 *Narrative of the United States Exploring Expedition During the Years 1838, 1839, 1849, 1842*, vol. IV. Lea and Blanchard, Philadelphia.

Yardley, P. T.
1981 *Millstones and Milestones: The Career of B.F. Dillingham, 1844-1918*. University of Hawaii Press, Honolulu.

Appendix G

View Study of Proposed Mahi Solar Farm, Kunia, Oʻahu
Prepared by G70
February 2021



Mahi Solar

Project Location

longroad ENERGY

G70

February 24 , 2021

Mahi Solar

H-1 Freeway Westbound before Exit 8B (Waipahu) – Looking Northwest
(4.9 Miles Away)

longroad ENERGY

G70

February 24 , 2021

Mahi Solar

Kunia Road
(1.2 Miles Away)

longroad ENERGY

G70

February 24 , 2021

Mahi Solar

Kunia Road and Pālāwai Road
(0.1 Miles Away)

longroad ENERGY

G70

February 24 , 2021

Mahi Solar

Pālāwai Road
(0.1 Miles Away)

longroad ENERGY

G70

February 24 , 2021

Mahi Solar

Kunia Road and Plantation Road
(0.6 Miles Away)

longroad ENERGY

G70

February 24 , 2021

Mahi Solar

Kunia Road
(0.2 Miles Away)

longroad ENERGY

G70

February 24 , 2021

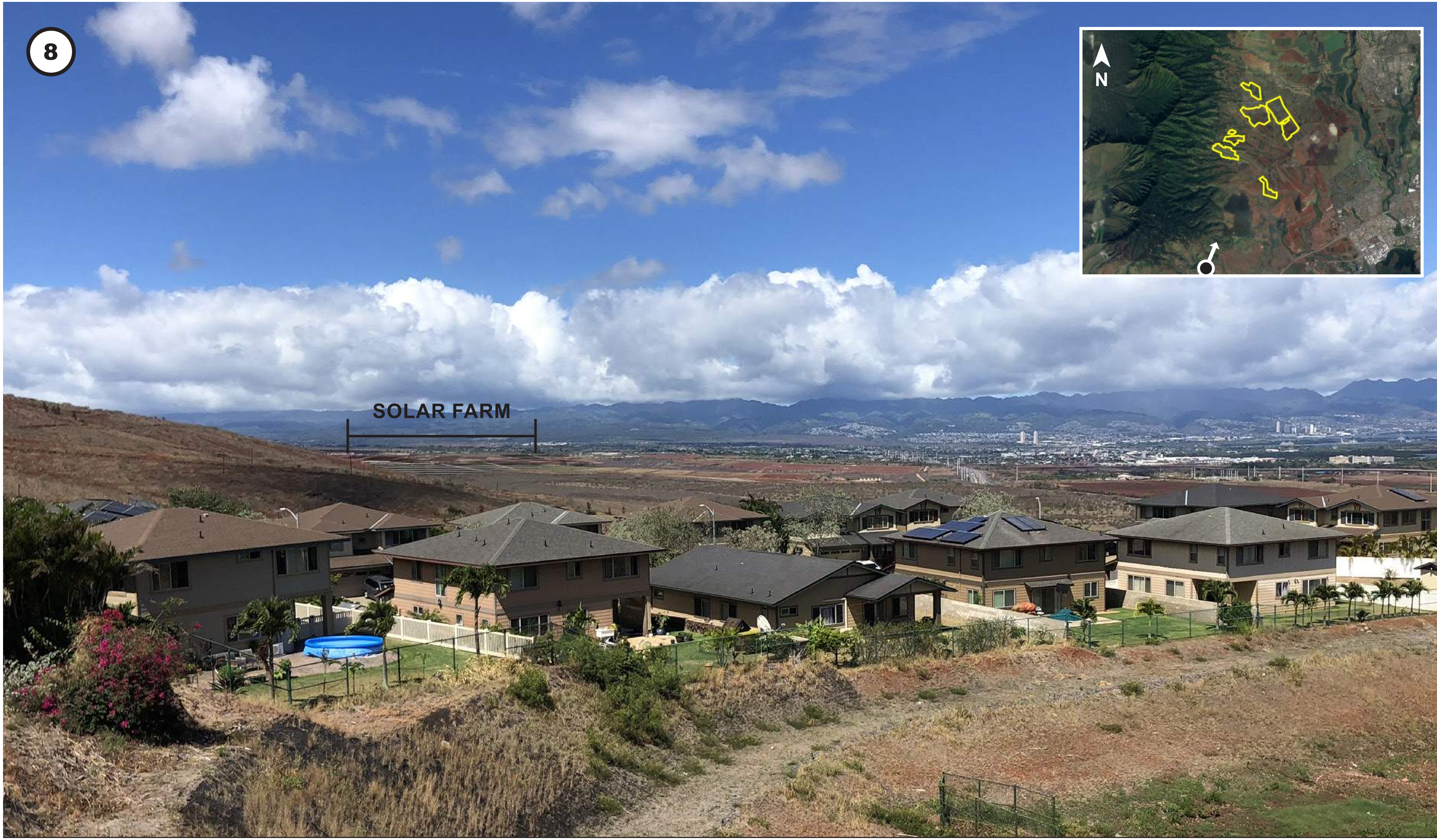
Mahi Solar

Kunia Road and Anonui Road
(1.6 Miles Away)

longroad ENERGY

G70

February 24 , 2021



Mahi Solar

Makakilo Drive
(2.3 Miles Away)

longroad ENERGY

G70

February 24 , 2021

Mahi Solar

Waipahu Elementary
(3.4 Miles Away)

longroad ENERGY

G70

February 24 , 2021

Mahi Solar

Niu Street, Mililani
(2.0 Miles Away)

longroad ENERGY

G70

February 24 , 2021

Mahi Solar

Alternative Gen-Tie Site Layout with Substation View from Kunia Road
(0.2 Miles Away)

longroad ENERGY

G70

February 24 , 2021

Appendix H

Glare Analysis for the Mahi Longroad Energy Solar Project in Oʻahu, Hawaiʻi Prepared by Power Engineers October 2020

POWER ENGINEERS, INC.
2041 SOUTH COBALT POINT WAY
MERIDIAN, ID 83642 USA

PHONE 208-288-6100
FAX 208-288-6199

October 2, 2020

Jeffrey H. Overton
Group 70 International, Inc.
111 S. King Street, Suite 170
Honolulu, Hawaii 96813

Subject: Glare analysis for the Mahi Longroad Energy Solar Project in Oahu, Hawaii

Dear Mr. Overton:

At your request, POWER Engineers Inc. (POWER) has evaluated the proposed Mahi Longroad Energy Solar Project (Project) to ensure Federal Aviation Administration (FAA) compliance regarding hazardous solar glare in or around airports. This technical memo describes our findings.

Project Description – The proposed Project is located in Oahu, Hawaii and will utilize single-axis tracking photovoltaic solar technology and produce up to 120 megawatts (MW) of energy (See Appendix A). This Glare Study was commissioned by Group 70 International Inc. and prepared for Kalaeloa Airport officials, Wheeler Army Airfield, and the FAA. Specifically, this study does the following:

- Identifies any sensitive viewers near the Project including structures, major roadways and approach slopes associated with the Kalaeloa Airport and Wheeler Army Airfield.
- Characterizes typical glare behavior experienced from the solar project throughout the day and year.
- Evaluates when and where glare may be visible to structures, motorists and pilots on final approach.

Sensitive Viewers – The FAA has expressed concern for glare resulting from PV systems potentially causing distractions to pilots. For this reason, the FAA has asked solar developers to perform a glare hazard analysis to evaluate and document potential occurrences of glare. Proposed solar operations were studied for six landing approaches at the Kalaeloa Airport, two landing approaches at Wheeler Army Airfield. In addition to airport operations, POWER analyzed Highway 750 and any nearby structures (See Appendix B). POWER identified and analyzed the following sensitive viewers:

- **Structures** – Single point analysis was completed for nearby structures
  - An aerial survey using Google Earth was completed to identify structures within the study boundary provided by Group 70
  - Distance from Project: Up to one mile
  - Viewer Height: One story Structure 8 feet, two story structure 16 feet
- **Highway 750**
  - Distance from Project: Up to one mile
  - Viewer Height: 10 Feet

- **Kalaeloa Airpor**t – 2-mile final approaches analyzed at 3% slope
    - Runway 11 Landing Approach:
        - Distance from Project: 6.11 miles
        - Heading: 118 degrees true
        - Runway Elevation: 29.25 feet
        - Final Approach Slope: 3.0 degrees
    - Runway 22L Landing Approach:
        - Distance from Project: 5.80 miles
        - Heading: 235 degrees true
        - Runway Elevation: 26.25 feet
        - Final Approach Slope: 3.0 degrees
    - Runway 22R Landing Approach:
        - Distance from Project: 5.70 miles
        - Heading: 235 degrees true
        - Runway Elevation: 29.53 feet
        - Final Approach Slope: 3.0 degrees
    - Runway 29 Landing Approach:
        - Distance from Project: 6.45 miles
        - Heading: 298 degrees true
        - Runway Elevation: 9.84 feet
        - Final Approach Slope: 3.0 degrees
    - Runway 4L Landing Approach:
        - Distance from Project: 6.21 miles
        - Heading: 55 degrees true
        - Runway Elevation: 22.12 feet
        - Final Approach Slope: 3.0 degrees
    - Runway 4R Landing Approach:
        - Distance from Project: 6.73 miles
        - Heading: 55 degrees true
        - Runway Elevation: 13.12 feet
        - Final Approach Slope: 3.0 degrees
- **Wheeler Army Airfield** – 2-mile final approaches analyzed at 3% slope
    - Runway 24 Landing Approach:
        - Distance from Project: 3.90 miles
        - Heading: 249.1 degrees true
        - Runway Elevation: 836.66 feet
        - Final Approach Slope: 3.0 degrees

- Runaway 6 Landing Approach:
  - Distance from Project: 3.29 miles
  - Heading: 70.2 degrees true
  - Runway Elevation: 816.13 feet
  - Final Approach Slope: 3.0 degrees

Solar Technology – The Project proposes the use of single-axis tracking PV panels rotating around a north/south axis. Single-axis trackers are designed to maximize solar efficiency by tracking the east-west position of the sun throughout the day. Panels will be operating as true tracking panels (See Appendix C). Details of the solar technologies were provided by Group 70 and are described below:

- Tracking: Single-axis True Tracking
- Tracking Axis Orientation: 180 due south
- Maximum Tracking Angle: ± 60 Degrees
- Coating/Texture: Anti-Reflective Coated Lightly Textured Glass
- Mount Height: 6.0 feet above grade (used to represent worst-case scenario)

Glare Analysis – POWER used GlareGauge licensed by ForgeSolar. The GlareGauge uses Solar Glare Hazard Analysis Tool technology and is a web based glare assessment tool allowing input of viewer position, solar facility location, solar technology, and elevation data. The GlareGauge provides a quantified assessment of when and where glare may occur throughout the year from a solar installation, as well as identifying the potential effects on the human eye when glare does occur. Glare was analyzed at one minute intervals throughout the entire year to determine when and where glare may be visible to structures, motorists, and pilots. The GlareGauge meets FAA glare analysis requirements. Due to the size and complexity of the Project, each major block of PV arrays was subdivided and analyzed in smaller areas to reduce any over-reporting of generalized glare.

Results – After review of the Glare Gauge tool analysis, POWER determined no potential glare will be visible from the proposed solar operations due to the orientation of the true tracking PV panels and the distance from sensitive viewers to the Project. Based on these findings, it is POWER's professional opinion that the proposed Mahi Solar Project will not impact airport operations at the, Kalaeloa Airport, Wheeler Army Airfield, nearby structures, and motorists on Highway 750.

POWER's independent analysis using the GlareGauge concluded the following:

- Structures – Nearby structures reported no Glare.
- Highway 750 – Two-way route receptor reported no Glare.
- Kalaeloa Airport – Runways 11, 22L, 22R, 29, 4L, and 4R reported no Glare.
- Wheeler Army Airfield – Runways 24 and 6 reported no Glare.

For a detailed description of the GlareGauge analysis report please see Appendix D.

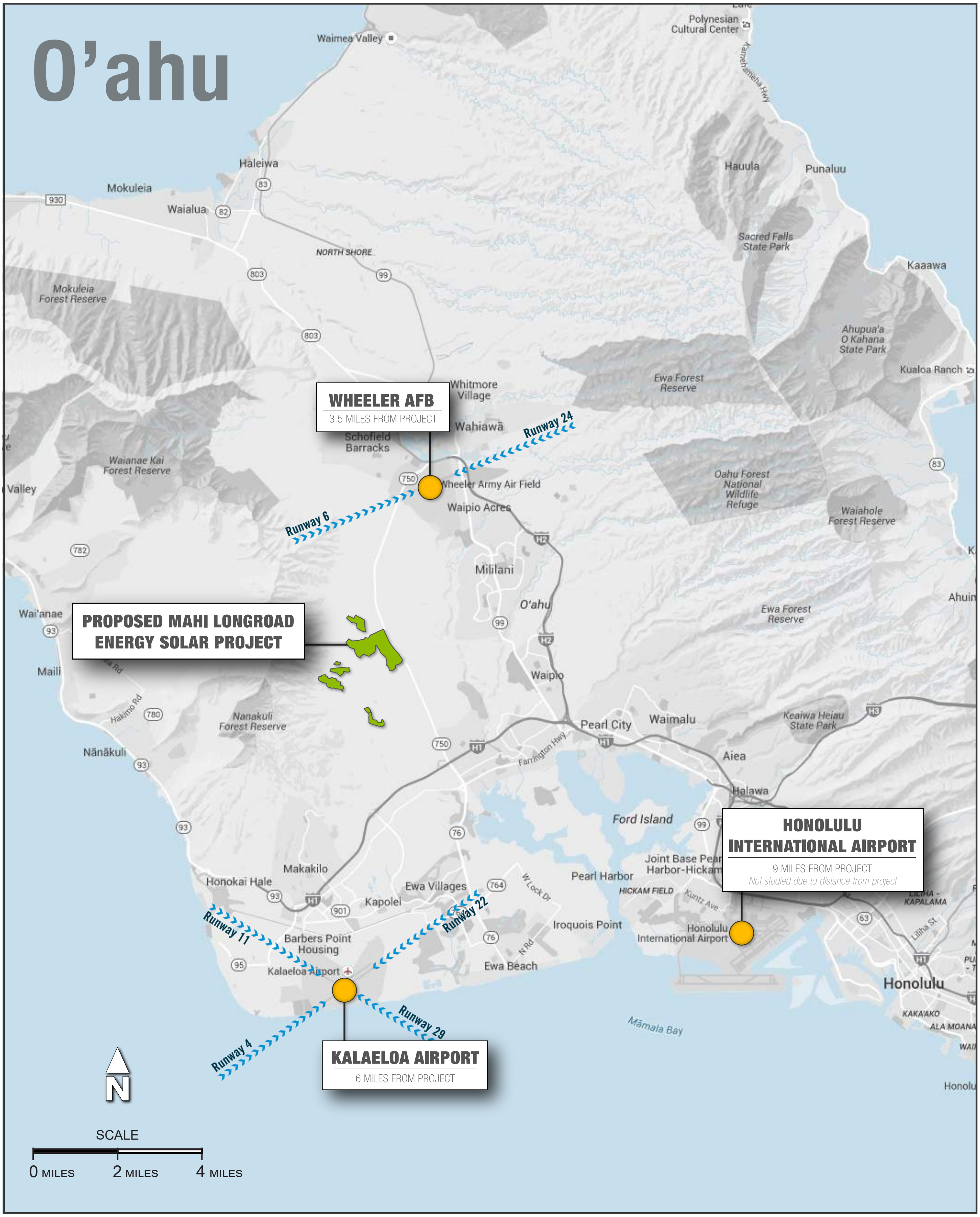
Please let me know if you have any questions as I would be happy to discuss process and recommendations.

Sincerely,

Priscilla Guerrero, Ph.D.
Air Quality Specialist

Enclosure: Appendix A – Project Location
Appendix B – Project Layout
Appendix C – Solar Behavior
Appendix D – GlareGauge output glare analysis

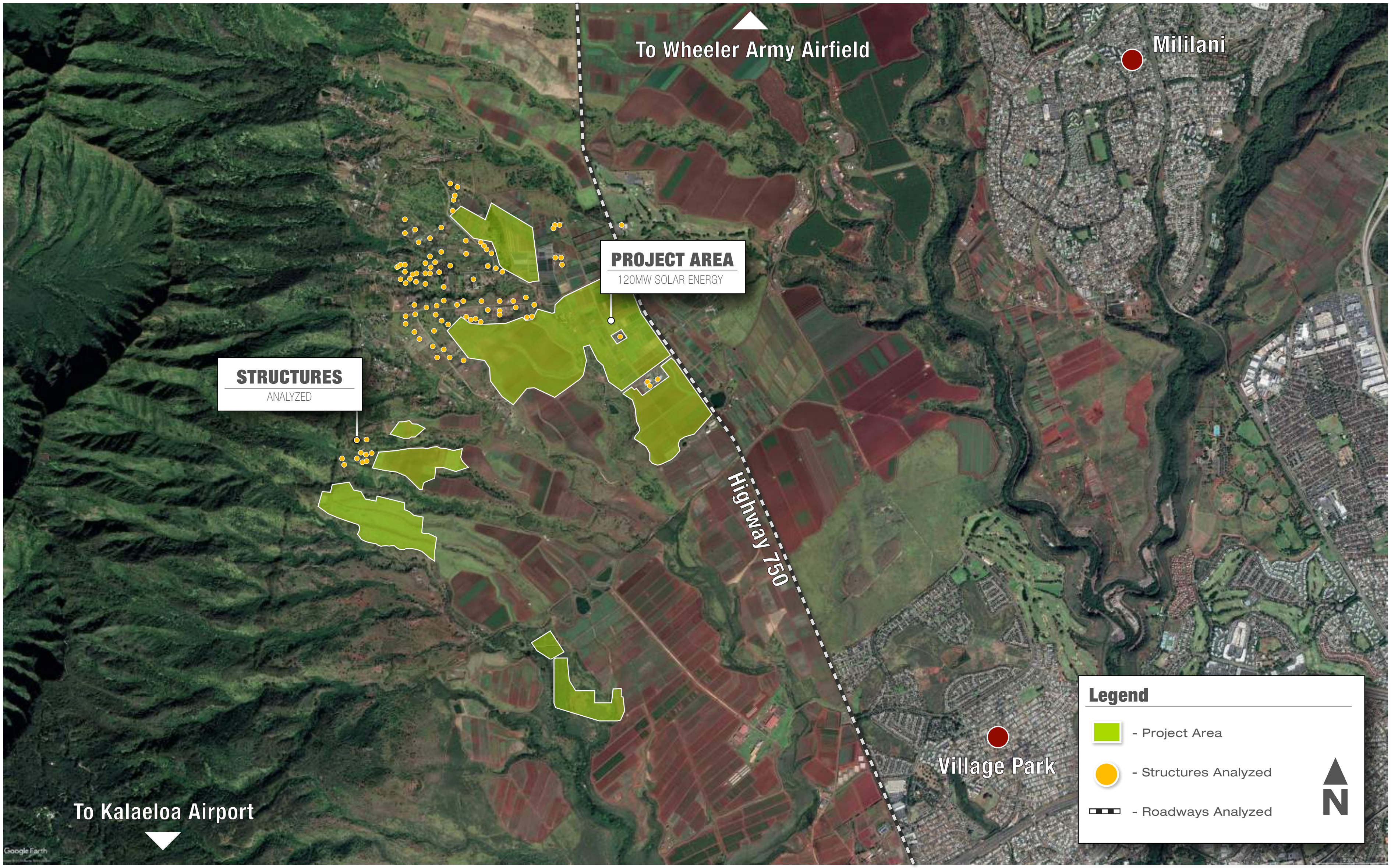
APPENDIX A PROJECT LOCATION



Prepared By,

POWER ENGINEERS

APPENDIX B PROJECT LAYOUT



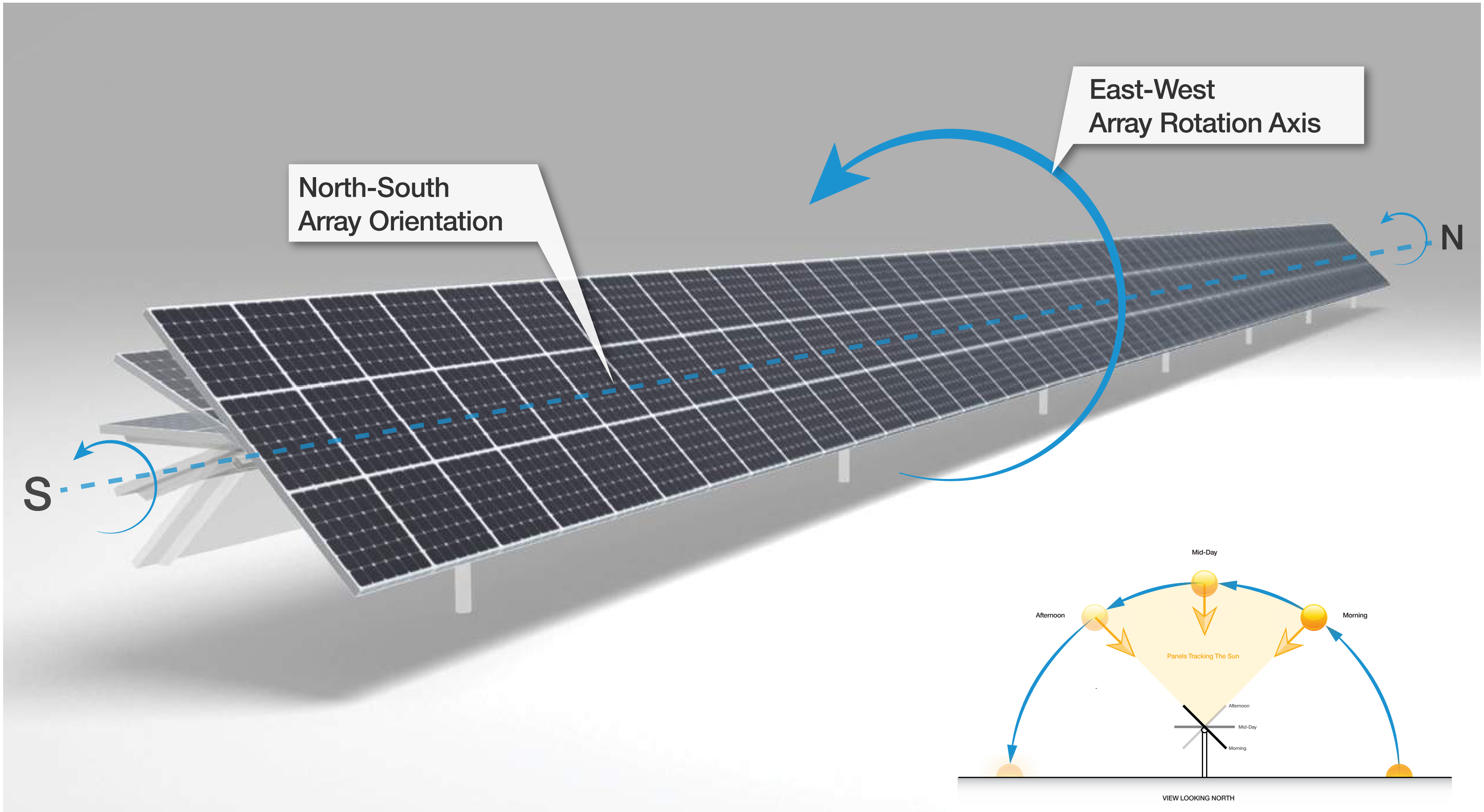
Prepared By,

POWER ENGINEERS

Mahi Longroad Energy Solar Project Glare Analysis

Project Layout - Appendix B

APPENDIX C SOLAR BEHAVIOR



Prepared By,

POWER ENGINEERS

Mahi Longroad Energy Solar Project Glare Analysis

Solar Behavior - Appendix C

APPENDIX D GLAREGAUGE OUTPUT GLARE ANALYSIS

Site Configuration: Mahi - Areas 1 and 2 and 5

Project site configuration details and results.

Created **Sept. 28, 2020 3:47 p.m.**
Updated **Sept. 28, 2020 11:03 p.m.**
DNI **varies** and peaks at **1,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC-10**
Site Configuration ID: 43819.7757

Summary of Results No glare predicted!

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh
Area 1-1	SA tracking	SA tracking	0	0	-
Area 1-2	SA tracking	SA tracking	0	0	-
Area 1-3	SA tracking	SA tracking	0	0	-
Area 1-4	SA tracking	SA tracking	0	0	-
Area 2-1	SA tracking	SA tracking	0	0	-
Area 3-2	SA tracking	SA tracking	0	0	-
Area 3-3	SA tracking	SA tracking	0	0	-
Area 3-4	SA tracking	SA tracking	0	0	-
Area 5-1	SA tracking	SA tracking	0	0	-
Area 5-2	SA tracking	SA tracking	0	0	-

Component Data

PV Array(s)

Site Configuration: Mahi - Areas 3 and 4B

Project site configuration details and results.

Created **Sept. 28, 2020 3:24 p.m.**
Updated **Sept. 28, 2020 11:11 p.m.**
DNI **varies** and peaks at **1,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC-10**
Site Configuration ID: 43817.7757

Summary of Results No glare predicted!

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh
Area 3-1	SA tracking	SA tracking	0	0	-
Area 3-2	SA tracking	SA tracking	0	0	-
Area 3-3	SA tracking	SA tracking	0	0	-
Area 3-4	SA tracking	SA tracking	0	0	-
Area 3-5	SA tracking	SA tracking	0	0	-
Area 4B-1	SA tracking	SA tracking	0	0	-
Area 4B-1	SA tracking	SA tracking	0	0	-
Area 4B-2	SA tracking	SA tracking	0	0	-
Area 4B-3	SA tracking	SA tracking	0	0	-
Area 4B-4	SA tracking	SA tracking	0	0	-
Area 4B-5	SA tracking	SA tracking	0	0	-
Area 4B-6	SA tracking	SA tracking	0	0	-

Component Data

PV Array(s)

Site Configuration: Mahi - Revised Areas 4A and 4C

Project site configuration details and results.

Created **Sept. 28, 2020 9:10 p.m.**
Updated **Sept. 30, 2020 7:36 p.m.**
DNI **varies** and peaks at **1,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC-10**
Site Configuration ID: 43832.7757

Summary of Results No glare predicted!

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
Area 4A-1	SA tracking	SA tracking	0	0	-
Area 4A-2	SA tracking	SA tracking	0	0	-
Area 4A-3	SA tracking	SA tracking	0	0	-
Area 4A-4	SA tracking	SA tracking	0	0	-
Area 4A-5	SA tracking	SA tracking	0	0	-
Area 4A-6	SA tracking	SA tracking	0	0	-
Area 4A-7	SA tracking	SA tracking	0	0	-
Area 4A-8	SA tracking	SA tracking	0	0	-
Area 4A-9	SA tracking	SA tracking	0	0	-
Area 4C-1	SA tracking	SA tracking	0	0	-
Area 4C-2	SA tracking	SA tracking	0	0	-
Area 4C-3	SA tracking	SA tracking	0	0	-
Area 4C-4	SA tracking	SA tracking	0	0	-
Area 4C-5	SA tracking	SA tracking	0	0	-
Area 4C-6	SA tracking	SA tracking	0	0	-

Component Data

PV Array(s)

Name: Area 1-1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 1,000,763 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.412872	-158.076871	1095.15	6.00	1101.15
2	21.411264	-158.077247	1089.07	6.00	1095.07
3	21.410375	-158.077258	1051.61	6.00	1057.61
4	21.410075	-158.076667	1025.74	6.00	1031.74
5	21.409786	-158.075401	976.38	6.00	982.38
6	21.409716	-158.074629	951.62	6.00	957.62
7	21.413022	-158.074372	995.64	6.00	1001.64
8	21.413152	-158.075992	1054.16	6.00	1060.16
9	21.412722	-158.076013	1060.22	6.00	1066.22

Name: Area 1-2
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 546,349 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.413032	-158.074425	998.05	6.00	1004.05
2	21.412912	-158.073846	975.10	6.00	981.10
3	21.411953	-158.073438	963.84	6.00	969.84
4	21.411923	-158.072172	911.38	6.00	917.38
5	21.410355	-158.072129	884.11	6.00	890.11
6	21.410435	-158.074543	972.39	6.00	978.40

Name: Area 1-3
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 427,555 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.410455	-158.074575	973.73	6.00	979.73
2	21.409726	-158.074629	952.50	6.00	958.50
3	21.409506	-158.074189	937.39	6.00	943.39
4	21.409586	-158.073470	917.29	6.00	923.29
5	21.409206	-158.072108	861.67	6.00	867.67
6	21.408787	-158.071893	843.04	6.00	849.04
7	21.408577	-158.071410	836.97	6.00	842.98
8	21.410275	-158.071292	860.65	6.00	866.65
9	21.410355	-158.072151	884.55	6.00	890.56

Name: Area 1-4
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 883,262 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.413871	-158.080090	1231.88	6.00	1237.88
2	21.412682	-158.080530	1250.75	6.00	1256.75
3	21.412033	-158.079586	1194.08	6.00	1200.08
4	21.411284	-158.077258	1089.71	6.00	1095.71
5	21.412882	-158.076882	1095.32	6.00	1101.32
6	21.413681	-158.076946	1089.58	6.00	1095.58
7	21.413961	-158.077794	1123.85	6.00	1129.85
8	21.414211	-158.078159	1141.97	6.00	1147.98
9	21.413911	-158.079017	1190.26	6.00	1196.27

Name: Area 2-1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 291,241 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.418770	-158.074227	1004.36	6.00	1010.36
2	21.418975	-158.072918	953.05	6.00	959.05
3	21.418546	-158.072017	915.51	6.00	921.51
4	21.417996	-158.072704	936.11	6.00	942.11
5	21.417597	-158.073707	970.40	6.00	976.40
6	21.417881	-158.074844	1030.02	6.00	1036.02

Name: Area 3-2
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 382,588 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.417023	-158.075413	1040.95	6.00	1046.95
2	21.415424	-158.076223	1061.51	6.00	1067.51
3	21.415165	-158.074415	999.88	6.00	1005.88
4	21.417072	-158.073932	973.52	6.00	979.52
5	21.417197	-158.075386	1044.97	6.00	1050.97

Name: Area 3-3
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 411,145 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.416513	-158.074050	1005.41	6.00	1011.41
2	21.416478	-158.073707	993.97	6.00	999.97
3	21.417013	-158.073519	965.50	6.00	971.50
4	21.416788	-158.069362	841.55	6.00	847.55
5	21.416014	-158.069442	844.23	6.00	850.23
6	21.416278	-158.074098	1008.48	6.00	1014.48

Name: Area 3-4
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 771,717 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.416228	-158.074103	1008.18	6.00	1014.18
2	21.415209	-158.074339	1000.47	6.00	1006.47
3	21.414900	-158.073535	968.69	6.00	974.69
4	21.414231	-158.072912	932.97	6.00	938.97
5	21.413971	-158.072322	923.19	6.00	929.19
6	21.414510	-158.071925	909.59	6.00	915.59
7	21.414820	-158.071518	890.02	6.00	896.02
8	21.415160	-158.071421	870.00	6.00	876.00
9	21.414970	-158.070016	819.23	6.00	825.23
10	21.414950	-158.069490	805.27	6.00	811.27
11	21.415929	-158.069361	840.34	6.00	846.34

Name: Area 5-1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 1,044,255 sq-ft

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	21.401151	-158.062176	558.91	6.00	564.91
2	21.401196	-158.060993	575.34	6.00	581.34
3	21.398484	-158.060864	553.35	6.00	559.35
4	21.398449	-158.058606	532.42	6.00	538.42
5	21.396541	-158.058584	504.51	6.00	510.51
6	21.397420	-158.062060	502.03	6.00	508.03

Name: Area 5-2
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 453,363 sq-ft

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	21.397860	-158.058584	550.09	6.00	556.09
2	21.397840	-158.057538	514.65	6.00	520.65
3	21.398439	-158.057565	525.04	6.00	531.04
4	21.398419	-158.056481	563.74	6.00	569.74
5	21.396411	-158.056406	528.26	6.00	534.26
6	21.396411	-158.058552	497.94	6.00	503.94

2-Mile Flight Path Receptor(s)

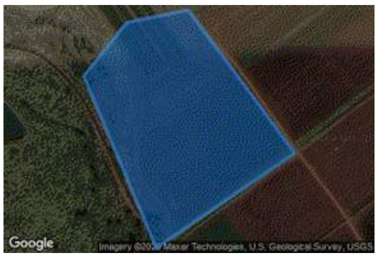
Name: Area 3-1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 951,036 sq-ft

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	21.419387	-158.049286	647.57	6.00	653.57
2	21.418138	-158.050574	645.55	6.00	651.55
3	21.417839	-158.050949	642.53	6.00	648.53
4	21.417579	-158.052001	648.09	6.00	654.09
5	21.419297	-158.053277	676.37	6.00	682.37
6	21.421145	-158.050627	661.37	6.00	667.37

Name: Area 3-2
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 896,654 sq-ft

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	21.419227	-158.053331	676.55	6.00	682.55
2	21.417789	-158.055477	639.84	6.00	645.84
3	21.417179	-158.054865	640.36	6.00	646.36
4	21.415581	-158.053867	631.30	6.00	637.30
5	21.416141	-158.052419	640.18	6.00	646.18
6	21.416660	-158.051958	644.24	6.00	650.24
7	21.417529	-158.052054	648.17	6.00	654.17

Name: Area 3-3
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 536,823 sq-ft



Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.420186	-158.056099	648.34	6.00	654.34
2	21.420835	-158.055536	689.52	6.00	695.52
3	21.420985	-158.054736	698.69	6.00	704.69
4	21.419257	-158.053352	676.96	6.00	682.97
5	21.418108	-158.055155	644.21	6.00	650.21

Name: Area 3-4
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 536,616 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.420935	-158.054618	698.36	6.00	704.36
2	21.422143	-158.052902	679.54	6.00	685.54
3	21.420446	-158.051647	670.22	6.00	676.22
4	21.419287	-158.053288	676.43	6.00	682.43

Name: Area 3-5
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 417,242 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.422952	-158.053417	681.59	6.00	687.59
2	21.423462	-158.052473	689.97	6.00	695.97
3	21.421185	-158.050649	661.86	6.00	667.86
4	21.420475	-158.051614	669.57	6.00	675.57

Name: Area 4B-1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 862,305 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.427414	-158.062111	760.30	6.00	766.30
2	21.427953	-158.061414	769.87	6.00	775.87
3	21.428922	-158.059279	780.18	6.00	786.18
4	21.426725	-158.058378	753.67	6.00	759.67
5	21.425606	-158.060802	705.17	6.00	711.17

Name: Area 4B-1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 821,396 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.425809	-158.056381	720.73	6.00	726.73
2	21.422723	-158.054181	699.80	6.00	705.80
3	21.423741	-158.052647	693.26	6.00	699.26
4	21.426668	-158.054879	735.65	6.00	741.65

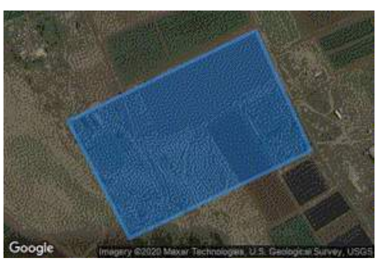
Name: Area 4B-2
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 961,303 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.430210	-158.056468	761.31	6.00	767.31
2	21.428952	-158.059247	779.50	6.00	785.50
3	21.426735	-158.058335	752.90	6.00	758.90
4	21.427774	-158.055406	748.63	6.00	754.63

Name: Area 4B-3
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 504,744 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.426685	-158.058303	750.97	6.00	756.97
2	21.425317	-158.057595	727.97	6.00	733.97
3	21.426685	-158.054912	735.91	6.00	741.91
4	21.427724	-158.055417	748.54	6.00	754.54

Name: Area 4B-4
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 529,931 sq-ft



Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.425579	-158.060812	704.78	6.00	710.78
2	21.424161	-158.060007	697.62	6.00	703.62
3	21.425220	-158.057647	724.87	6.00	730.87
4	21.426678	-158.058366	752.39	6.00	758.39

Name: Area 4B-5
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 785,845 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.424590	-158.058934	693.06	6.00	699.06
2	21.421145	-158.056574	682.22	6.00	688.22
3	21.422034	-158.055168	709.13	6.00	715.13
4	21.425160	-158.057529	725.31	6.00	731.31

Name: Area 4B-6
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 417,952 sq-ft

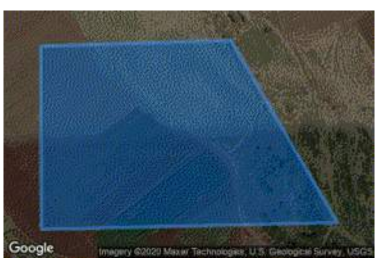
Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.424560	-158.056949	723.48	6.00	729.48
2	21.425130	-158.055962	723.74	6.00	729.74
3	21.422713	-158.054224	700.51	6.00	706.51
4	21.422074	-158.055115	709.78	6.00	715.78

2-Mile Flight Path Receptor(s)

Name: Area 4A-1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 533,558 sq-ft

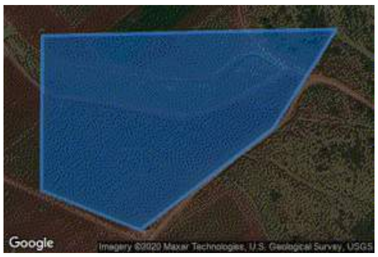
Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	21.427270	-158.063253	741.06	6.00	747.06
2	21.427446	-158.061992	762.80	6.00	768.80
3	21.425289	-158.060597	701.58	6.00	707.58
4	21.425249	-158.063103	781.56	6.00	787.56
5	21.426559	-158.063491	767.49	0.00	767.49

Name: Area 4A-2
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 877,122 sq-ft



Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	21.425219	-158.063086	781.46	6.00	787.47
2	21.423002	-158.063076	759.22	6.00	765.22
3	21.423082	-158.059224	672.33	6.00	678.33
4	21.425289	-158.060608	701.62	6.00	707.62

Name: Area 4A-3
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 778,792 sq-ft



Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	21.422992	-158.063076	759.11	6.00	765.11
2	21.421124	-158.063086	764.36	6.00	770.36
3	21.420645	-158.061799	760.30	6.00	766.30
4	21.421873	-158.060072	710.54	6.00	716.54
5	21.423072	-158.059246	672.97	6.00	678.97

Name: Area 4A-4
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 1,070,498 sq-ft

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	21.423669	-158.066021	829.23	6.00	835.23
2	21.420665	-158.066058	759.62	6.00	765.62
3	21.420066	-158.065082	759.34	6.00	765.34
4	21.421304	-158.063977	774.62	6.00	780.62
5	21.421124	-158.063086	764.36	6.00	770.36
6	21.423674	-158.063092	774.13	6.00	780.13

Name: Area 4A-5
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 783,980 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.426557	-158.069451	908.31	6.00	914.31
2	21.425524	-158.070320	931.41	6.00	937.41
3	21.423631	-158.068966	846.16	6.00	852.16
4	21.423212	-158.067464	825.76	6.00	831.76
5	21.426118	-158.067357	847.42	6.00	853.42
6	21.426017	-158.067920	872.93	0.00	872.93
7	21.426081	-158.068462	886.06	6.00	892.06

Name: Area 4A-6
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 491,723 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.426118	-158.067367	847.85	6.00	853.85
2	21.426130	-158.066064	838.07	6.00	844.07
3	21.423222	-158.066037	822.35	6.00	828.35
4	21.423202	-158.067464	825.09	6.00	831.09

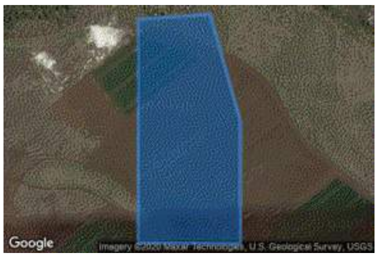
Name: Area 4A-7
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 303,767 sq-ft

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	21.423212	-158.067464	825.76	6.00	831.76
2	21.421953	-158.067239	790.72	6.00	796.72
3	21.420635	-158.066058	758.75	6.00	764.75
4	21.423232	-158.066037	822.56	6.00	828.56

Name: Area 4A-8
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 515,804 sq-ft

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	21.426097	-158.066044	839.52	6.00	845.52
2	21.426437	-158.064904	805.38	0.00	805.38
3	21.426442	-158.064445	803.40	6.00	809.40
4	21.423685	-158.064434	801.32	6.00	807.32
5	21.423685	-158.066033	829.62	6.00	835.62

Name: Area 4A-9
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 421,000 sq-ft



Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.426397	-158.064424	804.46	6.00	810.46
2	21.426457	-158.063490	769.98	6.00	775.98
3	21.425173	-158.063093	781.86	6.00	787.86
4	21.423685	-158.063093	774.62	6.00	780.62
5	21.423695	-158.064424	801.09	6.00	807.09

Name: Area 4C-1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 523,147 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.435982	-158.064722	909.91	6.00	915.91
2	21.433815	-158.065489	909.19	6.00	915.19
3	21.433223	-158.063681	873.55	0.00	873.55
4	21.433550	-158.062045	864.77	6.00	870.77
5	21.434000	-158.062082	868.85	6.00	874.85
6	21.434429	-158.063606	895.80	0.00	895.80

Name: Area 4C-2
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 470,126 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.433785	-158.065521	910.21	6.00	916.21
2	21.432167	-158.065939	873.69	6.00	879.69
3	21.430999	-158.063321	856.28	6.00	862.28
4	21.432322	-158.063547	874.79	6.00	880.79
5	21.433163	-158.063692	872.67	0.00	872.67

Name: Area 4C-3
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 680,944 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.432157	-158.065947	873.09	6.00	879.09
2	21.430499	-158.066374	817.02	6.00	823.02
3	21.429371	-158.064276	809.26	0.00	809.26
4	21.429181	-158.063187	808.92	6.00	814.92
5	21.429421	-158.063139	818.02	0.00	818.02
6	21.430160	-158.063279	839.01	6.00	845.01
7	21.430944	-158.063316	855.00	0.00	855.00

Name: Area 4C-4
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 723,797 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.435982	-158.064781	911.50	6.00	917.50
2	21.433795	-158.065585	912.10	6.00	918.10
3	21.435343	-158.069265	942.63	6.00	948.63
4	21.435952	-158.068750	955.27	6.00	961.28

Name: Area 4C-5
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 533,978 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.433730	-158.065558	911.57	6.00	917.57
2	21.430495	-158.066382	817.25	6.00	823.25
3	21.431340	-158.066713	834.72	0.00	834.72
4	21.432127	-158.067640	873.18	6.00	879.18
5	21.434374	-158.067087	916.85	6.00	922.85

Name: Area 4C-6
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad
Approx. area: 724,472 sq-ft

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	21.434194	-158.070392	957.42	6.00	963.42
2	21.433021	-158.069145	918.31	0.00	918.31
3	21.432544	-158.068462	894.74	0.00	894.74
4	21.432127	-158.067651	873.26	6.00	879.26
5	21.434404	-158.067077	917.76	6.00	923.76
6	21.435323	-158.069276	942.74	6.00	948.74

2-Mile Flight Path Receptor(s)

Name: Kalaeloa Runway 11
Description:
Threshold height : 50 ft
Direction: 118.0 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
Threshold	21.310418	-158.081419	29.25	50.00	79.25
2-mile point	21.323992	-158.108853	27.74	604.96	632.70

Name: Kalaeloa Runway 22L
Description:
Threshold height : 50 ft
Direction: 235.0 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
Threshold	21.312385	-158.060470	26.25	50.00	76.25
2-mile point	21.328969	-158.035018	32.13	597.58	629.71

Name: Kalaeloa Runway 11
Description:
Threshold height : 50 ft
Direction: 118.0 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
Threshold	21.310418	-158.081419	29.25	50.00	79.25
2-mile point	21.323992	-158.108853	27.74	604.96	632.70

Name: Kalaeloa Runway 22L
Description:
Threshold height : 50 ft
Direction: 235.0 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
Threshold	21.312385	-158.060470	26.25	50.00	76.25
2-mile point	21.328969	-158.035018	32.13	597.58	629.71

Name: Kalaeloa Runway 22R
Description:
Threshold height : 50 ft
Direction: 235.0 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
Threshold	21.313745	-158.061639	29.53	50.00	79.53
2-mile point	21.330328	-158.036187	32.81	600.17	632.99

Name: Kalaeloa Runway 29
Description:
Threshold height : 50 ft
Direction: 298.0 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
Threshold	21.302810	-158.066317	9.84	50.00	59.85
2-mile point	21.289236	-158.038884	0.00	613.30	613.30

Name: Kalaeloa Runway 4L
Description:
Threshold height : 50 ft
Direction: 55.0 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
Threshold	21.307028	-158.071860	22.12	50.00	72.12
2-mile point	21.290444	-158.097311	0.00	625.57	625.57

Name: Kalaeloa Runway 4R
Description:
Threshold height : 50 ft
Direction: 55.0 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
Threshold	21.300094	-158.079183	13.12	50.00	63.13
2-mile point	21.283510	-158.104633	0.00	616.58	616.58

Name: Wheeler Runway 24
Description:
Threshold height : 50 ft
Direction: 249.1 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
Threshold	21.484181	-158.030484	836.66	50.00	886.66
2-mile point	21.494486	-158.001419	984.91	455.20	1440.11

Name: Wheeler Runway 6
Description:
Threshold height : 50 ft
Direction: 70.2 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
Threshold	21.479499	-158.043259	816.13	50.00	866.13
2-mile point	21.469715	-158.072530	1166.94	252.65	1419.59

Route Receptor(s)

Name: Highway 750
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	ft	ft	ft
1	21.384020	-158.032346	179.95	10.00	189.95
2	21.384899	-158.033097	201.37	10.00	211.37
3	21.386867	-158.033891	251.78	10.00	261.78
4	21.393051	-158.036488	365.79	10.00	375.79
5	21.398115	-158.038741	409.46	10.00	419.46
6	21.402551	-158.040661	484.59	10.00	494.59
7	21.406127	-158.042303	513.25	10.00	523.25
8	21.410701	-158.044411	564.45	10.00	574.45
9	21.413568	-158.045747	591.73	10.00	601.73
10	21.416400	-158.047114	615.62	10.00	625.62
11	21.417503	-158.047678	625.34	10.00	635.34
12	21.419286	-158.049030	645.34	10.00	655.34
13	21.422717	-158.051663	681.62	10.00	691.62
14	21.425264	-158.053600	709.60	10.00	719.60
15	21.426982	-158.054850	736.97	10.00	746.97
16	21.430297	-158.056298	761.30	10.00	771.30
17	21.433648	-158.057591	786.20	10.00	796.20
18	21.434871	-158.058085	761.17	10.00	771.17
19	21.437618	-158.059168	810.51	10.00	820.51
20	21.438022	-158.059313	818.57	10.00	828.57
21	21.439041	-158.059581	836.55	10.00	846.55
22	21.440149	-158.059689	814.33	10.00	824.33
23	21.441447	-158.059748	814.60	10.00	824.60
24	21.443959	-158.059866	868.75	10.00	878.75
25	21.446770	-158.059994	836.30	10.00	846.30
26	21.449192	-158.060107	845.13	10.00	855.13
27	21.451483	-158.060210	848.38	10.00	858.38
28	21.452552	-158.060049	840.16	10.00	850.16
29	21.455517	-158.058954	824.05	10.00	834.05
30	21.461199	-158.056680	838.47	10.00	848.47
31	21.467928	-158.054062	827.13	10.00	837.13
32	21.473194	-158.051838	820.27	10.00	830.27
33	21.475936	-158.050888	757.07	10.00	767.07
34	21.479675	-158.049359	820.05	10.00	830.05
35	21.482685	-158.047723	839.44	10.00	849.44

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	ft	ft	ft
OP 1	21.436139	-158.069691	957.29	8.00	965.29
OP 2	21.435310	-158.069925	960.90	8.00	968.90
OP 3	21.435610	-158.069855	958.79	8.00	966.79
OP 4	21.436386	-158.070182	963.46	8.00	971.46
OP 5	21.434622	-158.070031	957.61	8.00	965.61
OP 6	21.432735	-158.073628	1036.70	8.00	1044.70
OP 7	21.433005	-158.072941	1006.89	8.00	1014.89
OP 8	21.432066	-158.072753	982.75	8.00	990.75
OP 9	21.432411	-158.071750	965.07	8.00	973.07
OP 10	21.433110	-158.070892	962.02	8.00	970.02
OP 11	21.431387	-158.070929	923.46	16.00	939.46
OP 12	21.432236	-158.068891	894.98	8.00	902.98
OP 13	21.431242	-158.068971	887.66	8.00	895.66
OP 14	21.432074	-158.067738	873.02	8.00	881.02
OP 15	21.431799	-158.067512	862.31	8.00	870.31
OP 16	21.431539	-158.067276	850.64	8.00	858.64
OP 17	21.431280	-158.066992	838.64	8.00	846.64
OP 18	21.430211	-158.066595	828.15	8.00	836.15
OP 19	21.429957	-158.066144	801.57	8.00	809.57
OP 20	21.429337	-158.068376	880.23	8.00	888.24
OP 21	21.427693	-158.067805	876.59	8.00	884.59
OP 22	21.427718	-158.066244	840.62	8.00	848.62
OP 23	21.427798	-158.065214	806.56	8.00	814.56
OP 24	21.428058	-158.064265	766.34	16.00	782.34
OP 25	21.427518	-158.063685	746.66	8.00	754.66
OP 26	21.426595	-158.063712	777.29	8.00	785.29
OP 27	21.426543	-158.064118	791.93	8.00	799.93
OP 28	21.427297	-158.065024	796.10	8.00	804.10
OP 29	21.427028	-158.066344	828.32	16.00	844.32
OP 30	21.427168	-158.067202	846.25	8.00	854.25
OP 31	21.426723	-158.066392	812.65	8.00	820.65
OP 32	21.426179	-158.067996	871.18	8.00	879.18
OP 33	21.426329	-158.068656	886.95	8.00	894.95
OP 34	21.426369	-158.068248	877.71	8.00	885.71
OP 35	21.426513	-158.069026	895.07	8.00	903.08
OP 36	21.427772	-158.069112	894.66	8.00	902.66
OP 37	21.427437	-158.069670	921.22	8.00	929.22
OP 38	21.425899	-158.070336	941.14	8.00	949.14
OP 39	21.426229	-158.070786	956.04	8.00	964.05
OP 40	21.426808	-158.071323	975.03	8.00	983.03
OP 41	21.425575	-158.071462	953.94	16.00	969.94
OP 42	21.424366	-158.071527	934.31	8.00	942.32
OP 43	21.423587	-158.071215	909.60	8.00	917.60
OP 44	21.423602	-158.070223	885.65	8.00	893.65
OP 45	21.424151	-158.070813	906.08	8.00	914.08
OP 46	21.423472	-158.069161	839.19	8.00	847.19
OP 47	21.424964	-158.072618	982.15	8.00	990.15
OP 48	21.425463	-158.073004	1013.35	8.00	1021.35
OP 49	21.426118	-158.073602	1042.38	8.00	1050.38
OP 50	21.426722	-158.073366	1044.14	16.00	1060.14
OP 51	21.426822	-158.072932	1032.42	8.00	1040.42
OP 52	21.427471	-158.073093	1023.11	8.00	1031.11
OP 53	21.427267	-158.072063	995.32	8.00	1003.33
OP 54	21.427431	-158.071274	967.03	8.00	975.03
OP 55	21.427796	-158.070743	942.64	8.00	950.64
OP 56	21.428780	-158.070652	940.96	8.00	948.96
OP 57	21.428949	-158.072095	990.41	8.00	998.41

OP 58	21.429119	-158.072835	1019.98	8.00	1027.98
OP 59	21.429294	-158.073297	1032.73	8.00	1040.73
OP 60	21.429074	-158.073640	1023.82	8.00	1031.82
OP 61	21.429324	-158.074042	1045.47	8.00	1053.47
OP 62	21.429878	-158.073736	1035.08	8.00	1043.08
OP 63	21.429619	-158.073028	1028.82	8.00	1036.82
OP 64	21.429694	-158.072824	1020.76	8.00	1028.76
OP 65	21.429709	-158.072057	995.52	8.00	1003.52
OP 66	21.429728	-158.071768	985.24	8.00	993.24
OP 67	21.429824	-158.071093	965.01	8.00	973.01
OP 68	21.430377	-158.070135	929.62	8.00	937.63
OP 69	21.430277	-158.071788	969.83	8.00	977.83
OP 70	21.430679	-158.071611	953.44	8.00	961.44
OP 71	21.430519	-158.072134	968.65	8.00	976.65
OP 72	21.431031	-158.071782	946.21	8.00	954.21
OP 73	21.430217	-158.074279	1046.62	8.00	1054.62
OP 74	21.430315	-158.074148	1051.41	8.00	1059.41
OP 75	21.430462	-158.074011	1058.34	8.00	1066.34
OP 76	21.430429	-158.073671	1049.93	8.00	1057.93
OP 77	21.433738	-158.073654	1042.74	8.00	1050.74
OP 78	21.430361	-158.067222	850.22	16.00	866.22
OP 79	21.417482	-158.076695	1112.13	8.00	1120.13
OP 80	21.417427	-158.077408	1147.37	8.00	1155.37
OP 81	21.416434	-158.076255	1086.68	8.00	1094.68
OP 82	21.416399	-158.076732	1107.52	8.00	1115.52
OP 83	21.416483	-158.077108	1120.49	8.00	1128.49
OP 84	21.415939	-158.076700	1095.73	8.00	1103.73
OP 85	21.415849	-158.076936	1105.09	8.00	1113.09
OP 86	21.416074	-158.077365	1125.77	8.00	1133.77
OP 87	21.415674	-158.078374	1156.52	8.00	1164.52
OP 88	21.416009	-158.078610	1162.07	8.00	1170.07
OP 89	21.430935	-158.061421	838.85	16.00	854.85
OP 90	21.430465	-158.061346	829.78	8.00	837.78
OP 91	21.430915	-158.061851	840.45	8.00	848.45
OP 92	21.433332	-158.061829	857.12	8.00	865.12
OP 93	21.433172	-158.062022	852.77	8.00	860.77
OP 94	21.433534	-158.061459	855.60	8.00	863.60
OP 95	21.425166	-158.056749	737.32	8.00	745.32
OP 96	21.421760	-158.054528	704.24	16.00	720.24
OP 97	21.422060	-158.053713	693.48	16.00	709.48
OP 98	21.421490	-158.054314	700.47	16.00	716.47

PV Array Results

Summary of PV Glare Analysis PV configuration and predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
Area 1-1	SA tracking	SA tracking	0	0	-	-
Area 1-2	SA tracking	SA tracking	0	0	-	-
Area 1-3	SA tracking	SA tracking	0	0	-	-
Area 1-4	SA tracking	SA tracking	0	0	-	-
Area 2-1	SA tracking	SA tracking	0	0	-	-
Area 3-2	SA tracking	SA tracking	0	0	-	-
Area 3-3	SA tracking	SA tracking	0	0	-	-
Area 3-4	SA tracking	SA tracking	0	0	-	-
Area 5-1	SA tracking	SA tracking	0	0	-	-
Area 5-2	SA tracking	SA tracking	0	0	-	-

Click the name of the PV array to scroll to its results

PV & Receptor Analysis Results detailed results for each PV array and receptor

Area 1-1 no glare found

PV Array Results

Summary of PV Glare Analysis PV configuration and predicted glare

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh	Data File
Area 3-1	SA tracking	SA tracking	0	0	-	-
Area 3-2	SA tracking	SA tracking	0	0	-	-
Area 3-3	SA tracking	SA tracking	0	0	-	-
Area 3-4	SA tracking	SA tracking	0	0	-	-
Area 3-5	SA tracking	SA tracking	0	0	-	-
Area 4B-1	SA tracking	SA tracking	0	0	-	-
Area 4B-1	SA tracking	SA tracking	0	0	-	-
Area 4B-2	SA tracking	SA tracking	0	0	-	-
Area 4B-3	SA tracking	SA tracking	0	0	-	-
Area 4B-4	SA tracking	SA tracking	0	0	-	-
Area 4B-5	SA tracking	SA tracking	0	0	-	-
Area 4B-6	SA tracking	SA tracking	0	0	-	-

Click the name of the PV array to scroll to its results

PV & Receptor Analysis Results detailed results for each PV array and receptor

Area 3-1 no glare found

PV Array Results

Summary of PV Glare Analysis PV configuration and predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
Area 4A-1	SA tracking	SA tracking	0	0	-	-
Area 4A-2	SA tracking	SA tracking	0	0	-	-
Area 4A-3	SA tracking	SA tracking	0	0	-	-
Area 4A-4	SA tracking	SA tracking	0	0	-	-
Area 4A-5	SA tracking	SA tracking	0	0	-	-
Area 4A-6	SA tracking	SA tracking	0	0	-	-
Area 4A-7	SA tracking	SA tracking	0	0	-	-
Area 4A-8	SA tracking	SA tracking	0	0	-	-
Area 4A-9	SA tracking	SA tracking	0	0	-	-
Area 4C-1	SA tracking	SA tracking	0	0	-	-
Area 4C-2	SA tracking	SA tracking	0	0	-	-
Area 4C-3	SA tracking	SA tracking	0	0	-	-
Area 4C-4	SA tracking	SA tracking	0	0	-	-
Area 4C-5	SA tracking	SA tracking	0	0	-	-
Area 4C-6	SA tracking	SA tracking	0	0	-	-

Click the name of the PV array to scroll to its results

PV & Receptor Analysis Results detailed results for each PV array and receptor

Area 4A-1 no glare found

Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Glare analysis methods used: OP V1, FP V1, Route V1
- Refer to the **Help page** for assumptions and limitations not listed here.

Appendix I

Decommissiong Plan

Decommissioning Plan

The design and operational life of the Mahi Solar Project (project) is approximately 35 years. Industry standards assume that module end-of-life occurs when output is reduced to 70% of new value or at the end of 35 years, whichever comes first. The contract with Hawaiian Electric Company, Inc. (HECO) is expected to last 25 years with an option to extend to 35 years. At the end of the project's useful life, the project will be decommissioned by Mahi Solar. Decommissioning is anticipated to take 18 months.

Removal, Recycling, and Restoration

The decommissioning activities will include the complete removal of the foundational piles and modules and all associated components to a depth of 24 inches below grade, which include any concrete foundations. The site will be restored to the original topography and revegetated, except where the landowner requests that access roads remain. Site fencing and electrical power will temporarily remain in place during decommissioning. Once the materials have been removed and the terrain revegetated, then the site will be fully de-energized, and the security fence will be removed. Based on a surety estimate performed for the project in December 2020, the estimated cost to decommission is $3 million (Attachment 1).

At the end of project life, components of the PV panels can be recycled or landfilled. The First Solar panels used for the project include cells with thin film cadmium telluride (CdTe) semiconductor. CdTe is a very small fraction of a thin film PV module, but still must be extracted to provide raw material for future thin film PV module production (Virginia Tech, 2019). Because of the small quantity and low solubility of the material, the modules are characterized as federal non-hazardous waste at end-of-life using the Toxicity Characteristic Leaching Procedure. With current technology, over 90 percent of a CdTe PV power system is recyclable, roughly twice what is recoverable from consumer electronics such as laptops and desktop computer. Research reviewed for the project further shows that CdTe has been shown to be non-toxic if released to the environment (NC Clean Energy, 2017 and Virginia Tech, 2019). Non-PV panel components of utility-scale PV systems, such as racking, are made of typical construction materials such as galvanized steel or aluminum. Inverters may contain fluids associated with cooling systems and not unlike cooling systems of a computer, while the transformers contain non-toxic fluid such as non-toxic mineral oil or a biodegradable non-toxic vegetable oil. According to research reviewed, exposure to toxic chemicals attributed to the project is not anticipated and materials used will not pose any health or environmental dangers.

A local recycling and salvage contractor will provide a detailed assessment of the materials that can be re-used, recycled, or landfilled prior to the end of the project life. All hazardous materials will be separated from the site and property disposed at a permitted disposal facility. Solar panels and other components, such as inverters and substation components, are expected to retain value and may be resold on the solar resale market. Structural components that cannot be reused will be scrapped and recycled at a recycling facility. Concrete will be broken up into transportable sized pieces by a hydraulic hoe ram, then transported to a location for re-use in road base.

Financial Security for Decommissioning

Mahi Solar will post security to decommission the Project after the end of commercial operation, which is a standard requirement in our other land agreements for energy projects across the country. A reclamation cost estimate (RCE) will be completed prior to the commercial operations date for the project, and Mahi Solar will post financial security in the form of a bond, letter of credit or similar instrument in favor of the landowner, to ensure that the decommissioning funds will be available at the time that the project is decommissioned should the Project owner be unable to complete the decommissioning. This is also required in the SUP. Land agreements, PPAs and other documents typically allow at least 12 months for decommissioning.

Upon completion of removal of project components and grading of the site, revegetation will be initiated using native or agricultural species at a time when germination and growing success is optimized. Erosional protection will be in place in accordance with a decommissioning stormwater protection plan. It is expected that up to three years may be required to complete revegetation if the site is going to be restored to a natural state. The vegetation that will be planted will be determined in concert with the landowner's intended use of the site following decommissioning.

Attachment 1

2020 Surety Estimate, Rev. 1
Engineering Analytics, Inc.
December 16, 2020

December 16, 2020 Project No. 110946

Mr. Deron Lawrence
Longroad Energy Management, LLC
330 Congress St. 6th Floor
Boston, MA 02110

Subject: 2020 Surety Estimate, Rev. 1
Mahi Solar Project
Oahu, HI

Dear Mr. Lawrence:

Engineering Analytics, Inc. (EA) is pleased to present this 2020 surety estimate for the Mahi Solar Project near Honolulu, Hawaii. This letter provides a brief description of EA's approach to create the surety estimate based on a review of the following provided documents:

- 2020 Mahi Solar Project: Basis of Design (BOD) Drawings by Revamp Engineering, Inc.

Site disturbance areas were estimated using the BOD drawings. Costs were estimated using Standardized Reclamation Cost Estimator Version 1.4.1, Build 17b (SRCE) along with the SRCE Cost Data File 1 12 Std 2020. The SCRE was developed by U.S. Department of the Interior-Bureau of Land Management (BLM), and Nevada Division of Environmental Protection (NDEP), and the Nevada Mining Association (NMA). RS Means costs were also used to determine the costs to remove the site infrastructure. RS Means City Cost Index data was used to convert the developed costs for Nevada to localized costs in Hawaii. Las Vegas, Nevada was selected as the origin location cost index location basis from the SCRE. Honolulu, Hawaii was selected as the project location cost index location basis. According to RS Means, the City Cost Index for Honolulu, Hawaii and Las Vegas, Nevada was found to be 120.9 and 106.9, respectively. The cost index ratio between the two locations was calculated as 1.13. The cost index ratio was used to convert the estimated SRCE cost results to an equivalent cost in Hawaii.

The total disturbed area was estimated to be 450.08 acres, with an estimated reclamation cost of $2,996,652 (adjusted by the location cost index ratio). These values were calculated using the following criteria and assumptions:

- Disturbed areas were calculated using plan dimensions from the BOD drawings including the access roads and areas of each solar array group.
- The BOD estimated that the 7 solar array groups (Areas 1, 2, 3, 4a, 4b, 4c, and 5) have a total disturbed area of 438.75 acres.

- The BOD estimated that approximately 11,872 feet of overhead electrical powerlines would be needed. EA assumed that the power poles for the overhead lines are spaced 300 feet apart, and used 42 power poles in calculating disturbed areas around each pole.
- The disturbed area around each pole was estimated in the POD to be a 20-foot radius.
- The POD estimated that 10% of the power poles would require grading. Grading would create a disturbance area of 50-foot around each pole.
- The proposed access roads are 5.52 miles long x 16 feet wide.
- The SCRE's seed mixture "Mix 1-Basin" was used to estimate revegetation materials costs over the disturbed areas.
- Structure removal included disassembly and removal of solar panels, PV racks, and inverters. Labor costs for removal of these structures was provided from RS Means data. Quantities of the various structures were calculated using plan dimensions from the BOD drawings.
- Salvage costs of the solar panels were estimated from historical salvage pricing of PV modules from 2005 to 2012 provided by the U.S. Department of Energy. EA examined the average salvage price of PV modules for each year from 2005 to 2012, and determined that 2010 was the year with the lowest average value of $0.15 per watt. Due to market fluctuations, it is difficult to determine with certainty what future salvage values of PV modules will be. Therefore, EA estimated that current salvage pricing for PV modules is $0.15 per watt, similar to the lowest average values reported in 2010.
- The project site is accessible and moderately sloped terrain requiring basic and non-specialized equipment and vehicles to complete reclamation work.

EA appreciates this opportunity to work on the Mahi Solar project. Please contact us with any questions or if we can work with you further on this project.

Respectfully Submitted,
Engineering Analytics, Inc.

Rachael M Park

Jason S. Andrews, P.E. (Colorado) Rachael M. Park, P.E.
Project Manager Senior Staff Engineer

Attachments:

A – References
B – Mahi Solar Project Surety Cost Estimate, December 2020
C – Disturbed Area Estimates, December 2020
D – 2020 Mahi Solar Project: Basis of Design (BOD) Drawings

ATTACHMENT A
REFERENCES

Nevada Division of Environmental Protection (NDEP) & Nevada Bureau of Land Management (NV BLM) (2019). SRCE Cost Data File 1 12 Std 2019.

SRCE Software (2004-2011). Standardized Reclamation Cost Estimator Version 1.4.1, Build 17b (Revised May 16, 2019)

Revamp Engineering, Inc. (2020). Mahi Solar Project: Basis of Design (BOD) Drawings. November 9.

McCabe, Joseph. (2014). Salvage Values Determines Reliability of Used Photovoltaics. United States Department of Energy (DOE).

ATTACHMENT B
MAHI SOLAR PROJECT
SURETY COST ESTIMATE
DECEMBER 2020

Enter Data Below in Green and Blue Spaces

STANDARDIZED RECLAMATION COST ESTIMATOR

Version 1.4.1
Build 017b (Revised 16 May 2019)

Approved for use in Nevada, August 1, 2012

COST DATA FILE INFORMATION

File Name:	20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm
Cost Data File:	SRCE_Cost_Data_File_1_12_Std_2020.xlsm
Cost Data Date:	August 1, 2020
Cost Data Basis:	User Data — Data Cost Units: Imperial
Author/Source:	Nevada Division of Environmental Protection (NDEP) & NV BLM

PROJECT INFORMATION

Property/Mine Name:	— Property Code:
Project Name:	Mahi Solar
Date of Submittal:	15Dec2020 — Average Altitude: 850 ft.
Select One:	(•) Notice or Sm Exploration Plan ( ) Lg Exploration Plan ( ) Mine Operation
Select One:	( ) Private Land (•) Public or Public/Private
Cost Estimate Type:	Surety
Cost Basis Category:	S. Nevada Notice Level
	Clark, Esmeralda, Lincoln and Nye Counties
Cost Basis Description:	

Closure Cost Estimate
Cost Summary

Project Name: Mahi Solar
Project Date: 15Dec2020
Model Version: Version 1.4.1
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm

A. Earthwork/Recontouring	Labor (1)	Equipment (2)	Materials	Total
Exploration	$0	$0	$0	$0
Exploration Roads & Drill Pads	$138,359	$283,167	$0	$421,526
Roads	$0	$0	$0	$0
Well Abandonment	$0	$0	$0	$0
Pits	$0	$0	N/A	$0
Quarries & Borrow Areas	$0	$0	$0	$0
Underground Openings	$0	$0	$0	$0
Process Ponds	$0	$0	$0	$0
Heaps	$0	$0	$0	$0
Waste Rock Dumps	$0	$0	$0	$0
Landfills	$0	$0	$0	$0
Tailings	$0	$0	$0	$0
Foundation & Buildings Areas	$0	$0	$0	$0
Yards, Etc.	$0	$0	$0	$0
Drainage & Sediment Control	$0	$0	$0	$0
Generic Material Hauling	$0	$0	$0	$0
Other User Costs (from Other User sheet)	$0	$0	$0	$0
Other**				$0
Subtotal	**$138,359**	**$283,167**	**$0**	**$421,526**
Mob/Demob if included in Other User sheet	$0	$0	$0	$0
Mob/Demob				$0
Subtotal "A"	**$138,359**	**$283,167**	**$0**	**$421,526**

B. Revegetation/Stabilization	Labor (1)	Equipment (2)	Materials	Total
Exploration	$0	$0	$0	$0
Exploration Roads & Drill Pads	$63,011	$22,504	$136,149	$221,664
Roads	$0	$0	$0	$0
Well Abandonment				N/A
Pits	$0	$0	$0	$0
Quarries & Borrow Areas	$0	$0	$0	$0
Underground Openings				N/A
Process Ponds	$0	$0	$0	$0
Heaps	$0	$0	$0	$0
Waste Rock Dumps	$0	$0	$0	$0
Landfills	$0	$0	$0	$0
Tailings	$0	$0	$0	$0
Foundation & Buildings Areas	$0	$0	$0	$0
Yards, Etc.	$0	$0	$0	$0
Drainage & Sediment Control	$0	$0	$0	$0
Generic Material Hauling	$0	$0	$0	$0
Other User Costs (from Other User sheet)	$0	$0	$0	$0
Other**				$0
Subtotal "B"	**$63,011**	**$22,504**	**$136,149**	**$221,664**

C. Detoxification/Water Treatment/Disposal of Wastes**	Labor (1)	Equipment (2)	Materials	Total
Process Ponds/Sludge				$0
Heaps				$0
Dumps (Waste & Landfill)				$0
Tailings				$0
Surplus Water Disposal				$0
Monitoring				$0
Miscellaneous				$0
Solid Waste - On Site	$0	$0	N/A	$0
Solid Waste - Off Site				$0
Hazardous Materials				$0
Hydrocarbon Contaminated Soils	$0	$0	$0	$0
Other User Costs (from Other User sheet)	$0	$0	$0	$0
Other**				$0
Subtotal "C"	**$0**	**$0**	**$0**	**$0**

D. Structure, Equipment and Facility Removal, and Misc.	Labor (1)	Equipment (2)	Materials	Total
Foundation & Buildings Areas	$0	$0	$0	$0
Other Demolition	$161,580,875	$0	$0	$161,580,875
Equipment Removal	$0	$0	$0	$0
Fence Removal	$0	$0		$0
Fence Installation	$0	$0	$0	$0
Culvert Removal	$0	$0	N/A	$0
Pipe Removal	$0	$0	N/A	$0
Powerline Removal	$0			$0
Transformer Removal	$0			$0
Rip-rap, rock lining, gabions	$0	$0	$0	$0
Other Misc. Costs	$0	$0	$0	$0
Other User Costs (from Other User sheet)	$0	$0	-$160,064,263	-$160,064,263
Other**				$0
Subtotal "D"	**$161,580,875**	**$0**	**-$160,064,263**	**$1,516,612**

E. Monitoring	Labor (1)	Equipment (2)	Materials	Total
Reclamation Monitoring and Maintenance	$0	$0	$0	$0
Ground and Surface Water Monitoring	$0	$0	$0	$0
Other User Costs (from Other User sheet)	$0	$0	$0	$0
Subtotal "E"	**$0**	**$0**	**$0**	**$0**

F. Construction Management & Support	Labor	Equipment (2)	Materials	Total
Construction Management	$0	$0	N/A	$0
Construction Support	$0	$0	$0	$0
Road Maintenance	$0	$0	$0	$0
Other User Costs (from Other User sheet)	$0	$0	$0	$0
Other**				$0
Subtotal "F"	**$0**	**$0**	**$0**	**$0**

Subtotal Operational & Maintenance Costs	Labor (1)	Equipment (2)	Materials (3)	Total
Subtotal A through F	**$161,782,245**	**$305,671**	**-$159,928,114**	**$2,159,802**

** Other Operator supplied costs - additional documentation required.

Closure Cost Estimate
Cost Summary

Project Name: Mahi Solar
Project Date: 15Dec2020
Model Version: Version 1.4.1
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm

Indirect Costs		**Include?**	**Total**
1. Engineering, Design and Construction (ED&C) Plan (7)			N/A
2. Contingency (8)			N/A
3. Insurance (9)	$2,426,734		
4. Performance Bond (10)			$64,794
5. Contractor Profit (11)			$215,980
6. Contract Administration (12)			$172,784
7. Government Indirect Cost (13)			$36,285
Subtotal Add-On Costs			**$489,843**
Total Indirect Costs as % of Direct Cost			23%
GRAND TOTAL			**$2,649,645**

Administrative Cost Rates (%)

	Cost Ranges for Indirect Cost Percentages				
	<=	<=	<=	>	
1. Engineering, Design and Construction (ED&C) Plan (7)	$1,000,000	$25,000,000		$25,000,000	Small Plan
Variable Rate	8%	6%		4%	0%
	<=	<=	<=	>	
2. Contingency (8)	$500,000	$5,000,000	$50,000,000	$50,000,000	Small Plan
Variable Rate	10%	8%	6%	4%	0%
3. Insurance (9)	1.5%	of labor costs			
4. Bond (10)	3.0%	of the O&M costs if O&M costs are >$100,000			
5. Contractor Profit (11)	10%	of the O&M costs			
	<=	<=	<=	>	
6. Contract Administration (12)	$1,000,000	$25,000,000		$25,000,000	
Variable Rate	10%	8%		6%	
Government Indirect Cost (13)	21%	of contract administration			

RECLAMATION COST ESTIMATION SUMMARY SHEET FOOTNOTES

1. Federal construction contracts require Davis-Bacon wage rates for contracts over $2,000. Wage rate estimates may include base pay, payroll loading,
2. The reclamation cost estimate must include the estimated plugging cost of at least one drill hole for each active drill rig in the project area. Where the
3. Miscellaneous items should be itemized on accompanying worksheets.
4. Fluid management should be calculated only when mineral processing activities are involved. Fluid management represents the costs of maintaining proper
5. Handling of hazardous materials includes the cost of decontaminating, neutralizing, disposing, treating and/or isolating all hazardous materials used, produced,
6. Any mitigation measures required in the Plan of Operations must be included in the reclamation cost estimate. Mitigation may include measures to avoid,
7. Engineering, design and construction (ED&C) plans are often necessary to provide details on the reclamation needed to contract for the required work. To
8. A contingency cost is included in the reclamation cost estimation to cover unforeseen cost elements. Calculate the contingency cost as a percentage of the
9. Insurance premiums are calculated at 1.5% of the total labor costs. Enter the premium amount if liability insurance is not included in the itemized unit costs.
10. Federal construction contracts exceeding $100,000 require both a performance and a payment bond (Miller Act, 40 USC 270et seq.). Each bond premium is
11. For Federal construction contracts, use 10% of estimated O&M cost for the contractor's profit.
12. To estimate the contract administration cost, use 6 to 10% of the operational and maintenance (O&M) cost. Calculate the contract administration cost as a
13. Government indirect cost rate is 21% of the contract administration costs.

Closure Cost Estimate
Other User

Project Name: Mahi Solar- Notice or Exploration
Date of Submittal: 15Dec2020
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm
Model Version: Version 1.4.1
Cost Data: User Data
Cost Data File: SRCE_Cost_Data_File_1_12_Std_2020.xlsm
Cost Estimate Type: Surety   Cost Basis: S. Nevada Notice Level

Other Cost Items Calculated Elsewhere

	Description (required)	ID Code	Facility Type	Quantity	Units	Total Capital Cost $	Material Unit Cost $	Labor Unit Cost $	Equipment/ Operating Unit Cost $	Cost Type (select)	Total Cost $	Comments
1	Salvage Value of Solar Panels		Interest & Other Income	1,074,256,800	Watts		-$0.15			D. Facility & Equipment	-$160,064,263	
2												
3												
4												
5												
						$0	-$160,064,263	$0	$0		-$160,064,263	

Notes: Capital cost is lump sum (i.e. not multiplied by the quantity).
Material, Labor and Equipment/Operating costs are unit costs (i.e. multiplied by the quantity).

Closure Cost Estimate
Expl. Roads & Pads

Project Name: Mahi Solar- Notice or Exploration
Date of Submittal: 15Dec2020
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm
Model Version: Version 1.4.1
Cost Data: User Data
Cost Data File: SRCE_Cost_Data_File_1_12_Std_2020.xlsm
Cost Estimate Type: Surety   Cost Basis: S. Nevada Notice Level

Exploration Roads & Pads - Cost Summary	Labor	Equipment	Materials	Totals
Grading Costs	$0	$0	N/A	$0
Cover Placement Cost	$137,624	$281,101	N/A	$418,725
Ripping/Scarifying Cost	$735	$2,066	N/A	$2,801
Subtotal Earthworks	**$138,359**	**$283,167**		**$421,526**
Revegetation Cost	$63,011	$22,504	$136,149	$221,664
TOTALS	**$201,370**	**$305,671**	**$136,149**	**$643,190**

Exploration Roads & Pads - User Input **You must fill in ALL green cells and relevant blue cells in this section for each road**

	Facility Description		Physical (1) - MANDATORY										User Overrides		Growth Media		
	Description (required)	ID Code	Underlying Ground Slope % grade	Ungraded Slope _H:1V	Cut Slope degrees	Road + Drill Pad Length ft	Road Width ft	Number of Drill Pads	Individual Sump Volume cy	Drill Pad Width ft	Drill Pad Length ft	Slope Replacement Percent %	Regrade Volume (if calculated elsewhere) cy	Disturbed Area (if calculated elsewhere) acres	Growth Media Thickness in	Distance to Growth Media Stockpile ft	Slope from Road to Stockpile % grade
1	Disturbd Areas (Array Areas, Roads, Power Poles)	1	5.8	0.0	0.0	29,139	16.0	0	0	40.0	40	10%		450.08	4	0	5.8
2																	
3																	
4																	
5																	

Notes:
1. All Physical parameters must be input even if manual overrides for volume or area are used.
2. Slope replacement refers to the percentage of cut volumn replaced during regrading.
3. If Slope from facility to borrow source is >20, downhill travel time may be underestimated due to limitation of uphill travel time curves and downhill speed tables from CAT Handbook (see Productivty Sheet)
4. Sump volume will be applied to all roads on slopes <20%. On slopes >20% pad width (i.e. cut volume) should be adequate to account for sump volume.

Closure Cost Estimate
Expl. Roads & Pads

Project Name: Mahi Solar- Notice or Exploration
Date of Submittal: 15Dec2020
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm
Model Version: Version 1.4.1
Cost Data: User Data
Cost Data File: SRCE_Cost_Data_File_1_12_Std_2020.xlsm
Cost Estimate Type: Surety Cost Basis: S. Nevada Notice Level

Exploration Roads & Pads - Cost Summary	Labor	Equipment	Materials	Totals
Grading Costs	$0	$0	N/A	$0
Cover Placement Cost	$137,624	$281,101	N/A	$418,725
Ripping/Scarifying Cost	$735	$2,066	N/A	$2,801
Subtotal Earthworks	**$138,359**	**$283,167**		**$421,526**
Revegetation Cost	$63,011	$22,504	$136,149	$221,664
TOTALS	**$201,370**	**$305,671**	**$136,149**	**$643,190**

Exploration Roads & Pads - User Input (cont.) — You must fill in ALL green cells and relevant blue cells in this section for each road

		Grading				Growth Media				Revegetation				
	Description (required)	Regrade Material Condition (select)	Cut Material Type (select)	Recontouring Equipment Fleet (select)	Additional Hrs for Walk-in (1)	Growth Media Material Type (select)	Growth Media Placement Equipment Fleet (select)	Maximum Fleet Size (user override)	Additional Hrs for Walk-in (1)	Seed Mix (select)	Mulch (select)	Fertilizer (select)	Scarifying/ Ripping? (select)	Ripping Fleet (select)
1	**Disturbd Areas (Array Areas, Roads, Power Poles)**	**1**	**Topsoil**	**Small Dozer**	**0.0**	**Topsoil**	**Small Truck**		**0.0**	**Mix 1**	**None**	**None**	**Yes**	**Grader**
2														
3														
4														
5														

Notes:
1. Include one-way hours necessary to walk equipment in from drop-off point to work area
2. Material Types are used for density correction based on material densities in Caterpillar Performance Handbook material density table

Project Name: Mahi Solar- Notice or Exploration
Date of Submittal: 15Dec2020
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm
Model Version: Version 1.4.1
Cost Data: User Data
Cost Data File: SRCE_Cost_Data_File_1_12_Std_2020.xlsm
Cost Estimate Type: Surety Cost Basis: S. Nevada Notice Level

Exploration Roads & Pads - Cost Summary

	Labor	Equipment	Materials	Totals
Grading Costs	$0	$0	N/A	$0
Cover Placement Cost	$137,624	$281,101	N/A	$418,725
Ripping/Scarifying Cost	$735	$2,066	N/A	$2,801
Subtotal Earthworks	**$138,359**	**$283,167**		**$421,526**
Revegetation Cost	$63,011	$22,504	$136,149	$221,664
TOTALS	**$201,370**	**$305,671**	**$136,149**	**$643,190**

Exploration Roads & Pads - Calculations

Regrading Volume and Footprint Volume

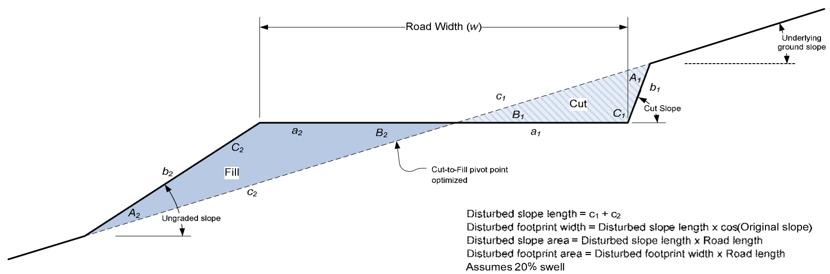


Figure 1 - Regrading Volume Calculation

Will not allow dozer for slopes greater than 30%
For dozer regrading push distance = road width
Assumes dozer push is uphill
Assumes minimum push distance of 100 ft

Swell Factor: 1.2

Ripping/Scarifying Calculations

Minimum 1 hr ripping/scarifying time per area
Number of passes = Final slope length ÷ Grader width
Travel distance = Number of passes x Road length
Total hours = (Travel distance ÷ Grader productivity) + (Number of passes x Grader maneuver time)
For dozer regrading assumes push distance = 3 x road width

Revegetation Calculations

Minimum of 1 acre crew time per area

Project Name: Mahi Solar- Notice or Exploration
Date of Submittal: 15Dec2020
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm
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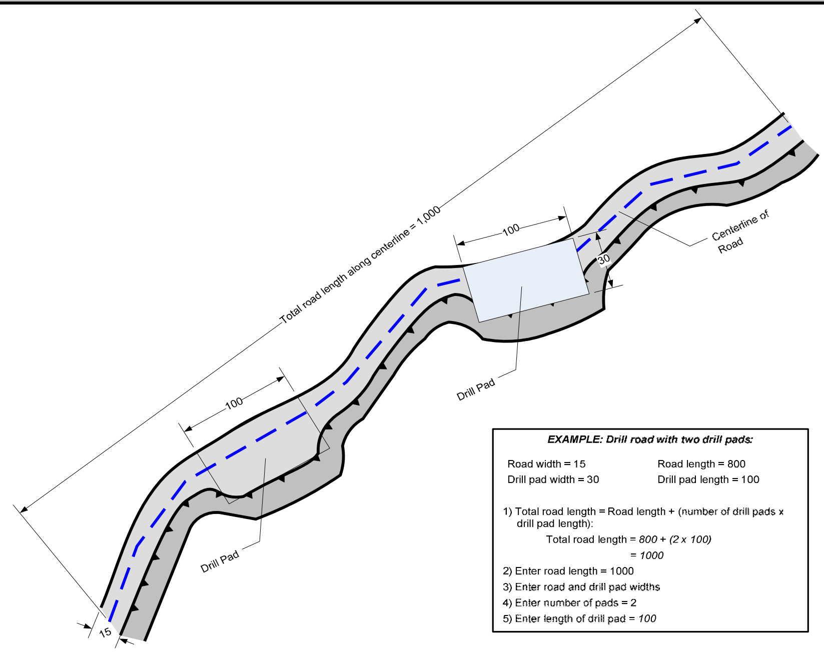
Cost Data: User Data
Cost Data File: SRCE_Cost_Data_File_1_12_Std_2020.xlsm
Cost Estimate Type: Surety   Cost Basis: S. Nevada Notice Level

Exploration Roads & Pads - Cost Summary

	Labor	Equipment	Materials	Totals
Grading Costs	$0	$0	N/A	$0
Cover Placement Cost	$137,624	$281,101	N/A	$418,725
Ripping/Scarifying Cost	$735	$2,066	N/A	$2,801
Subtotal Earthworks	**$138,359**	**$283,167**		**$421,526**
Revegetation Cost	$63,011	$22,504	$136,149	$221,664
TOTALS	**$201,370**	**$305,671**	**$136,149**	**$643,190**

Inputting Exploration Roads and Drill Pads



EXAMPLE: Drill road with two drill pads:

Road width = 15   Road length = 800
Drill pad width = 30   Drill pad length = 100

1) Total road length = Road length + (number of drill pads x drill pad length):
Total road length = *800 + (2 x 100)*
= *1000*
2) Enter road length = 1000
3) Enter road and drill pad widths
4) Enter number of pads = 2
5) Enter length of drill pad = *100*

Project Name: Mahi Solar- Notice or Exploration
Date of Submittal: 15Dec2020
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm
Model Version: Version 1.4.1
Cost Data: User Data
Cost Data File: SRCE_Cost_Data_File_1_12_Std_2020.xlsm
Cost Estimate Type: Surety Cost Basis: S. Nevada Notice Level

Exploration Roads & Pads - Cost Summary

	Labor	Equipment	Materials	Totals
Grading Costs	$0	$0	N/A	$0
Cover Placement Cost	$137,624	$281,101	N/A	$418,725
Ripping/Scarifying Cost	$735	$2,066	N/A	$2,801
Subtotal Earthworks	**$138,359**	**$283,167**		**$421,526**
Revegetation Cost	$63,011	$22,504	$136,149	$221,664
TOTALS	**$201,370**	**$305,671**	**$136,149**	**$643,190**

Exploration Roads & Pads - Regrading Costs

	Description (required)	Total Road Length ft	Total Drill Pad Length ft	Regrading Volume cy	Recontouring Fleet	Equipment Productivity cy/hr	Total Equipment Hours [(1)] hr	Total Labor Cost $	Total Equipment Cost $	Total Regrading Cost $
1	**Disturbd Areas (Array Areas, Roads, Power Poles)**	29,139	0	0		**Select Fleet**		$0	$0	$0
2								$0	$0	$0
3								$0	$0	$0
4								$0	$0	$0
5								$0	$0	$0
		29,139						**$0**	**$0**	**$0**

(1) Includes walk-in time based on distance and travel speed (see Productivity sheet for speeds)

Project Name: Mahi Solar- Notice or Exploration
Date of Submittal: 15Dec2020
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm
Model Version: Version 1.4.1
Cost Data: User Data
Cost Data File: SRCE_Cost_Data_File_1_12_Std_2020.xlsm
Cost Estimate Type: Surety Cost Basis: S. Nevada Notice Level

Exploration Roads & Pads - Cost Summary

	Labor	Equipment	Materials	Totals
Grading Costs	$0	$0	N/A	$0
Cover Placement Cost	$137,624	$281,101	N/A	$418,725
Ripping/Scarifying Cost	$735	$2,066	N/A	$2,801
Subtotal Earthworks	**$138,359**	**$283,167**		**$421,526**
Revegetation Cost	$63,011	$22,504	$136,149	$221,664
TOTALS	**$201,370**	**$305,671**	**$136,149**	**$643,190**

Exploration Roads & Pads - Growth Media Costs

	Description (required)	Growth Media Volume cy	Growth Media Replacement Fleet	Fleet Productivity LCY/hr	Number of Trucks/ Scrapers	Total Fleet Hours	Total Labor Cost $	Total Equipment Cost $	Total Growth Media Cost $
1	**Disturbd Areas (Array Areas, Roads, Power Poles)**	5,756	725/966G/D7R	503	2	481	$137,624	$281,101	$418,725
2							$0	$0	$0
3							$0	$0	$0
4							$0	$0	$0
5							$0	$0	$0
		5,756				481	**$137,624**	**$281,101**	**$418,725**

Project Name: Mahi Solar- Notice or Exploration
Date of Submittal: 15Dec2020
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm
Model Version: Version 1.4.1
Cost Data: User Data
Cost Data File: SRCE_Cost_Data_File_1_12_Std_2020.xlsm
Cost Estimate Type: Surety Cost Basis: S. Nevada Notice Level

Exploration Roads & Pads - Cost Summary

	Labor	Equipment	Materials	Totals
Grading Costs	$0	$0	N/A	$0
Cover Placement Cost	$137,624	$281,101	N/A	$418,725
Ripping/Scarifying Cost	$735	$2,066	N/A	$2,801
Subtotal Earthworks	**$138,359**	**$283,167**		**$421,526**
Revegetation Cost	$63,011	$22,504	$136,149	$221,664
TOTALS	**$201,370**	**$305,671**	**$136,149**	**$643,190**

Exploration Roads & Pads - Scarifying/Revegetation Costs

	Description (required)	Surface Area acres	Ripping/ Scarifying Fleet	Ripping Hours hrs	Ripping Labor Costs $	Ripping Equipment Cost $	Total Ripping Costs $	Revegetation Labor Cost $	Revegetation Equipment Cost $	Revgetation Material Cost $	Total Revegetation Cost $
1	**Disturbd Areas (Array Areas, Roads, Power Poles)**	450.08	16G/H	9	$735	$2,066	$2,801	$63,011	$22,504	$136,149	$221,664
2								$0	$0	$0	$0
3								$0	$0	$0	$0
4								$0	$0	$0	$0
5								$0	$0	$0	$0
		450.08		9	**$735**	**$2,066**	**$2,801**	**$63,011**	**$22,504**	**$136,149**	**$221,664**

Closure Cost Estimate
Other Demo & Equip Removal

Project Name: Mahi Solar- Notice or Exploration
Date of Submittal: 15Dec2020
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm
Model Version: Version 1.4.1
Cost Data: User Data
Cost Data File: SRCE_Cost_Data_File_1_12_Std_2020.xlsm
Cost Estimate Type: Surety Cost Basis: S. Nevada Notice Level

Other Demoltion and Equipment Removal - Cost Summary	Labor	Equipment	Materials	Totals
Other Demolition	$161,580,875	$0	$0	$161,580,875
Equipment Removal	$0	$0	$0	$0
TOTALS	**$161,580,875**	**$0**	**$0**	**$161,580,875**

Other Demolition

	Facility Description								
	Description (required)	ID Code	Type	Quantity	Units	Labor Unit Cost $	Equipment Unit Cost $	Material Unit Cost $	Total Cost $
1	**Removal of Solar Panels**	**1**	**Site Facilities - Structures**	**2273376**	**Ea**	**$69.79**			
2	**Removal of PV racks**	**1**	**Site Facilities - Structures**	**58896**	**Ea**	**$49.46**			
3	**Removal of Inverters**	**1**	**Site Facilities - Structures**	**32**	**Ea**	**$280.25**			
4									
5									
						$161,580,875	**$0**	**$0**	

Notes:

Closure Cost Estimate
Other Demo & Equip Removal

Project Name: Mahi Solar- Notice or Exploration
Date of Submittal: 15Dec2020
File Name: 20200820_SRCE_Version_1_4_1_017b_NV_2020.xlsm
Model Version: Version 1.4.1
Cost Data: User Data
Cost Data File: SRCE_Cost_Data_File_1_12_Std_2020.xlsm
Cost Estimate Type: Surety Cost Basis: S. Nevada Notice Level

Other Demoltion and Equipment Removal - Cost Summary	Labor	Equipment	Materials	Totals
Other Demolition	$161,580,875	$0	$0	$161,580,875
Equipment Removal	$0	$0	$0	$0
TOTALS	**$161,580,875**	**$0**	**$0**	**$161,580,875**

Equipment & Material Removal

Facility Description									
	Description (required)	ID Code	Type	Quantity	Units	Labor Unit Cost ($)	Equipment Unit Cost ($)	Material Unit Cost ($)	Total Cost ($)
						$0	**$0**	**$0**	

Notes:

ATTACHMENT C
DISTURBED AREA ESTIMATES
DECEMBER 2020

Updated 12/11/2020

Mahi Solar Power Project
Disturbed Area Estimate

Gravel Road

	Road 1 (Main Road to Area 5)	Road 2 (Access Road to Area 5)	Road 3 (Main Road to Area 1, 2, 3, 4a	Road 4 (Access road to Area 2a)	Road 5 (Access road to Area 2b from 2a)	Road 6 (Access road to Area 4a	Road 7 (Access Road to Area 4c)
miles long	1.44	0.29	2.46	0.55	0.06	0.07	0.64
feet long	7,611.0	1,537.9	12,986.9	2,881.1	329.4	390.7	3,402.1
feet wide	10	10	10	10	10	10	10
ft^2	76,110	15,379	129,869	28,811	3,294	3,907	34,021
acres	1.75	0.35	2.98	0.66	0.08	0.09	0.78

6.69 total acres

5.52 total length (mi)

29,139 total length (mi)

Solar Array Areas

	Area 1	Area 2a	Area 2b	Area 3	Area 4a	Area 4b	Area 4c	Area 5
Perimeter (ft)	9,766.18	6,197.65	2,317.47	8,778.97	10,389.21	9,389.80	7,543.49	7,059.10
Area (ft2)	3,377,196.74	1,667,560.83	318,227.92	3,706,750.94	5,493,420.76	480,242.97	2,479,566.27	1,588,968.14
acres	77.53	38.28	7.31	85.10	126.11	11.02	56.92	36.48

438.75 total acres

Power Poles

Overhead Line 1

9966.89 ft (total length)
300 ft (pole spacing)
34 No. of Poles

		Area			
4	10% graded	50-ft radius	31,416 ft^2	0.72	acres
30		20-ft radius	37,699 ft^2	0.87	acres
				1.59	acres each powerline
				3.17	acres two powerlines

Overhead Line 2

1289.71 ft (total length)
300 ft (pole spacing)
5 No. of Poles

		Area			
1	10% graded	50-ft radius	7,854 ft^2	0.18	acres
4		20-ft radius	5,027 ft^2	0.12	acres
				0.30	acres each powerline
				0.59	acres two powerlines

Overhead Line 3

615.9 ft (total length)
300 ft (pole spacing)
3 No. of Poles

		Area			
1	10% graded	50-ft radius	7,854 ft^2	0.18	acres
2		20-ft radius	2,513 ft^2	0.06	acres
				0.24	acres each powerline
				0.48	acres two powerlines

Total powerpole length 11872.5 ft
Total Estimated No. of Power Poles 42

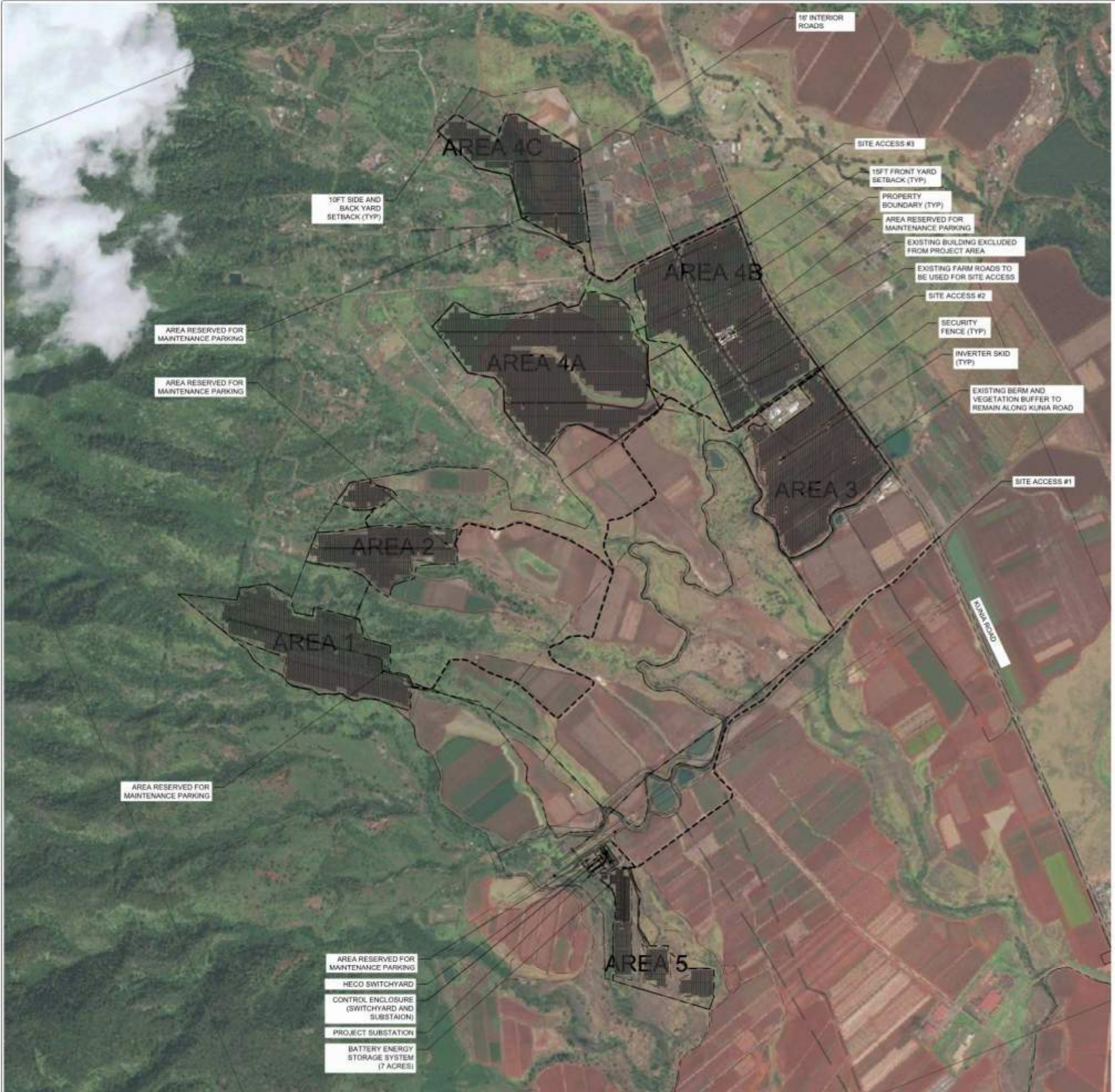
Underground

2	lines		
2	ft wide trenches	20	ft wide total
4224	ft long		
16896	ft^2	84480	ft^2
0.387878788	acres	1.93939394	acres
		0.4	acres in plan

Total acres

450.08

ATTACHMENT D
2020 MAHI SOLAR PROJECT
BASIS OF DESIGN (BOD) DRAWINGS



1 OVERALL SITE LAYOUT

1" = 800'

0' 400 800 1600

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

PV SYSTEM SPECIFICATIONS:

SYSTEM STC DC RATING (MW)	162.26	
SYSTEM AC CAPACITY (MW)	134.40	
SYSTEM AC RATING AT POI (MW)	120.00	
DC/AC RATIO AT INVERTER	1.21	
DC/AC RATIO AT POI	1.35	
MODULE MODEL	FIRST SOLAR S6	
MODULE STC DC RATING (W)	475	435
MODULE COUNT	213456	139920
MODULES PER STRING	6	6
STRING COUNT	35576	23320
16 STRING TABLE COUNT	2009	1257
8 STRING TABLE COUNT	429	401
INVERTER MODEL	SMA 4200	
INVERTER RATING @35 °C (MW)	4.20	
QUANTITY OF INVERTERS	32	
TRANSFORMER RATING @50°C / 35°C (MVA)	4.20	
QUANTITY OF TRANSFORMERS	32	
DC SYSTEM VOLTAGE (V)	1500	
RACKING SYSTEM	NEXTRACKER GEMINI	
MODULE TILT	+/- 50°	
AZIMUTH	0°	
GCR	VARIES	
ROW-TO-ROW SPACING (LF)	VARIES	
ASHRAE 2% DESIGN BULB TEMP MAX (°C)	31.6	
ASHRAE EXTREME ANNUAL MEAN MINIMUM DRY-BULB TEMP	12.7	
ROADS (L.F.)	33727	
FENCING LENGTH (L.F.)	61917	
FENCING AREA (ACRES)	491	

	SYSTEM STC DC RATING (MW)	SYSTEM AC CAPACITY (MW)	INVERTER QUANTITY	DC/AC RATIO AT INVERTER	DC/AC RATIO AT POI	GCR	ROW-TO-ROW SPACING	MODULE RATING
AREA 1	21.89	16.80	4	1.303	1.459	0.572	23.53	475
AREA 2	11.80	8.40	2	1.404	1.573	0.572	23.53	435
AREA 3 & 4B	64.84	54.60	13	1.188	1.330	0.600	22.43	475
AREA 4A	38.63	33.60	8	1.150	1.288	0.600	22.43	435
AREA 4C	19.81	16.80	4	1.179	1.321	0.620	21.71	475
AREA 5	5.29	4.20	1	1.259	1.411	0.572	23.53	475
TOTAL	162.26	134.40	32	1.21	1.35			

LEGEND

- PROPERTY LINE
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- OVERHEAD ELECTRICAL
- UNDERGROUND ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS

PRELIMINARY - NOT FOR CONSTRUCTION

MOSS SOLAR

REVAMP ENGINEERING, INC.
1110 Nuuanu Ave.
Honolulu, HI 96817
www.revamp-eng.com

ENGINEER'S STAMP

CLIENT

longroad ENERGY

PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE

1	10/19/2020	BOD LAYOUT
2	11/09/2020	BOD FOR CUP

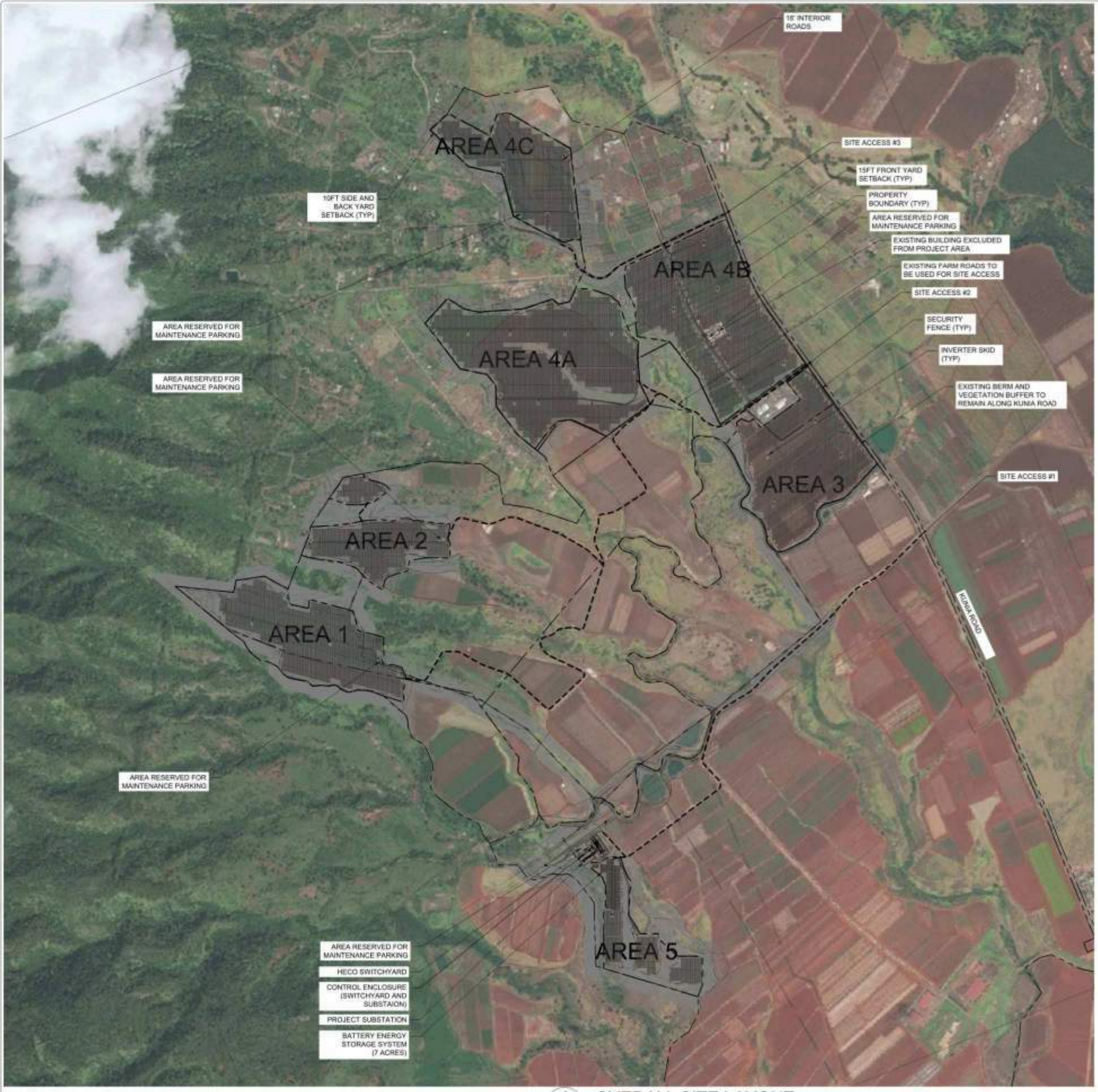
REVISION ISSUE

DRAWN BY: RO CHECKED BY: AAC

PROJECT NO.: 20105

DRAWING TITLE
OVERALL SITE LAYOUT

DRAWING NUMBER
E200



1 OVERALL SITE LAYOUT
1" = 800'
0' 400 800 1600

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

LEGEND

- PROPERTY LINE
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- OVERHEAD ELECTRICAL
- UNDERGROUND ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS
- CONTOURS

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CLIENT
longroad ENERGY

PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWING ISSUE	
1	10/19/2020 BOD LAYOUT
2	11/09/2020 BOD FOR CUP

REVISION ISSUE

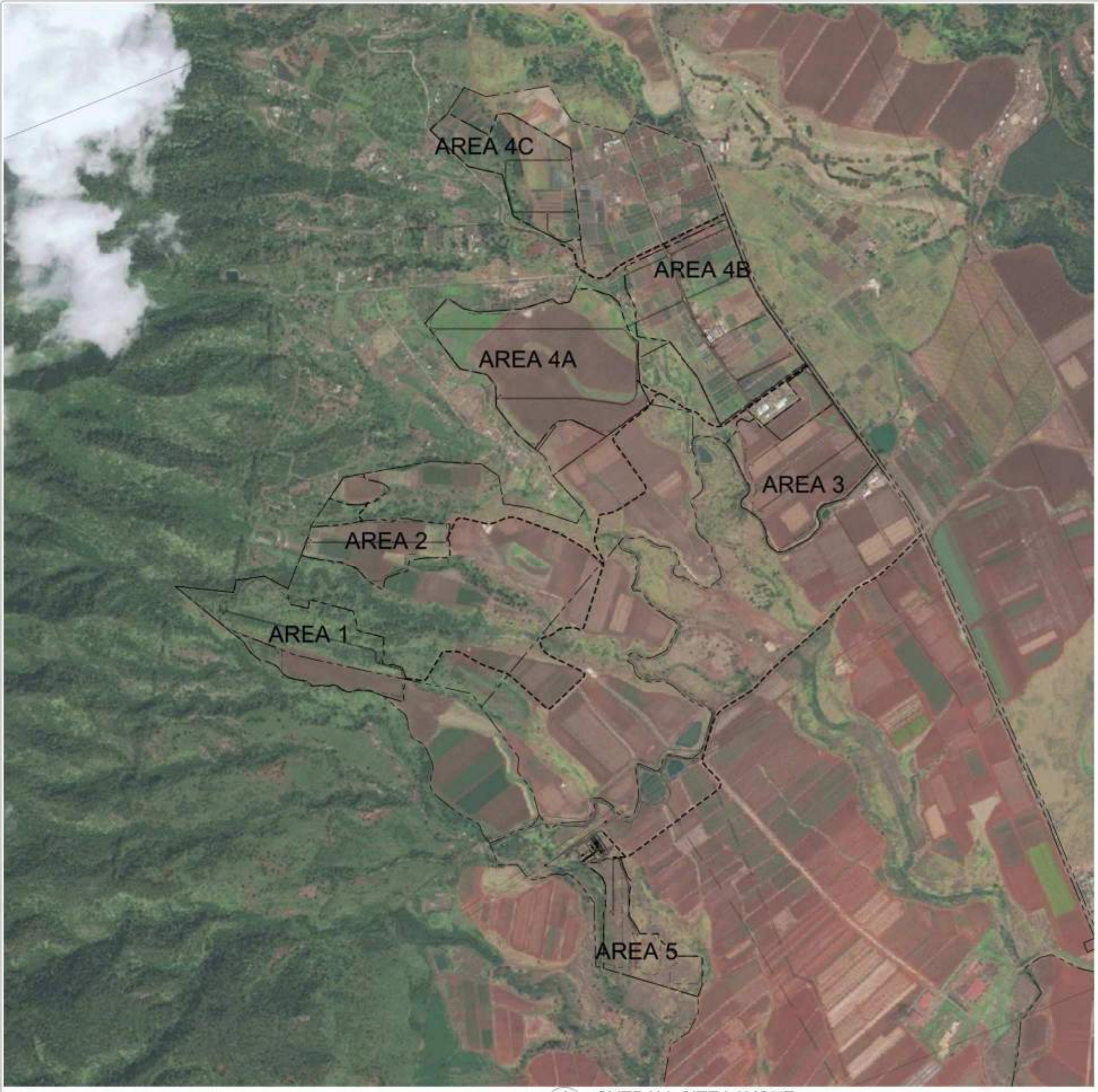
DRAWN BY: RO CHECKED BY: AAC
PROJECT NO.: 20105

DRAWING TITLE
OVERALL SITE LAYOUT WITH TOPO

DRAWING NUMBER
E201

20105 - MOSS - MAHI - E200 - LAYOUTS.DWG

11/9/2020 8:30 AM



1 OVERALL SITE LAYOUT
1" = 800'
0' 400 800 1600

SHEET NOTES:

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LEGEND

- PROPERTY LINE
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- OVERHEAD ELECTRICAL
- UNDERGROUND ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS

N

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PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

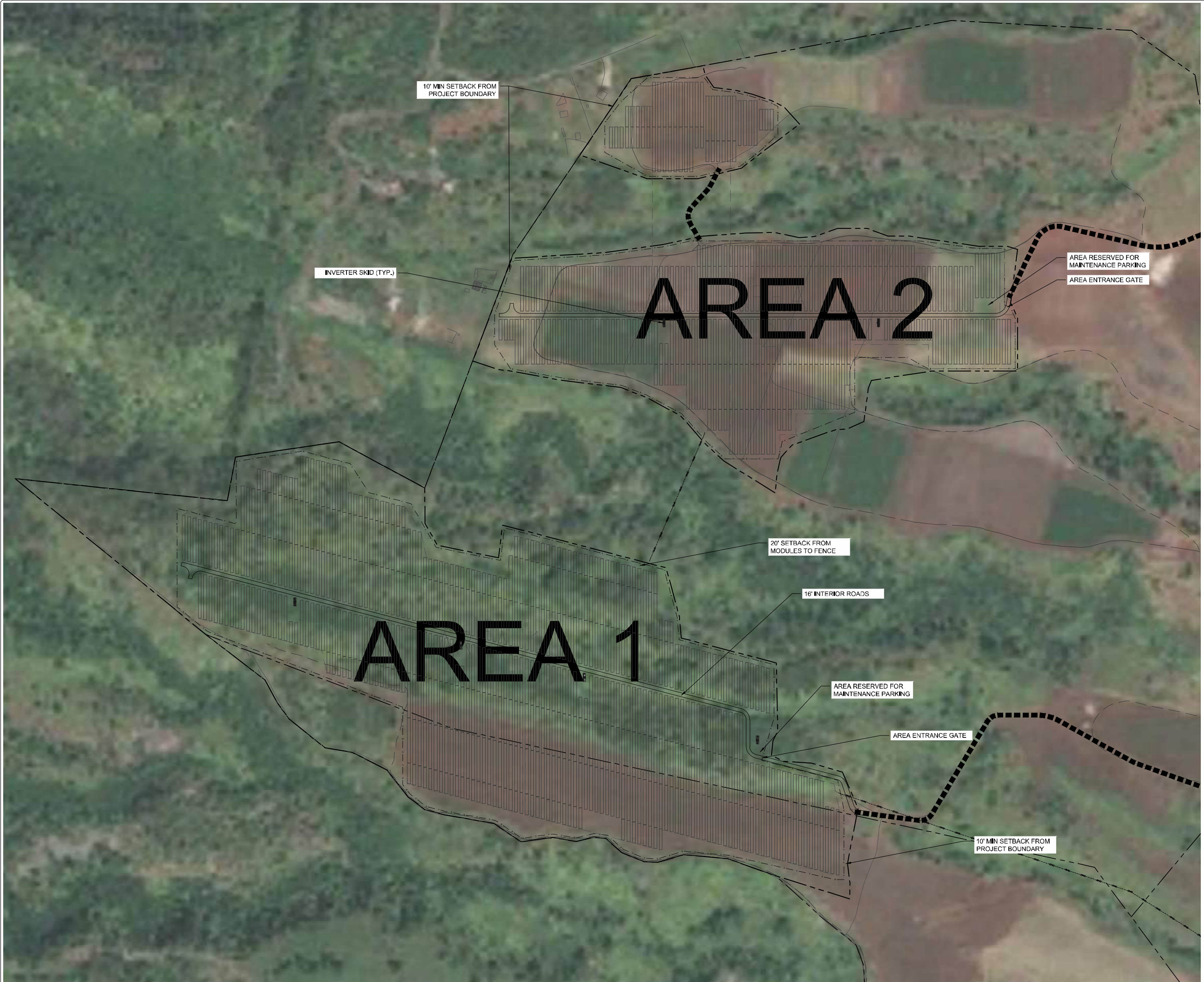
DRAWING ISSUE

1	10/10/2020	BOD LAYOUT
2	11/09/2020	BOD FOR CUP

REVISION ISSUE

DRAWN BY: RO CHECKED BY: AAC
PROJECT NO.: 20105
DRAWING TITLE
CIRCULATION PLAN

DRAWING NUMBER
E203



1 - AREAS 1 & 2
1" = 200'
0' 100 200 400

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

LEGEND

- PROJECT AREA
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- OVERHEAD ELECTRICAL
- UNDERGROUND ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS

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PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

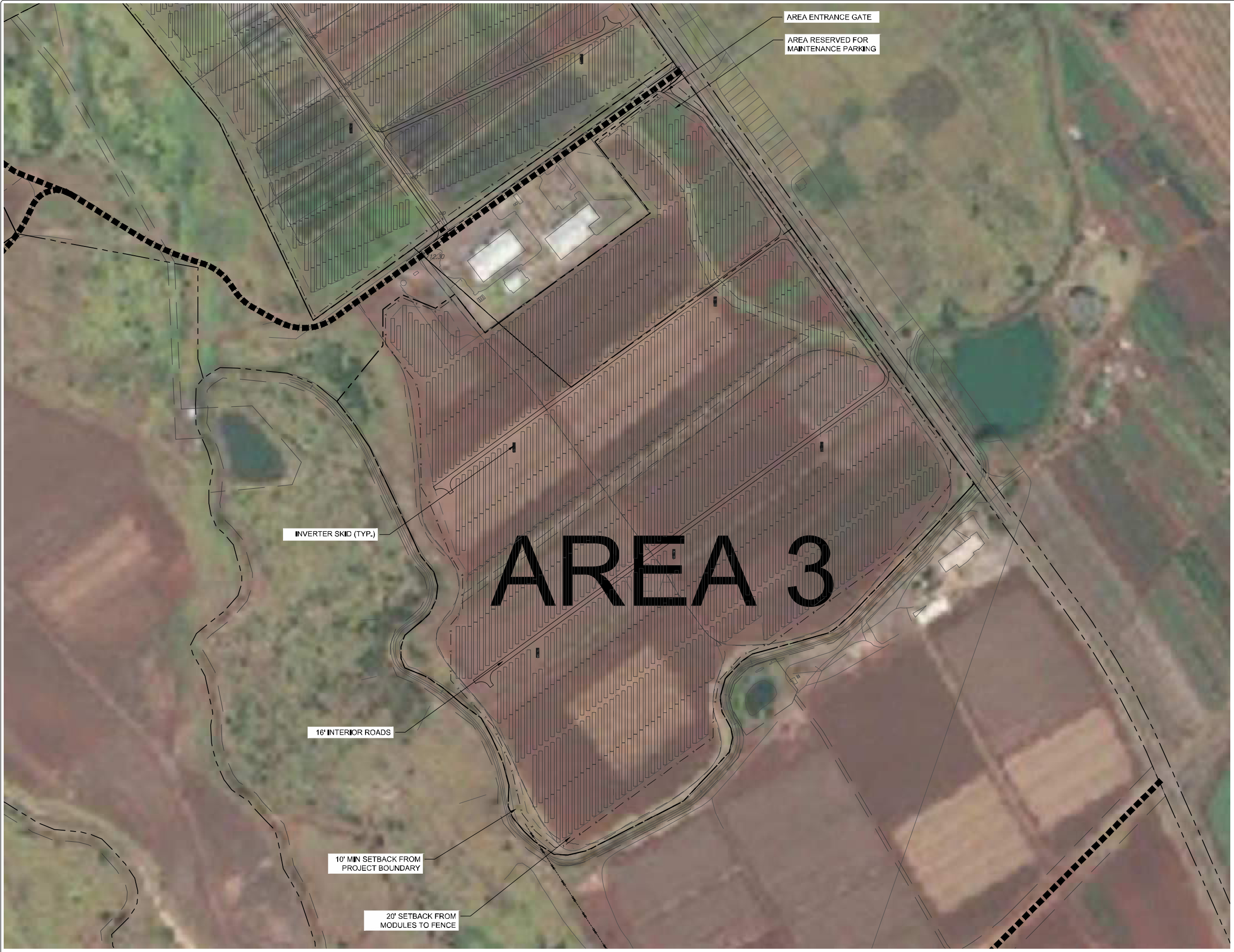
DRAWING ISSUE

1	10/19/2020 BOD LAYOUT
2	11/09/2020 BOD FOR CUP

REVISION ISSUE

DRAWN BY: RO CHECKED BY: AAC
PROJECT NO.: 20105
DRAWING TITLE
AREAS 1 & 2

DRAWING NUMBER
E204



1 - AREA 3
1" = 200'
0' 100 200 400

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

LEGEND

- PROJECT AREA
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- OVERHEAD ELECTRICAL
- UNDERGROUND ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS

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MAHI SOLAR

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KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE	
1	10/19/2020 BOD LAYOUT
2	11/09/2020 BOD FOR CUP

REVISION ISSUE

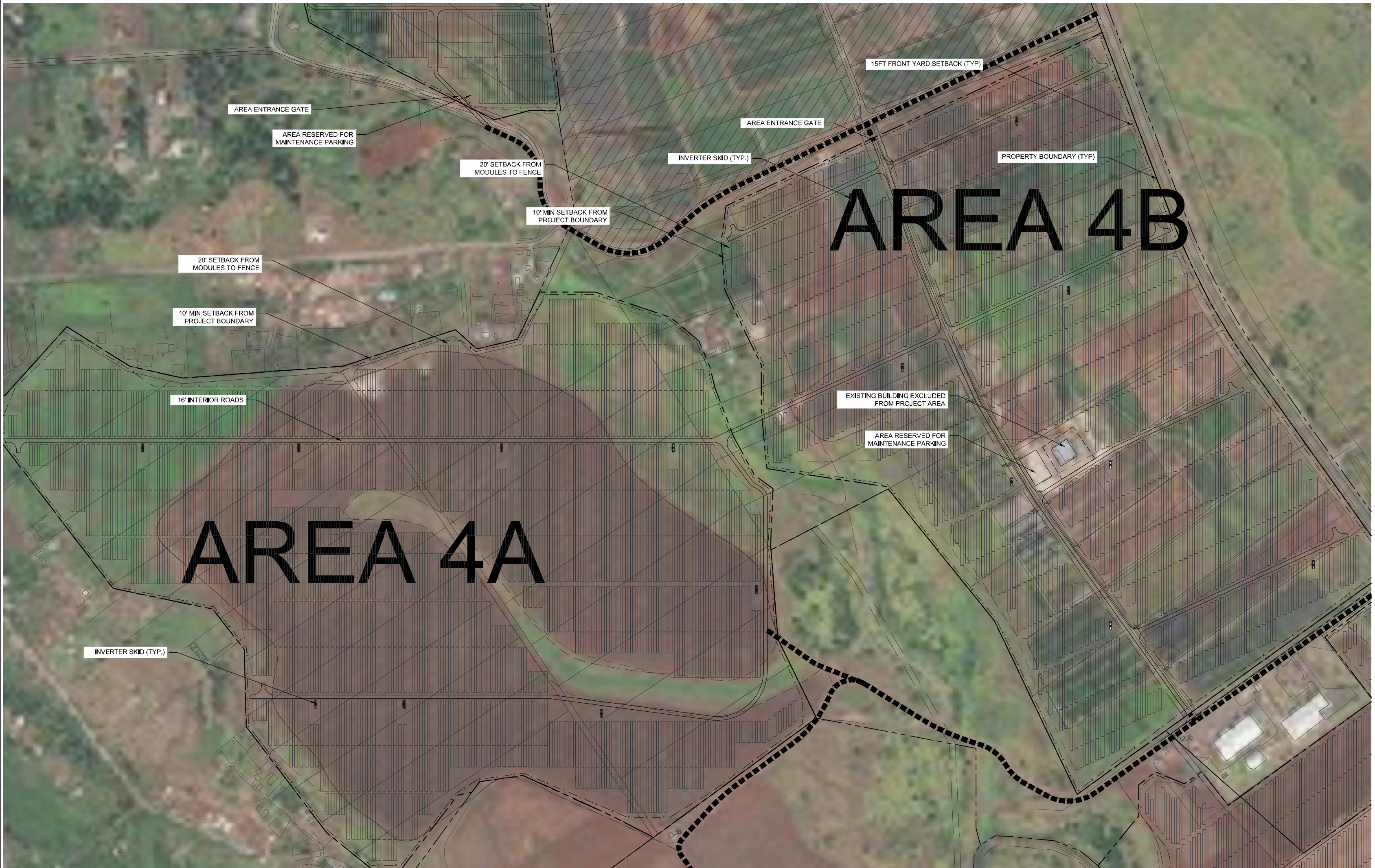
DRAWN BY: RO CHECKED BY: AAC
PROJECT NO.: 20105

DRAWING TITLE
AREA 3

DRAWING NUMBER
E205

11/9/2020 8:30 AM

20105 - MOSS - MAHI - E200 - LAYOUTS.DWG



1
-

AREAS 4A & 4B

1" = 200'

0' 100 200 400

N

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

LEGEND

- PROJECT AREA
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- OVERHEAD ELECTRICAL
- UNDERGROUND ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS

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ENGINEER'S STAMP

CLIENT

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PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE

1	10/19/2020 BOD LAYOUT
2	11/09/2020 BOD FOR CUP

REVISION ISSUE

DRAWN BY: RO CHECKED BY: AAC

PROJECT NO.: 20105

DRAWING TITLE
AREAS 4A & 4B

DRAWING NUMBER
E206

1 AREA 4C
1" = 200'
0' 100 200 400

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

LEGEND

- PROJECT AREA
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- OVERHEAD ELECTRICAL
- UNDERGROUND ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS

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CLIENT

PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE

1	10/19/2020	BOD LAYOUT
2	11/09/2020	BOD FOR CUP

REVISION ISSUE

DRAWN BY: RO CHECKED BY: AAC
PROJECT NO.: 20105
DRAWING TITLE
AREA 4C

DRAWING NUMBER
E207

11/9/2020 8:30 AM
20105 - MOSS - MAHI - E200 - LAYOUTS.DWG

1 / - AREAS 5 AND HV FACILITIES

1" = 200'

0' 100 200 400

SHEET NOTES:

1. LOCATIONS SHOWN ARE FOR GENERAL GUIDANCE ONLY. SLOPES OF THE SITE ARE NOT DEPICTED AND LOCATIONS MUST BE VERIFIED ON SITE BEFORE INSTALLATION.
2. FINAL STRING SIZING TO BE CONFIRMED BY ENGINEER-OF-RECORD.

LEGEND

- PROJECT AREA
- FENCE LINE
- ROAD
- EXISTING OVERHEAD ELECTRICAL
- OVERHEAD ELECTRICAL
- UNDERGROUND ELECTRICAL
- SETBACK
- EXISTING ROAD FOR SITE ACCESS

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PROJECT NAME
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SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE

1	10/19/2020 BOD LAYOUT
2	11/09/2020 BOD FOR CUP

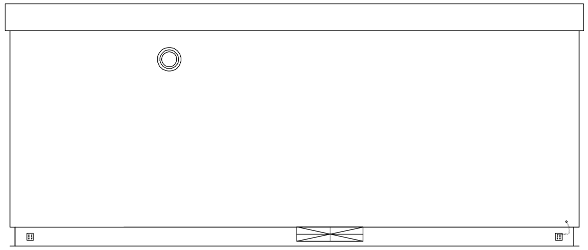
REVISION ISSUE

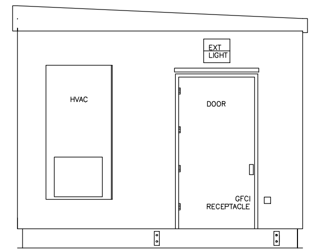
DRAWN BY: RO CHECKED BY: AAC

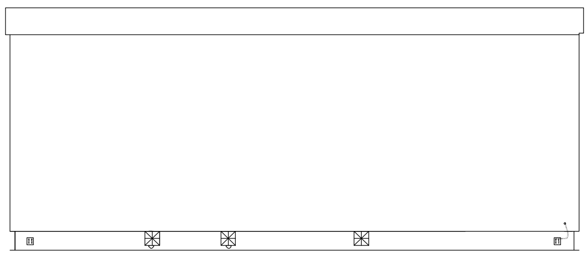
PROJECT NO.: 20105

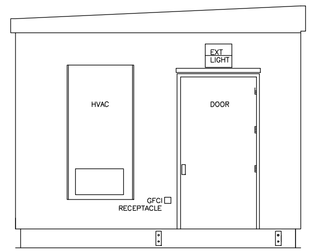
DRAWING TITLE
AREA 5 AND HV FACILITIES

DRAWING NUMBER
E208









1 - CONTROL ENCLOSURE TYPICAL

SCALE: N.T.S.

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Honolulu, HI 96817
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CLIENT

PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE	
1	10/19/2020 BOD LAYOUT
2	11/09/2020 BOD FOR CUP

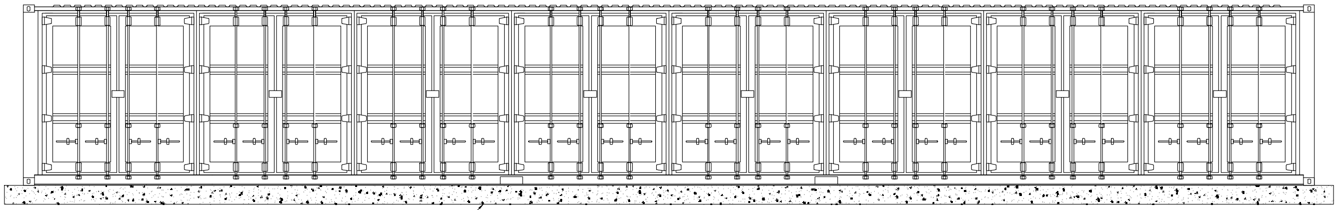
REVISION ISSUE

DRAWN BY: RO CHECKED BY: AAC

PROJECT NO.: 20105

DRAWING TITLE
CONTROL ENCLOSURE EXHIBIT

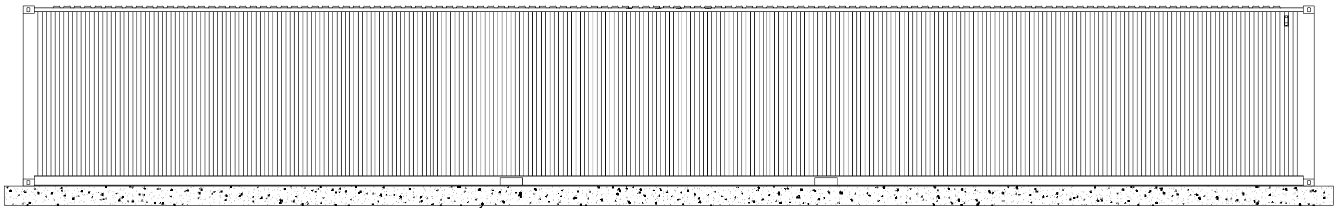
DRAWING NUMBER
EX-1



1 BESS CONTAINER TYPICAL FRONT

1" = 3'

0' 1.5' 3' 6'



2 BESS CONTAINER TYPICAL BACK

1" = 3'

0' 1.5' 3' 6'

PRELIMINARY - NOT FOR CONSTRUCTION

N

MOSS SOLAR

REVAMP ENGINEERING, INC.
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Honolulu, HI 96817
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ENGINEER'S STAMP

CLIENT

PROJECT NAME
MAHI SOLAR

SITE LOCATION
KUNIA, HAWAII
21.413°, -158.066°

DRAWING ISSUE

1	10/19/2020	BOD LAYOUT
2	11/09/2020	BOD FOR CUP

REVISION ISSUE

DRAWN BY: RO CHECKED BY: AAC

PROJECT NO.: 20105

DRAWING TITLE
BESS CONTAINER EXHIBIT

DRAWING NUMBER
EX-2

Appendix J

Construction Traffic Assessment for the Proposed Mahi Solar Farm Prepared by Fehr and Peers November 2020

November 13, 2020

Ms. Tracy Camuso
Group 70
111 S. King Street, Suite 170
Honolulu, HI 96813

Subject: ***Construction Traffic Assessment for the Proposed Mahi Solar Farm (Oahu, HI)***

Dear Ms. Camuso:

Fehr & Peers has prepared a traffic assessment for a proposed solar project to be constructed by Longroad Energy in the Kunia area on the island of O'ahu. This assessment was prepared to support the project in obtaining approvals from the State Land Use Commission and the City and County of Honolulu, Department of Planning and Permitting (DPP). This letter includes an assessment of the vehicle trip generation anticipated during both project construction and typical project operations, as well as an analysis of intersection operations to determine any traffic-related impacts from the project.

PROJECT DESCRIPTION

The proposed Mahi Solar project will produce clean energy and support local agriculture in the Kunia area, generally ewa of Kunia Road (State Highway 750), mauka of Royal Kunia, and downhill from Kunia Loa Ridge Farmlands. Construction of the site will consist of a 120-megawatt (MW) solar installation within an area of approximately 617 acres of land. The project also includes a 480-megawatt hour (MWh) battery system that would store solar energy and an electrical substation to connect to the O'ahu grid. Most of the surrounding land use consists of agriculture farming for seed corn and other crops. Construction of the Mahi project will allow farmers to continue cultivating land while generating clean energy on the less productive areas. This assessment focuses on traffic impacts related to the construction and operations of the proposed facility. Based on the nearby interchanges and regional roadways and the fact that materials will be transported from the Sand Island area to the site, trucks are expected to use the H-1 Freeway and Kunia Road to access the site. Three (3) site access points are proposed along Kunia Road at existing private roads, including Plantation Road and two (2) additional roads north of Plantation Road. **Figure 1** shows the project vicinity, proposed site plan, and access locations.

Once operational, the site will be primarily self-sustaining with minimal periodic maintenance required. The solar farm is anticipated to have no more than five (5) employees on-site at any given time. No permanent employees will be on-site; however, employees will visit the site over the course of the year to conduct maintenance such as mowing and/or panel washing. As a result, the number of employee vehicle trips generated by the proposed project during typical operations is considered negligible (i.e. less than the standard daily variation in traffic during peak hours). The primary traffic concerns for the proposed project are associated with potential temporary construction traffic impacts.

The project is anticipated to open in late 2022 following the completion of construction. Construction is expected to begin in the fourth quarter of 2021 and continue through the fourth quarter of 2022. Based on the needs of a 120-MW facility, project construction is anticipated to require up to 340 workers on-site at a time during the peak of construction, but fewer workers at various points during construction. As a conservative approach, this assessment evaluates the peak of construction with 340 workers on site. Construction workers will be encouraged to carpool; therefore, the analysis assumes 1.5 employees per vehicle, or up to 227 construction worker vehicles, will be arriving and departing the site each day during the peak of construction. Workers will generally be on-site between 7:30 AM and 5:00 PM Monday through Friday. Saturday construction work may occur in accordance with noise permit regulations.

PROJECT LOCATION AND STUDY AREA

The proposed project is located mauka of the H-1 freeway on the ewa side of Kunia Road. Portions of the site are used for agricultural and farming purposes and a portion of the site is undeveloped. The traffic assessment evaluated the operations at the following eight (8) intersections near the site and along the primary travel route:

1. Kunia Road/H-1 Eastbound On-Ramp
2. Kunia Road/H-1 Westbound Off-Ramp
3. Kunia Road/Kupuna Loop (South)
4. Kunia Road/Kupuna Loop (North)
5. Kunia Road/Anonui Street
6. Kunia Road/Site Access #1 (Plantation Road)
7. Kunia Road/Site Access #2
8. Kunia Road/Site Access #3

Figure 2 shows the locations of the study intersections.

STUDY SCENARIOS

The operations of the study intersections were evaluated during the busiest peak (one) hour in the morning (generally 6:45 to 7:45 AM) and in the afternoon (generally 4:00 to 5:00 PM) for the Kunia Road corridor. The peak hour for each intersection was determined from traffic count data collected in 2019, which serves as the basis of the Existing Conditions analysis. Construction of the project site is anticipated to occur from late 2021 through late 2022, with a targeted opening for the project to occur at the end of 2022. However, the traffic assessment assumes an opening year of 2023 to minimize confusion in the analysis and is considered conservative since traffic volumes for the 2023 scenario assume additional ambient growth between 2022 and 2023.

Traffic operations were evaluated for the following scenarios:

- **Existing Conditions** – New traffic count data was not collected for the project in 2020 due to travel restrictions related to the COVID-19 global pandemic and shifts in travel patterns. Therefore, the analysis of existing traffic conditions was based on peak hour intersection turning movement counts collected in October 2019.
- **2022 Plus Construction Conditions** – Analysis of 2022 Plus Construction traffic conditions includes existing peak hour volumes grown by one percent per year to account for ambient growth in traffic in the study area between October 2019 and the year of anticipated project construction (December 2022). This scenario includes Mahi Solar construction traffic, assuming the maximum or peak of construction of up to 227 worker vehicles arriving and departing the site each day. During non-peak months of construction there will be fewer worker vehicles arriving and departing each day. Given that the construction hours of operation will be between 7:00 AM and 5:30 PM, the majority of trips departing the site will not be traveling within the PM peak hour (4:00 to 5:00 PM) in the study area. To be conservative, the analysis assumed all worker trips arrive and depart during the AM and PM peak hours.

  Traffic generated by other planned projects within the project vicinity was also added to the 2022 Plus Construction volumes, including half of the estimated peak construction trips from the planned Ho'ohana Solar and Kupehau Solar projects, which are anticipated to be constructed before 2023 with varying peak construction periods.
- **Opening Year (2023) No Project Conditions** – Existing peak hour volumes were grown by one percent per year to forecast traffic under Opening Year (2023) Conditions. This scenario only includes increases in traffic volumes from ambient growth in the study area. No operational project traffic from Mahi Solar is assumed in this scenario.
- **Opening Year (2023) Plus Typical Operating Conditions** – This scenario consists of Opening Year (2023) Conditions traffic plus the addition of project generated traffic once Mahi Solar is fully operational. Once operational, project generated traffic from the solar site is anticipated to be no more than 10 trips per day (i.e. five employees arriving and departing) for maintenance such as mowing and/or panel washing.

VEHICLE ACCESS

The proposed access points for construction traffic are along Kunia Road at Plantation Road (Site Access #1) and two (2) existing roadways (unnamed with private/restricted use) that intersect Kunia Road north of Plantation Road. The entrances to the interior roads of the solar facility will be located ewa (west) of Kunia Road along these existing roadways. Kunia Road is under the jurisdiction of the State of Hawaii Department of Transportation - Highways Division (HDOT). All access roadways are private streets with restricted use, including gates at Site Access #1 and Site Access #2.

Based on the nearby interchanges and regional roadways and the fact that materials will be transported from the Sand Island area to the site, all inbound heavy trucks are expected to use the H-1 Freeway and turn right onto Kunia Road from the Ewa-bound H-1 Off-Ramp. Outbound truck trips will return to the Sand Island area using the opposite movements. Construction workers traveling to work in the morning will access the site from both the north and south along Kunia Road and turn onto the site access roads.

The speed limit along Kunia Road is posted as 45 miles per hour. Near the site access roadways, the shoulders along Kunia Road are unpaved and intermittent "no passing" zones are designated. Existing "no passing" zones along Kunia Road extend for approximately 1,500 feet between Site Access #2 and Site Access #3, and approximately 1,100 feet around Site Access #1 (Plantation Road).

EXISTING TRAFFIC VOLUMES

The addition of traffic from the proposed project may impact operations of intersections near the site during the anticipated construction period. To determine potential impacts, the operations of the eight (8) study intersections were evaluated during weekday AM and PM peak hour conditions. Traffic counts were collected at Study Intersections 1 through 6 in October 2019 and are included in **Attachment A**. Existing lane configurations and signal controls were obtained as part of the data collection. Due to the COVID19 pandemic and impact to travel patterns, new count data could not be obtained for the project and data for intersections 7 (Site Access #2) and 8 (Site Access #3 intersections) along Kunia Road was unavailable. Therefore, existing traffic volumes were estimated at each location based on available traffic data along Kunia Road and existing land uses. Given the minimal and dispersed land use patterns served by Site Access #2, 10 inbound and 10 outbound trips were assumed for both peak hours from the driveway. Inbound and outbound volumes at Site Access #3 were assumed to be similar to those at Site Access #1(Plantation Road) given the similar scale of agricultural land uses along both roads. **Figure 3** presents the Existing weekday AM and PM peak hour turning movement volumes and lane configurations at each study intersection.

2022 PLUS CONSTRUCTION TRAFFIC VOLUMES

For purposes of this analysis, 2019 traffic volumes were increased by a growth factor of one percent per year and rounded to the nearest ten to forecast 2022 traffic volumes to account for ambient growth. This rate was determined by considering the difference between historic and future traffic projections and planned growth in the study area. This methodology is consistent with other traffic studies completed for local and regional projects on Oahu.

In addition to ambient growth, 2022 Plus Construction traffic forecasts include construction trips generated by the Mahi Solar project as well as trips generated by other planned/approved development projects in the vicinity of the project site that are expected to be constructed or under construction within Mahi Solar's construction timeframe. Below is a list of cumulative projects identified in the immediate study area and associated construction schedules.

- *Ho'ohana Solar (by 174 Power Global):* proposed 52-MW photovoltaic system within approximately 161 acres of land, located mauka of Royal Kunia Country Club, east of Kunia Road. Access to the Ho'ohana Solar site will be provided at Plantation Road. Construction is expected to begin in April 2021 and continue through December 2022.
- *Kupehau Solar (by 174 Power Global):* proposed 60-MW photovoltaic system within approximately 210 acres of land, located in the Kunia area southwest of the Mahi Solar site. Details on site access and the construction schedule were in progress at the time this report was prepared; therefore, this assessment assumed access for Kupehau Solar trips will occur from the Site Access #1/Plantation Road intersection.

Given that the peak construction periods for these projects are not scheduled to align with the peak construction period for the Mahi Solar project, trips generated by the projects under 2022 Plus Construction conditions were assumed to be half (50 percent) of their peak construction traffic trip generation. Given the limited existing traffic along Kunia Road, this approach of applying ambient growth rates and cumulative projects to 2022 volumes is considered conservative.

OPENING YEAR (2023) TRAFFIC VOLUMES

Construction of the Mahi Solar project is expected to be complete by the end of 2022. For purposes of this analysis, the opening year for typical operations was assumed as 2023. Existing traffic volumes were increased by an average growth factor of one percent per year and rounded to the nearest tenth to forecast the Opening Year (2023) traffic volumes. Operational traffic from the Ho'ohana and Kupehau solar projects was included in the Opening Year (2023) traffic volumes since they will also be fully operational by that time. Forecasted trip generation from the Mahi Solar project during typical operations was added to the

Opening Year (2023) to calculate Opening Year (2023) Plus Operations traffic volumes to determine if any impacts are anticipated.

FORECAST PROJECT TRIP GENERATION

Construction traffic is comprised of private vehicles driven by construction workers and trucks delivering materials, hauling earth and debris, and providing other services (e.g., water trucks). In general, workers are assumed to make one (1) inbound trip and one (1) outbound trip for a total of two (2) daily trips. Detailed information on construction activities was provided by Longroad Energy and included the number of trucks needed to deliver the photovoltaic panels, steel piles for mounting the panels, gravel for on-site roadways, etc. This information was used to estimate the total number of truck trips during the planned construction period of 12 months. It is important to note that this information is preliminary and may be refined once a specific contractor is selected to construct the project. At that time, a construction traffic management plan must be prepared for the City and County of Honolulu.

The traffic assessment considered two (2) scenarios: the first scenario,2022 Plus Construction, represents 2022 traffic volumes plus the forecasted construction-related traffic during the peak of construction when the highest volume of trucks and worker vehicles will be on-site. The second scenario represents Opening Year (2023) traffic volumes plus the addition of project-generated traffic once the site is fully constructed and operational.

The 2022 Plus Construction scenario evaluates the peak periods of construction when a maximum of 340 workers are anticipated to be on-site. With an anticipated carpool factor of 1.5 workers per vehicle, the assessment assumes 227 construction worker vehicles will arrive at the project site during the AM peak hour and depart from the project site during PM peak hour. In reality, it is expected that additional carpooling will occur and that roughly half of the worker trips would be made outside of the peak hours of traffic along Kunia Road (before 7:30 AM and after 5:00 PM).

It is anticipated that up to five (5) trucks will arrive and depart the site each day during the peak of construction. All delivery and heavy truck trips were assumed to occur outside of the peak hours to reflect that heavy trucks typically arrive and depart the site during the hours that workers are present.

Forecasted trip generation for the project during construction is summarized in **Table 1**.

Table 1 – Peak Hour and Daily Project Construction Trip Generation							
Trip Type	**Daily Trips**	**AM Peak Hour**			**PM Peak Hour**		
		Total	**In**	**Out**	**Total**	**In**	**Out**
Auto[1]	454	227	227	0	227	0	227
Trucks[2]	5	0	0	0	0	0	0
Total	**459**	**227**	**227**	**0**	**227**	**0**	**227**

[1] Assumes 227 worker vehicles arrive and depart during peak hours.
[2] Assumes equipment, debris, hauling, excavation, etc. trucks arrive and depart during off peak hours.

Once operational, the solar project is anticipated to have a maximum of five (5) employees on site at any given time. As a result, the employee trips generated by the proposed project are nominal. The trip generation summary for the Opening Year (2023) Plus Operations scenario is presented in **Table 2** below.

Table 2 – Project Operations Trip Generation							
Trip Type	**Daily Trips**	**AM Peak Hour**			**PM Peak Hour**		
		Total	**In**	**Out**	**Total**	**In**	**Out**
Employees[1]	10	5	5	0	5	0	5

[1] Assumes five (5) employees on-site once project is operational

PROJECT TRIP DISTRIBUTION

Based on the location of nearby interchanges and regional highways and the fact that materials will be transported from the Sand Island area to the site, all heavy trucks (100%) are expected to use the H-1 Freeway and travel mauka on Kunia Road from the Ewa-bound H-1 Off-Ramp to the site access roads and return using the opposite movements. Construction workers and employees approaching the site in the morning will travel from both the north and south on Kunia Road and turn onto the site access roads. The trip distribution for the project was estimated based on the locations of urbanized residential communities on O'ahu and likelihood of workers to commute to and from those areas. The estimated trip distribution for construction worker vehicle trips is listed below:

- To/From the north — 20%
- To/From Ewa — 30%
- To/From Honolulu — 50%

Trip distribution percentages were applied to the forecasted trip generation for each scenario and assigned to the surrounding roadway network to assess potential traffic impacts in the area. **Figure 4** illustrates the project trip distribution and trip assignment.

INTERSECTION OPERATIONS ANALYSIS

The analysis of roadway operations performed for this study is based upon procedures presented in the *Highway Capacity Manual* (HCM), published by the Transportation Research Board. The operations of roadway facilities are described with the term level of service (LOS). LOS is a qualitative description of traffic flow based on factors such as speed, travel time, delay, and freedom to maneuver. Six (6) levels are defined from LOS A, with the least congested operating conditions, to LOS F, with the most congested operating conditions. LOS E represents "at-capacity" operations. Operations are designated as LOS F when volumes exceed capacity, resulting in stop-and-go conditions. A computerized analysis of intersection operations was performed utilizing the SYNCHRO 10 traffic analysis software.

Signalized Intersection Analysis

HCM methodology defines LOS for signalized intersections in terms of delay, or more specifically, average stopped delay per vehicle. Delay is a measure of driver and/or passenger discomfort, frustration, fuel consumption and lost travel time. This technique uses 1,900 vehicles per hour per lane (VPHPL) as the maximum saturation volume of an intersection. This saturation volume is adjusted to account for lane width, on-street parking, pedestrians, traffic composition (i.e., percentage trucks) and shared lane movements (i.e. through and right-turn movements originating from the same lane). The LOS criteria used for this technique are described in **Table 3.**

Table 3 – Signalized Intersection Level of Service Criteria

Average Stopped Delay Per Vehicle (seconds)	Level of Service (LOS) Characteristics
<10.0	*LOS A* describes operations with very low delay. This occurs when progression is extremely favorable, and most vehicles do not stop at all. Short cycle lengths may also contribute to low delay.
10.1 – 20.0	*LOS B* describes operations with generally good progression and/or short cycle lengths. More vehicles stop than for LOS A, causing higher levels of average delay.
20.1 – 35.0	*LOS C* describes operations with higher delays, which may result from fair progression and/or longer cycle lengths. Individual cycle failures may begin to appear at this level. The number of vehicles stopping is significant at this level, although many still pass through the intersection without stopping.
35.1 – 55.0	*LOS D* describes operations with high delay, resulting from some combination of unfavorable progression, long cycle lengths, or high volumes. The influence of congestion becomes more noticeable, and individual cycle failures are noticeable.
55.1 – 80.0	*LOS E* is considered the limit of acceptable delay. Individual cycle failures are frequent occurrences.
>80.0	*LOS F* describes a condition of excessively high delay, considered unacceptable to most drivers. This condition often occurs when arrival flow rates exceed the LOS D capacity of the intersection. Poor progression and long cycle lengths may also be major contributing causes to such delay.

Unsignalized Intersection Analysis

The HCM outlines methodology for unsignalized intersections, including two-way and all-way stop controlled intersections. The SYNCHRO 10 software supports this methodology and was utilized to produce LOS results. The LOS for a two-way stop controlled (TWSC) intersection is determined by the computed control delay and is defined for each minor movement. **Table 4** summarizes the LOS criteria for unsignalized intersections.

Table 4 – Unsignalized Intersection Level of Service Criteria

Average Control Delay (sec/veh)	Level of Service (LOS)
<10	A
>10 and ≤15	B
>15 and ≤25	C
>25 and ≤35	D
>35 and ≤50	E
>50	F

INTERSECTION IMPACT CRITERIA

The analysis compares existing traffic conditions to 2022 Plus Construction conditions to determine if the addition of construction traffic to existing roadways is expected to result in a significant impact on the surrounding area. Similarly, the analysis of Opening Year (2023) conditions compares future no-project operations with conditions when the project is fully built and operational to determine whether or not project implementation is expected to result in significant impacts. Based on previous studies conducted for both the City & County of Honolulu and HDOT, the minimum acceptable operating standard for a signalized intersection is LOS D. If the addition of project traffic is expected to degrade desirable service levels (LOS D or better) to lower than desirable service levels (LOS E or F) then the project is considered to have a project-specific impact. Impacts are also defined to occur when the addition of project traffic exacerbates locations already operating or projected to operate at LOS E or F, which are referred to as cumulative impacts. An impact is also considered a cumulative impact at a signalized intersection if the addition of project trips exacerbates baseline LOS E or F operations and increase overall intersection delay by more than 5 seconds. Construction-related impacts are considered temporary and are addressed with provisional mitigation measures during construction.

For unsignalized intersections, the criterion for a project-specific impact is the same as for signalized intersections regarding LOS as described above, but one or more signal warrants must also be met. The signal warrants used for this evaluation are described in Chapter 4V of the Manual on Uniform Traffic Control Devices (MUTCD, 2009) published by the U.S. Department of Transportation Federal Highways Administration (FHWA). However, the project is determined to have a potentially significant cumulative impact when it adds any amount of traffic to a study location which includes a controlled approach operating at an unacceptable level (i.e., LOS E or F) and one or more volume-based signal warrants are met.

Impacts to public transit, pedestrian facilities and travel, and bicycle facilities and travel are considered significant if the proposed project conflicts with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or if it will generate additional demand that cannot be reasonably accommodated by existing or planned multi-modal facilities

INTERSECTION LEVEL OF SERVICE (LOS) RESULTS

The analysis of intersection operations was completed for all scenarios, including Existing Conditions, 2022 Plus Construction Conditions, Opening Year (2023) Conditions, and Opening Year (2023) Plus Construction Conditions. The results of the intersection LOS analysis are summarized in **Table 5**. **Attachment B** includes the detailed LOS calculation worksheets. Peak hour traffic volumes for 2022 Plus Construction Conditions, Opening Year (2023) Conditions, and Opening Year (2023) Plus Operations Conditions are shown on **Figures 5, 6, and 7**, respectively.

Under Existing Conditions, all study intersections operate at Level of Service (LOS) D or better during the peak hours with the exception of Kunia Road/H1 Eastbound Ramps (AM peak hour only), Kunia Road/Plantation Road (AM and PM peak hours), and Kunia Road/Site Access #3 (AM peak hour only). At the unsignalized intersections, the delays reported are those experienced by vehicles on the side street site access approaches, which are stop controlled, waiting to turn left onto Kunia Road (uncontrolled).

Table 5 – Peak Hour Intersection Operations LOS Summary										
Intersection	**Peak Hour**	**Existing**		**2022 Plus Construction**		**Opening Year (2023)**		**Opening Year (2023) Plus Operations**	
		Delay[1]	**LOS[2]**	**Delay**	**LOS**	**Delay**	**LOS**	**Delay**	**LOS**
1. Kunia Road/ H1 Eastbound Ramps	AM	**55.6**	**E**	**71.1**	**E**	**70.9**	**E**	**71.0**	**E**
	PM	20.1	C	22.8	C	21.5	C	21.5	C
2. Kunia Road/ H1 Westbound Ramps	AM	3.2	A	3.1	A	3.2	A	3.2	A
	PM	6.2	A	7.7	A	6.7	A	6.7	A
3. Kunia Road/ Kupuna Loop (South)	AM	20.9	C	21.4	C	21.5	C	21.4	C
	PM	17.3	B	19.7	B	17.9	B	17.9	B
4. Kunia Road/ Kupuna Loop (North)	AM	11.4	B	13.5	B	12.4	B	12.4	B
	PM	17.1	B	19.8	B	19.1	B	19.1	B
5. Kunia Road/ Anonui Street	AM	17.9	B	21.7	C	19.5	B	19.5	B
	PM	16.9	B	**72.2**	**E**	23.5	C	23.8	C
6. Kunia Road/ Site Access #1 (Plantation Road)*	AM	**69.7**	**F**	**>100**	**F**	**>100**	**F**	**>100**	**F**
	PM	**45.5**	**E**	**>100**	**F**	**77.3**	**F**	**78.6**	**F**
7. Kunia Road/ Site Access #2*	AM	34.5	D	**>100**	**F**	**45.7**	**E**	**47.2**	**E**
	PM	29.4	D	**>100**	**F**	**35.1**	**E**	34.9	D[3]
6. Kunia Road/ Site Access #3 (Palawai Road)*	AM	**46.7**	**E**	**>100**	**F**	**62.4**	**F**	**66.2**	**F**
	PM	29	D	**53.5**	**F**	31.6	D	32.4	D

Source: Fehr & Peers, September 2020 * indicates unsignalized intersection

[1] Whole intersection weighted average stopped delay expressed in seconds per vehicle for signalized intersections. The worst movement is presented for unsignalized intersections.
[2] LOS calculations performed using the *Highway Capacity Manual (HCM) 6th Edition* method.
[3] The reported average delay is lowered as a result of project operations due to the minimal amount of vehicles forecast for the eastbound approach and because the added project trip is a right turn, which experiences less delay than the left turn movements
LOS E or F operations highlighted in **bold.**

Under 2022 Plus Construction conditions five locations are forecast to operate at LOS E or F: Kunia Road/H1 Eastbound Ramps, Kunia Road/Anonui Street, Kunia Road/Site Access #1, Kunia Road/Site Access #2, Kunia Road/Site Access #3.

Kunia Road/H1 Eastbound Ramps

During the AM peak hour, long queues of vehicles have been observed waiting to get onto the H1 Eastbound on-ramp from both the northbound (via Fort Weaver) and southbound (via Kunia Road) directions. During the peak of construction, the proposed project is forecast to add up to 34 northbound through trips at the Kunia Road/H1 Eastbound intersection during the AM peak hour. Since the addition of this traffic is a temporary condition during project construction only and is added to the mauka-bound through movement (and not to the mauka-bound right-turn movement), the addition of this construction traffic is not likely to be noticed by the average driver and is not considered a significant traffic impact. In addition, no feasible mitigation to ameliorate this temporary impact (e.g., temporary striping) could be identified.

Kunia Road/Anonui Street

Level of service worsens to LOS E during the PM peak hour under 2022 Plus Construction conditions due to the cumulative effect of the construction traffic for all of the solar projects combined (Mahi Solar, Ho'ohana and Kupehau), specifically in the southbound through movement. If construction traffic from only the Mahi Solar project is considered, the forecasted PM peak hour delay is LOS D. If construction traffic from only the Ho'ohana and Kupehau Solar projects are considered, the forecasted PM peak hour delay is LOS C. During the peak of construction, the proposed project is forecast to add up to 182 southbound through trips at the Kunia Road/Anonui Street intersection during the PM peak hour. An additional 112 southbound through trips are included from Ho'ohana and Kupehau Solar construction traffic, combined.

The results of analysis at this location are considered highly conservative given that the ambient growth was applied to all legs of traffic (specifically the eastbound approach which grew from under 5 peak hour trips to 10) and because many Mahi Solar worker trips are likely to occur outside of the PM peak hour of Kunia Road (4:00-5:00 PM) since construction operations will cease at 5:30 PM. The effect of all construction traffic from Mahi, Ho'ohana, and Kupehau Solar projects are considered cumulative and temporary.

Kunia Road/Site Access #1 (Plantation Road)

Kunia Road/Site Access #1 (Plantation Road) is unsignalized (side-street stop controlled) operates at LOS F during the AM peak hour and LOS E during the PM peak hour under Existing Conditions. At this location, the LOS represents the outbound vehicle delay from Plantation Road waiting for a gap in traffic along Kunia Road. Traffic flows on Kunia Road (north and southbound) are uncontrolled and operate at LOS A; the only movements experiencing long delays and additional delay resulting from the project are those turning from the Site Access #1-Plantation Road roadway (a total of 130 westbound and 91 eastbound vehicles during the PM peak hour, including project and non-project traffic). The site access roadway is a private, stop-controlled roadway.

Kunia Road/Site Access #2

Kunia Road/Site Access #2 is unsignalized (side-street stop controlled) and operates at LOS D during the AM and PM peak hours under Existing Conditions. The reported LOS for unsignalized intersections represents the approach with the longest delay. Traffic flows on Kunia Road (north and southbound) are uncontrolled and operate at LOS A; the only movements experiencing large delays and any additional delay resulting from the project are those from the site access roadway (which includes a total of 145 eastbound vehicles during the PM peak hour, including project and non-project traffic). The site access roadway is a private, stop-controlled roadway.

Kunia Road/Site Access #3

Kunia Road/Site Access #3 is unsignalized (side-street stop controlled) and operates at LOS E during the AM peak hour and LOS D during the PM peak hour under Existing Conditions. The reported LOS for unsignalized intersections represents the approach with the longest delay. Traffic flows on Kunia Road are uncontrolled and operate at LOS A; the only movements experiencing large delays and any additional delay resulting from the project are those from the site access roadway (which includes a total of 118 eastbound vehicles during the PM peak hour, including project and non-project traffic). The site access roadway is a private, stop-controlled roadway.

Heavy Vehicle Traffic and Opening Year Traffic

The average of five (5) daily truck deliveries will not noticeably change the composition of vehicle types along Kunia Road. As a result, construction truck traffic is not anticipated to have a major impact vehicular traffic along Kunia Road. However, the addition of heavy vehicles (even a small number) turning on and off Kunia Road will be a new activity that would not be anticipated by drivers in this corridor. As such, signage is recommended as part of construction activities (see next section).

Once fully operational, the solar project is anticipated to have approximately five (5) employees on site at any given time. Under 2023 Plus Operations Conditions all intersections through which project traffic is routed are forecast to operate at desirable LOS D or better during both peak hours under both project scenarios with the exception of Kunia Road/H1 Eastbound, Kunia Road/Site Access #1 (Plantation Road), and Kunia Road/Site Access #2 intersections along Kunia Road. The intersections are anticipated to operate similarly to no project (LOS E/F) operations and any noticeable impacts will be temporary. The effects of employee trips generated by the proposed project are considered negligible.

Please note that, while the results show delay decreasing by 0.2 seconds under Opening Year (2023) Plus Operations conditions at the intersection of Kunia Road/Site Access #2, only one project trip is being added to the eastbound right-turn movement. The reported average delay is lowered due to the minimal amount of vehicles forecast for the eastbound approach and because the added trip is a right turn, which experiences less delay than the left turn movements.

RECOMMENDED MODIFICATIONS DURING PROJECT CONSTRUCTION

As noted above, the volume of traffic generated by construction of the project does not result in the need for typical roadway capacity enhancements (e.g., new turn or through lanes). However, the addition of vehicles, especially large trucks, turning into and out of the site access road intersections along Kunia Road may necessitate some modification of traffic control devices in the area to raise driver awareness and enhance safety. To minimize the potential for conflicts and impacts to traffic operations, the contractor should include the following elements in a construction traffic management plan:

- Install temporary signage on mauka-bound Kunia Road prior to approaching the site access intersections to indicate the presence of trucks and inform drivers that trucks are entering/exiting the roadway near each of the three site access roads.
- Install temporary signage on makai-bound Kunia Road between Site Access #1 and Site Access #3 to indicate the presence of trucks and that vehicles are entering the roadway from the site access locations.
- Field verify available sight distance and maintain adequate sight distance for drivers exiting each site access location and turning onto Kunia Road. Maintenance may include pruning vegetation and not installing signage or other barriers that would block a driver’s field of vision at the intersection.
- Extend the painted median solid double yellow line delineating the “Do Not Pass” zone for mauka-bound vehicles at least an additional 500 feet approaching the site access intersections.

The trips generated by the project once it is fully operational are negligible compared to those generated by construction traffic, and no traffic improvements are required. The extension of the “Do Not Pass” zone could be maintained or be eliminated at the discretion of HDOT.

NON-AUTOMOBILE MODE ACCESS

Bicycle and Pedestrian Travel

Given the undeveloped nature of the project site and the low-density development of the immediate surrounding area, the potential conflict is low between site-generated traffic and non-automobile modes including walking and biking. While separate bicycle and pedestrian facilities are typically encouraged to reduce vehicle traffic, the rural circulation system and distant land uses in the vicinity of the project site are not conducive to multi-modal travel.

Transit

No existing transit service is provided to the project site on Kunia Road near the site access roadways. Existing bus stops are provided within the residential neighborhoods south of the project site, with the nearest stop located on Anonui Street. This would require walking at least 2.5 miles to reach the project site entrances ewa of Kunia Road.

Potential impacts to Active Modes and Transit

The City and County of Honolulu and HDOT do not specify impact criteria for pedestrian, bicycle, and transit impacts. However, these impacts are generally evaluated based on whether a proposed project would: 1) conflict with existing or planned pedestrian, bicycle, or transit facilities, or 2) create walking, bicycling, or transit use demand without providing adequate and appropriate facilities for non-motorized mobility. As noted above, the project is not expected to conflict with any existing active transportation modes (i.e., bicycling and walking) or transit, and it would not create demand for these modes given its isolated location. Accordingly, no impacts to non-automobile travel are anticipated.

CONCLUSION

The proposed project will generate a negligible amount of vehicle traffic when the solar farm is fully constructed and operational. During the peak of construction, the site is expected to generate up to 454 daily vehicle trips including trucks and worker vehicles, including up to 227 trips in the AM peak hour and 227 trips in the PM peak hour. During non-peak periods of construction, the forecast project-related trips will be approximately half of the data presented in this analysis. The traffic assessment indicates that the project would only result in temporary impacts during construction and negligible increases in delay once the project is operational, when a maximum of five employees or ten (10) total trips may be generated by the site. Intersections with large delays resulting from project construction include the site access intersections along Kunia Road and the Kunia Road/Anonui Street intersection. These are cumulative and temporary effects, which are isolated to traffic approaching the intersections along the private site access roadways and not along Kunia Road. At Kunia Road/Anonui Street, the forecasted effects of increased delay occur during the PM peak hour and is not specifically attributed to any one of the solar construction projects but rather the effect of the solar projects being constructed simultaneously.

Based on the evaluation presented in this report, the proposed points of access are sufficient to serve the anticipated construction traffic volume. However, several measures are recommended to enhance safety for vehicles turning into and out of the site access roadways that intersect Kunia Road. These measures are typically included in construction traffic management plans for the project and include: verification of adequate sight distance at each site access location, extension of the mauka-bound "Do Not Pass" zone on Kunia Road by at least 500 feet in the makai direction upon approach of each site access road, and installation of temporary signage approaching the intersections from both directions informing drivers on the roadway of construction activities and the presence of heavy vehicle traffic.

We appreciate the opportunity to assist you with this project. Please let us know if you have any questions on the information in this report.

Sincerely,

FEHR & PEERS

Sohrab Rashid, TE
Principal

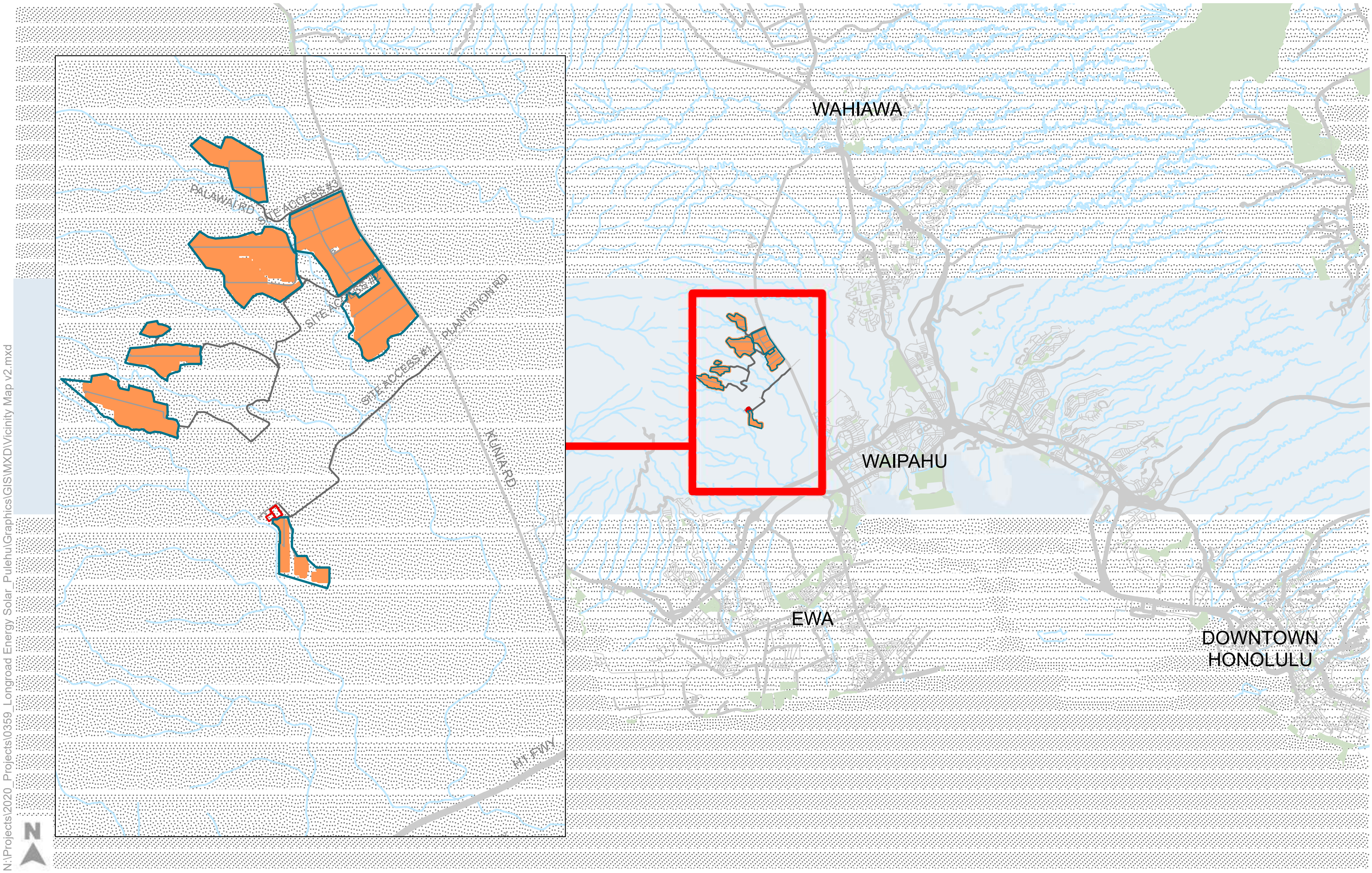
Stephanie Cheng, AICP
Associate

SD20-0358

Attachments:

Figure 1 – Vicinity Map and Site Plan
Figure 2 – Project Site and Study Intersections
Figure 3 – Peak Hour Traffic Volumes and Lane Configurations – Existing Conditions
Figure 4 – Construction Trip Distribution and Trip Assignment
Figure 5 – Peak Hour Traffic Volumes and Lane Configurations – 2022 Plus Construction Conditions
Figure 6 – Peak Hour Traffic Volumes and Lane Configurations – Opening Year (2023) Conditions
Figure 7 – Peak Hour Traffic Volumes and Lane Configurations – Opening Year (2023) Plus Operations Conditions

Attachment A – Traffic Count Data
Attachment B – Level of Service Analysis Worksheets



Legend

- Project Boundary
- Access Roads
- Array Driveways
- Substation
- Solar Facilities

Figure 1

Vicinity Map and Site Plan

Mahi Solar Traffic Assessment

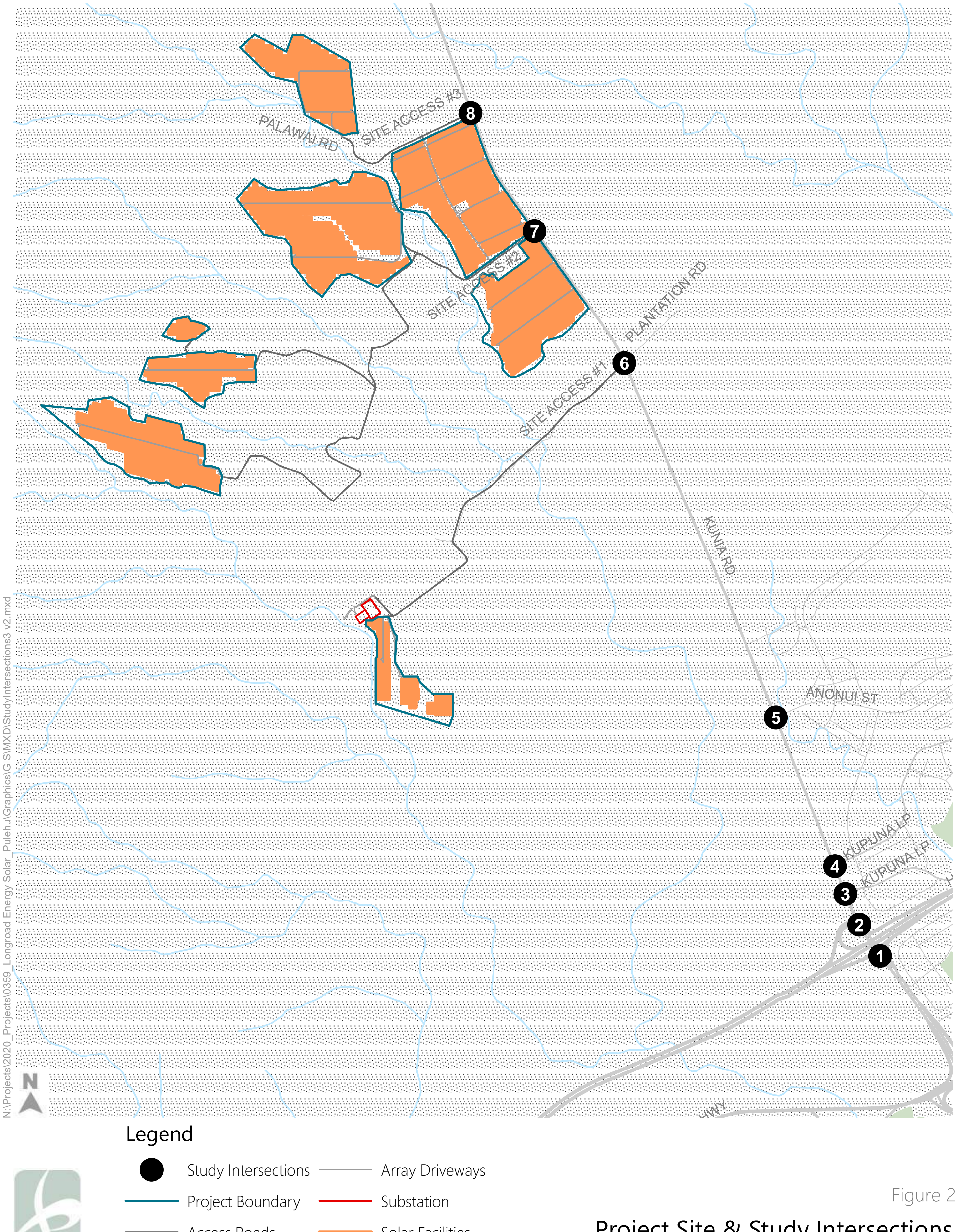
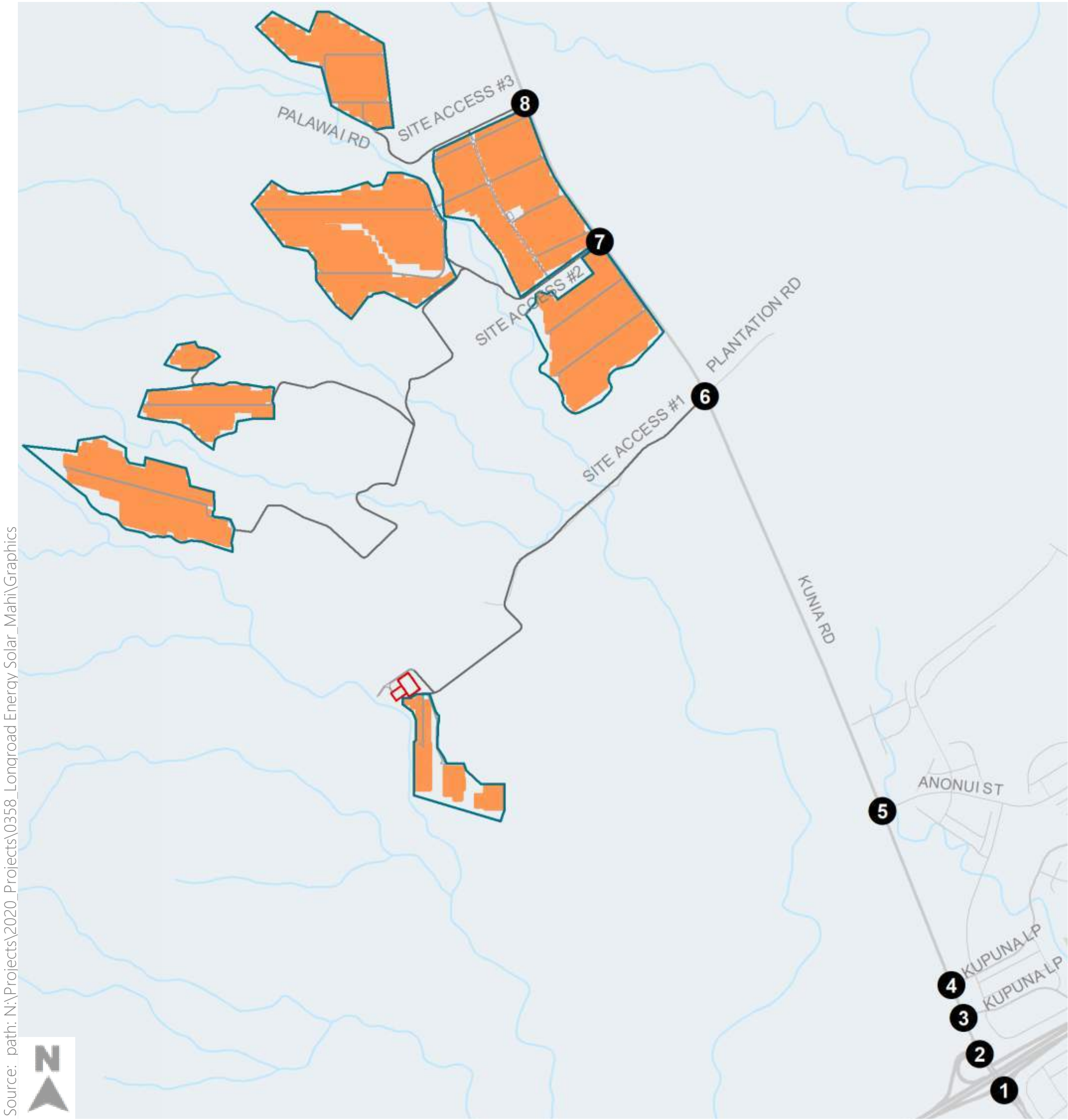


Figure 2

Project Site & Study Intersections

Mahi Solar Traffic Assessment



LEGEND

- Study Intersections
- AM (PM) — Peak Hour Traffic Volumes
- Project Boundary
- Project Site
- Lane Configuration
- AM PM — A-C, D, E, F — Level of Service (LOS)

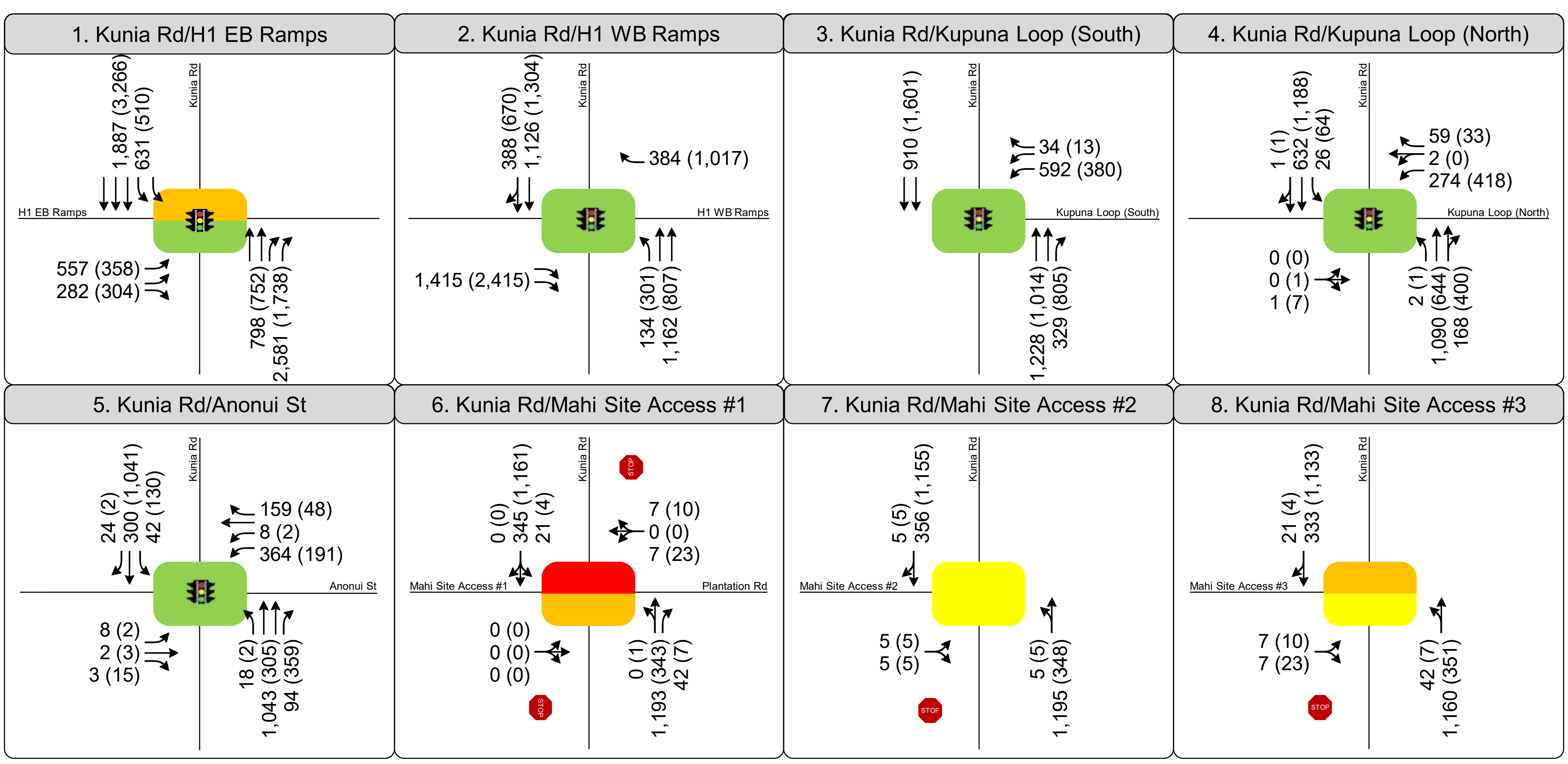
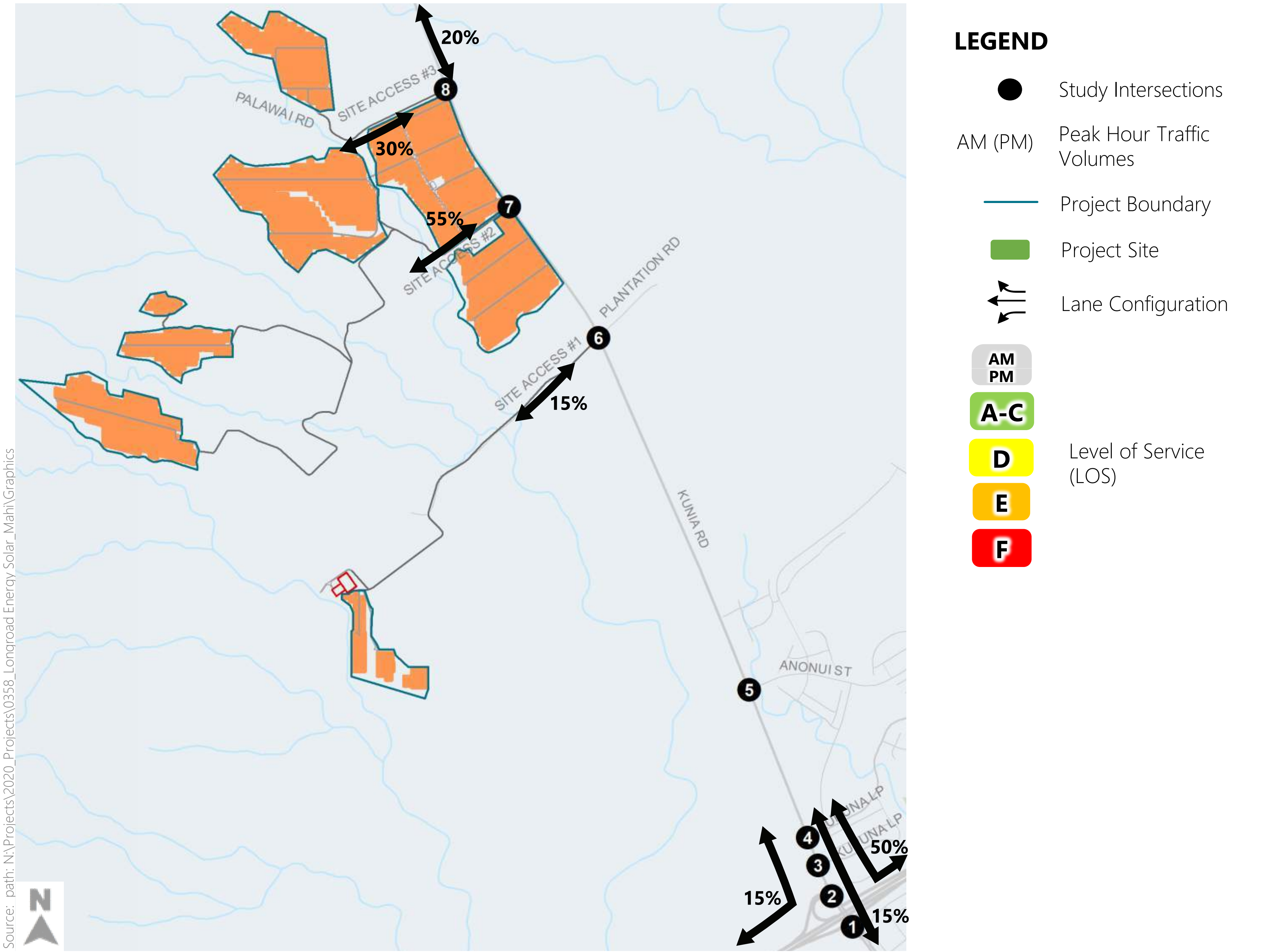


Figure 3

Peak Hour Traffic Volumes and Lane Configurations - Existing Conditions



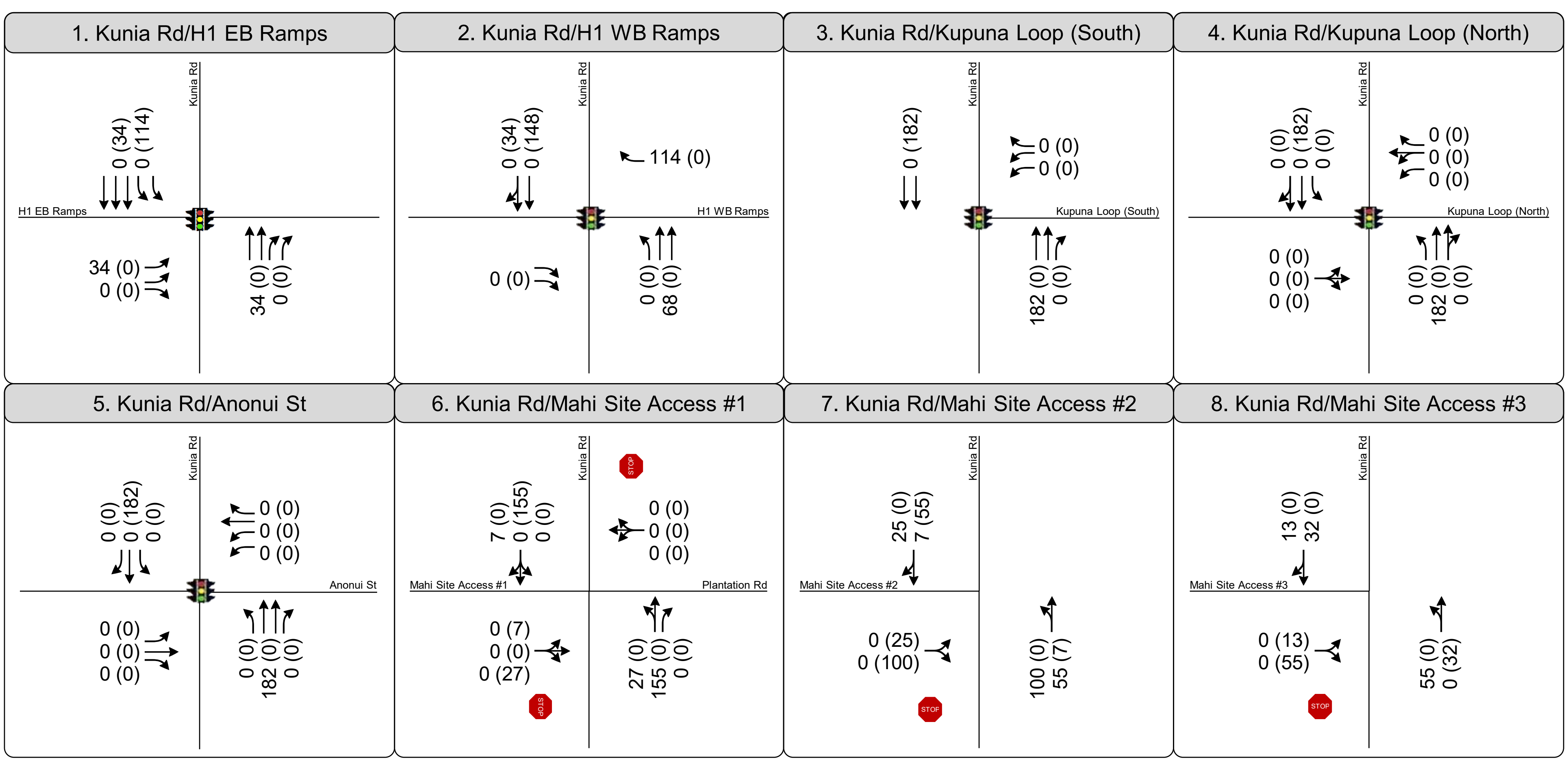
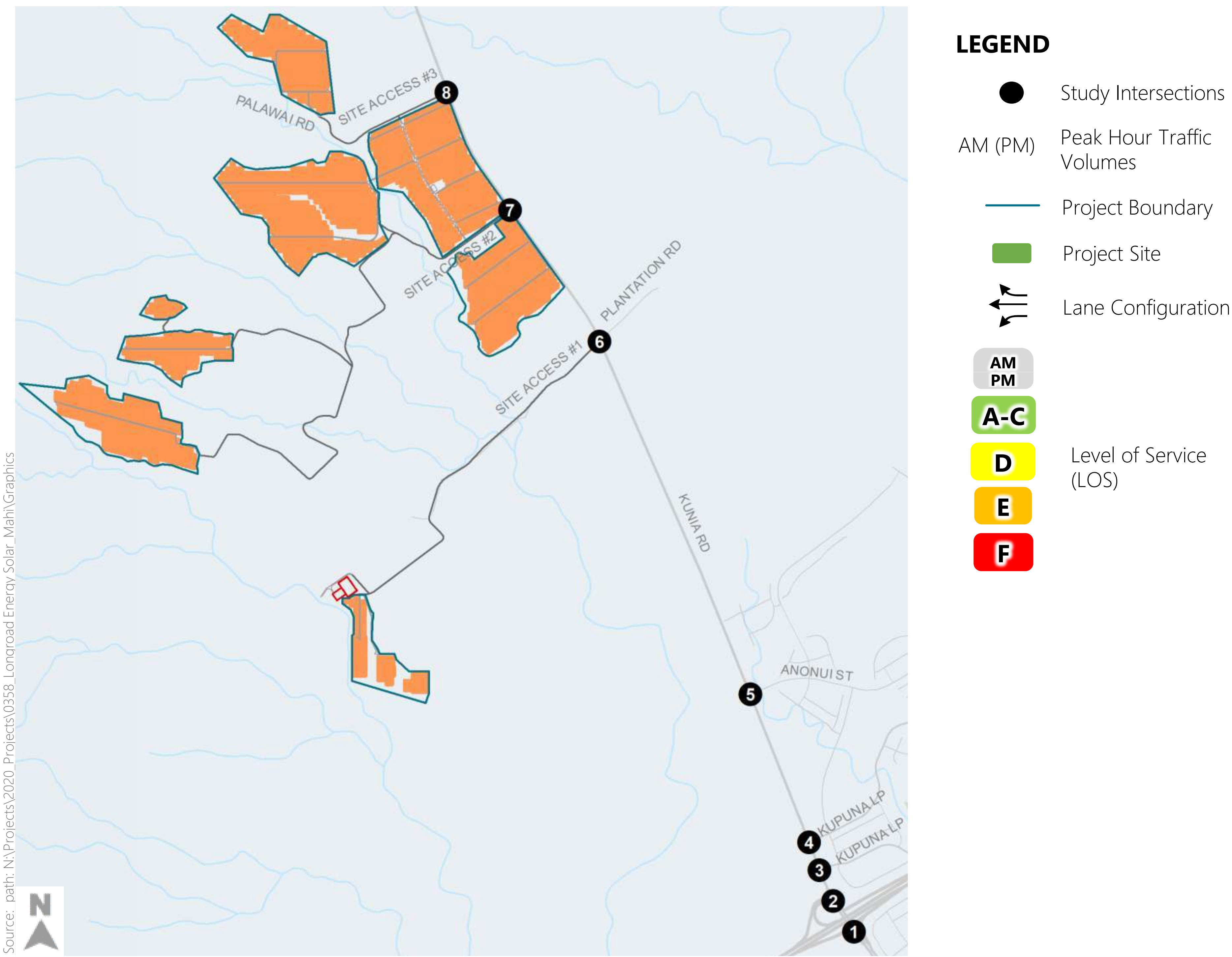


Figure 4

Peak Hour Traffic Volumes and Lane Configurations - Construction Trip Distribution and Assignment



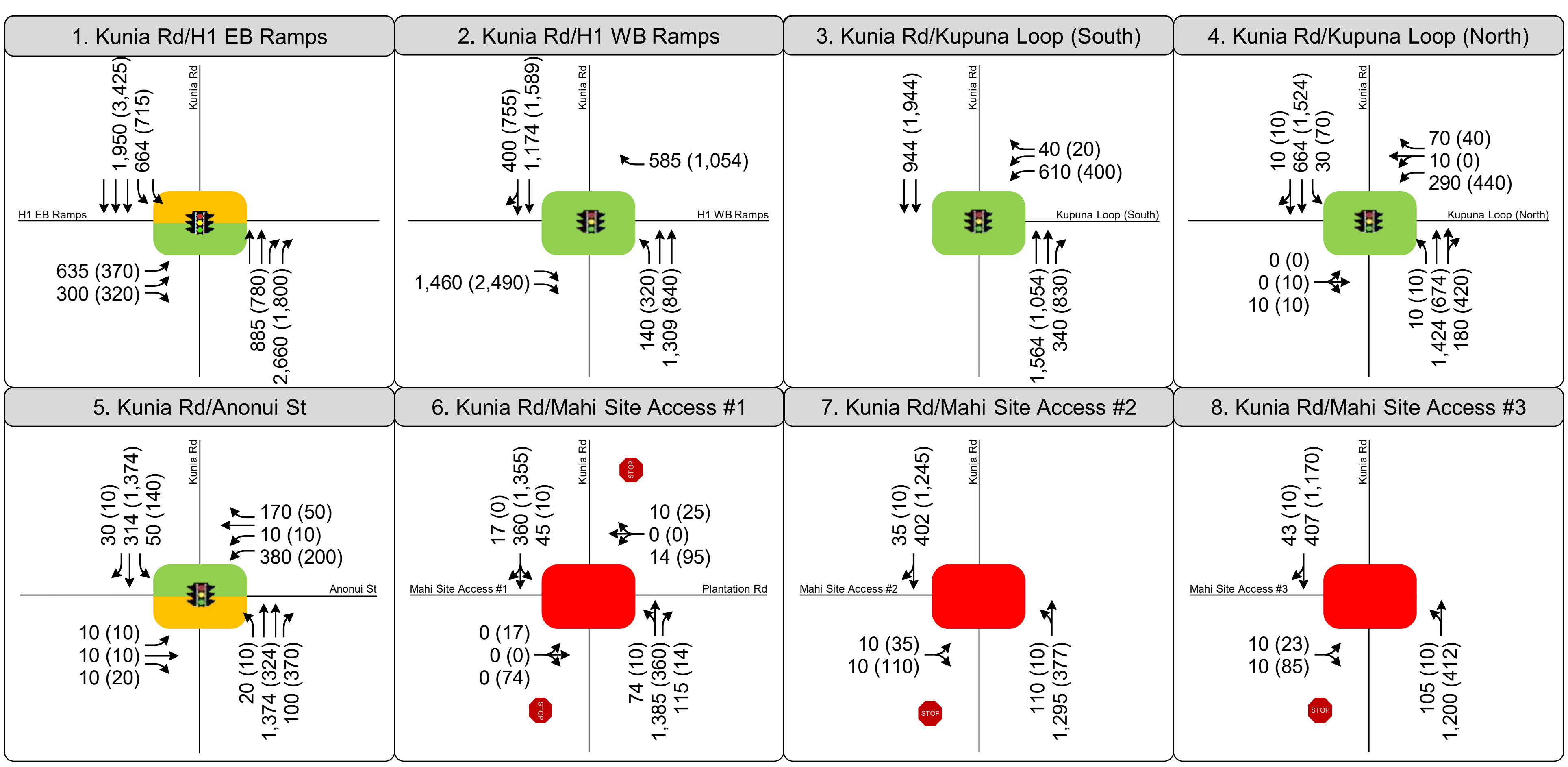


Figure 5

Peak Hour Traffic Volumes and Lane Configurations - 2022 Plus Construction Conditions

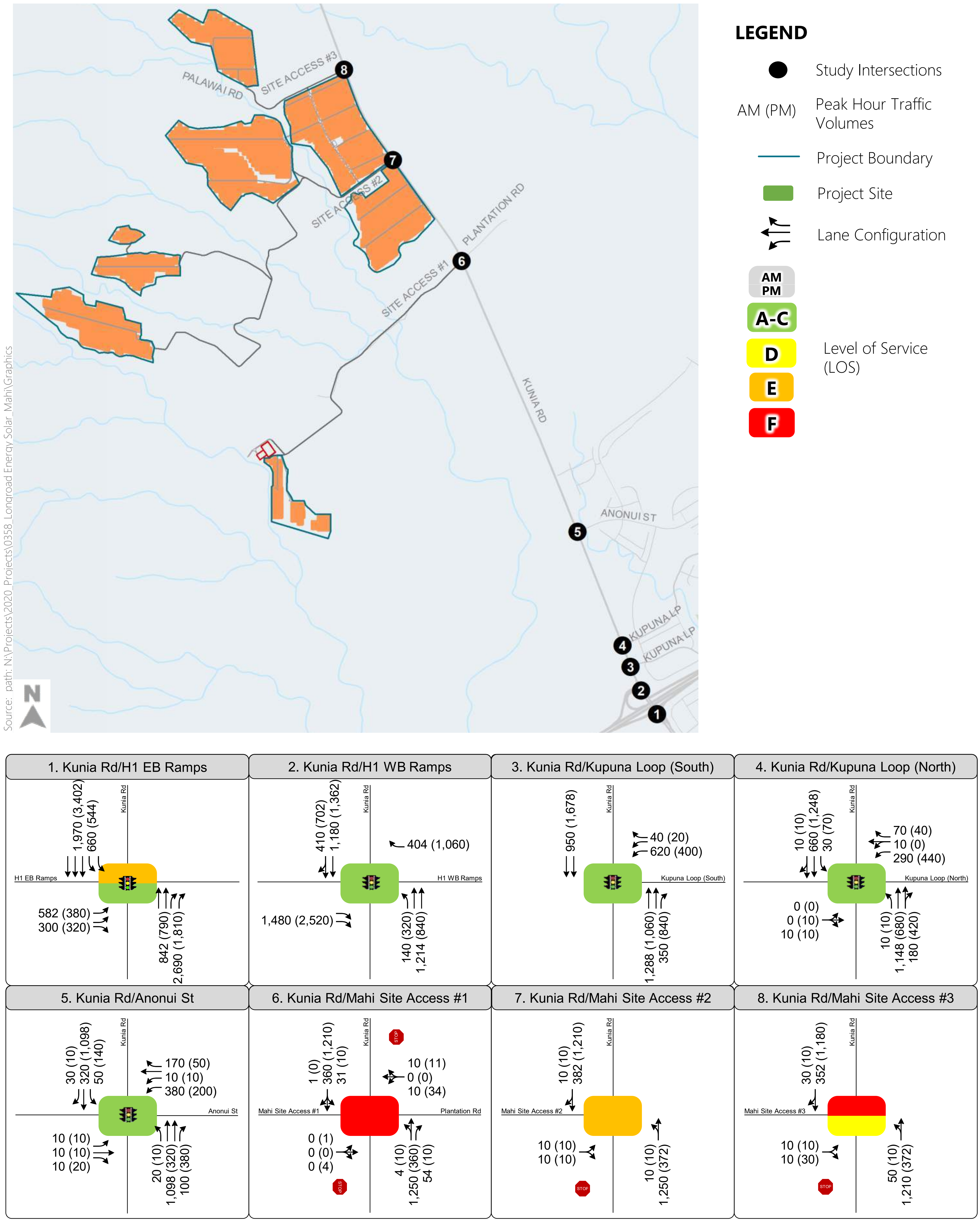


Figure 6

Peak Hour Traffic Volumes and Lane Configurations - Opening Year (2023) Conditions

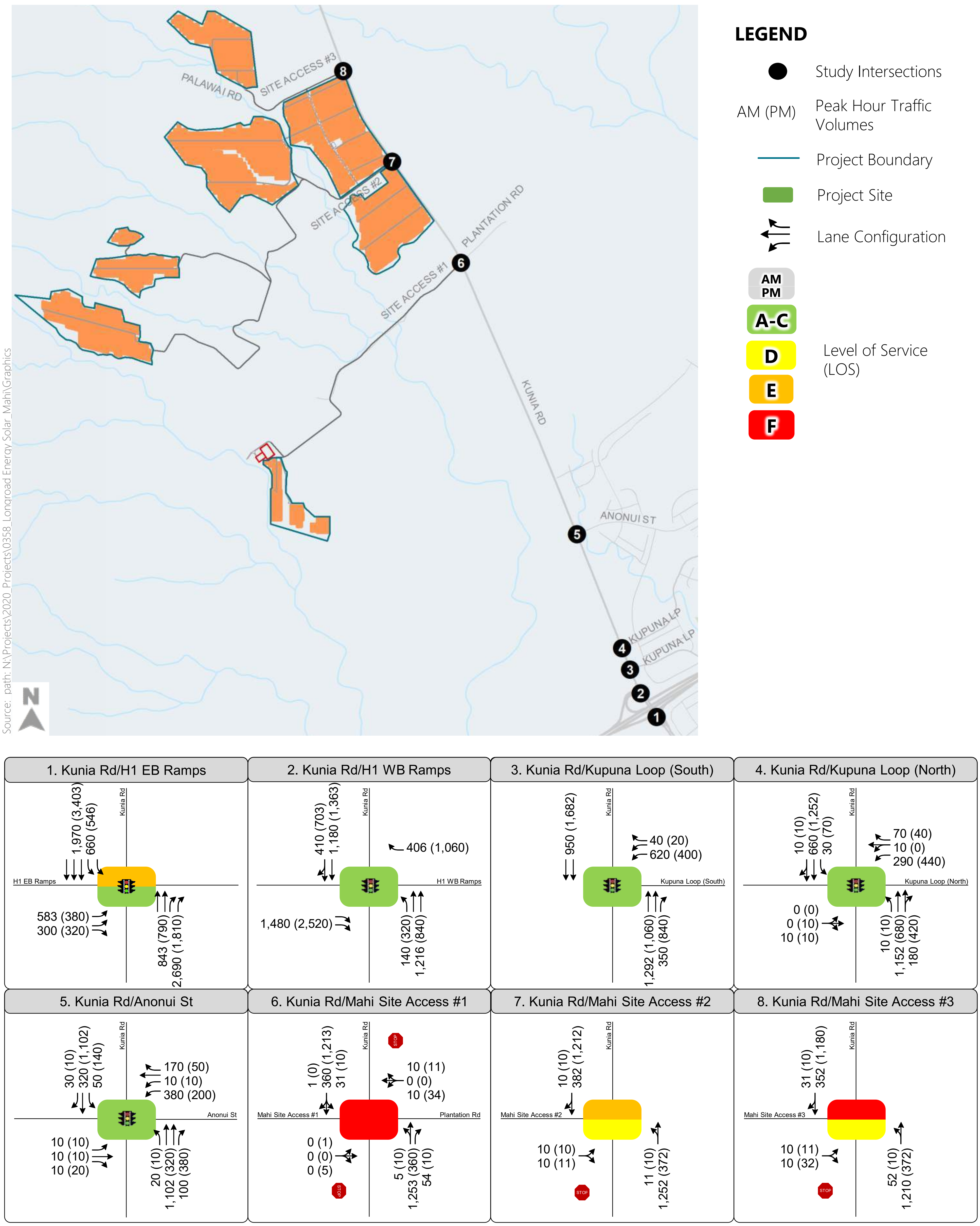


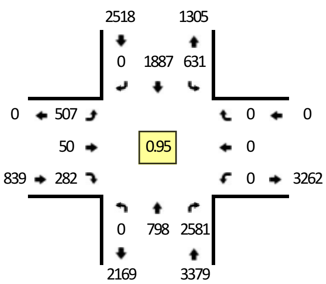
Figure 7

Peak Hour Traffic Volumes and Lane Configurations - Opening Year (2023) Plus Operations Conditions

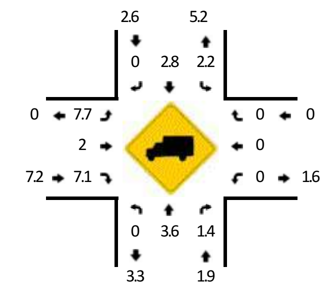
ATTACHMENT A: TRAFFIC COUNT DATA

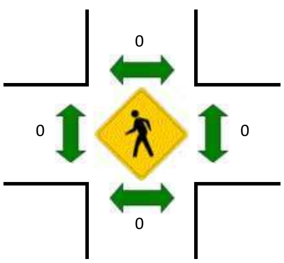
Type of peak hour being reported: System Peak   Method for determining peak hour: Total Entering Volume

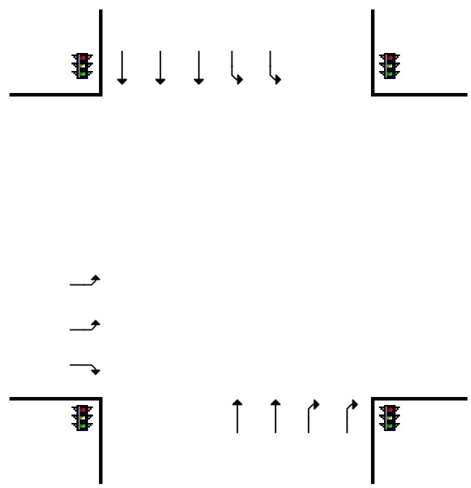
LOCATION: Kunia Rd -- H1 EB Ramps   **QC JOB #:** 15105701
CITY/STATE: Waipahu, HI   **DATE:** Tue, Oct 22 2019

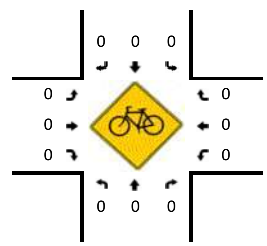


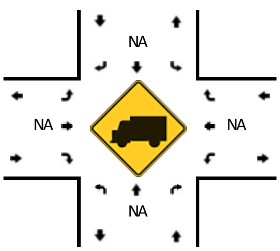
Peak-Hour: 6:45 AM -- 7:45 AM
Peak 15-Min: 7:30 AM -- 7:45 AM

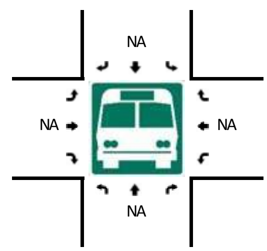












15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				H1 EB Ramps (Eastbound)				H1 EB Ramps (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
6:00 AM	0	188	746	0	150	266	0	0	124	19	61	0	0	0	0	0	1554	
6:15 AM	0	180	635	0	153	356	0	0	126	24	68	0	0	0	0	0	1542	
6:30 AM	0	205	541	0	154	409	0	0	144	26	53	0	0	0	0	0	1532	
6:45 AM	0	189	558	0	151	514	0	0	134	13	72	0	0	0	0	0	1631	6259
7:00 AM	0	200	649	0	175	446	0	0	121	16	55	0	0	0	0	0	1662	6367
7:15 AM	0	206	675	0	129	449	0	0	146	14	60	0	0	0	0	0	1679	6504
7:30 AM	0	203	699	0	176	478	0	0	106	7	95	0	0	0	0	0	1764	6736
7:45 AM	0	192	759	0	130	436	0	0	71	6	77	0	0	0	0	0	1671	6776
8:00 AM	0	182	675	0	142	422	0	0	87	1	68	0	0	0	0	0	1577	6691
8:15 AM	0	201	545	0	127	401	0	0	96	3	111	0	0	0	0	0	1484	6496
8:30 AM	0	175	562	0	147	390	0	0	83	0	85	0	0	0	0	0	1442	6174
8:45 AM	0	159	494	0	136	353	0	0	79	0	77	0	0	0	0	0	1298	5801

Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	0	812	2796	0	704	1912	0	0	424	28	380	0	0	0	0	0	7056
Heavy Trucks	0	28	36		32	76	0		64	0	24		0	0	0		260
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

Comments:

Report generated on 11/4/2019 3:22 PM   SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

Type of peak hour being reported: System Peak | Method for determining peak hour: Total Entering Volume

LOCATION: Kunia Rd -- H1 WB Off South | **QC JOB #:** 15105705
CITY/STATE: Waipahu, HI | **DATE:** Tue, Oct 22 2019

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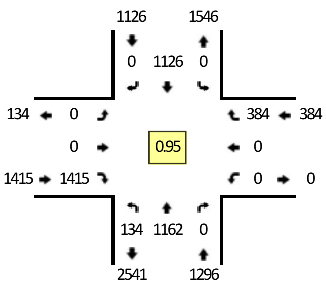
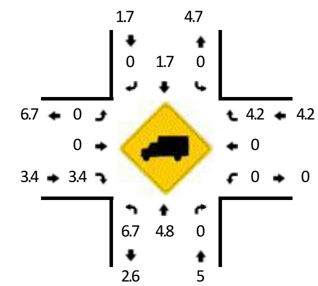
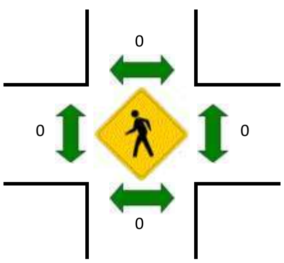
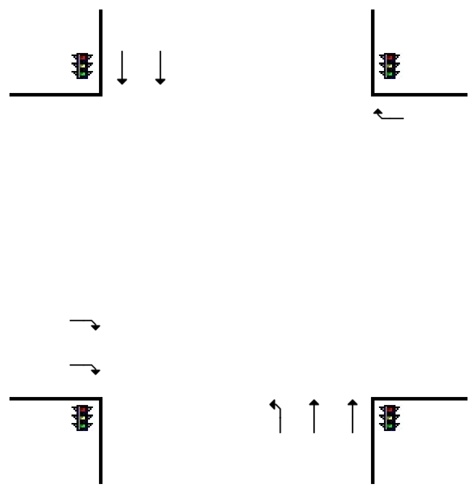
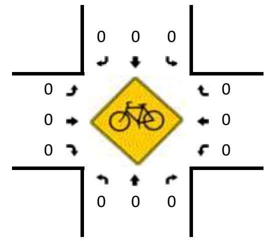
Peak 15-Min: 6:45 AM -- 7:00 AM

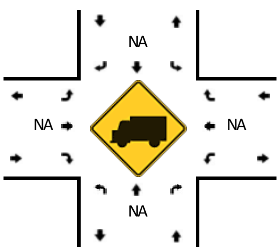


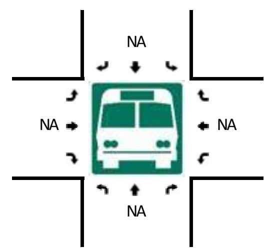












15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				H1 WB Off South (Eastbound)				H1 WB Off South (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
6:00 AM	36	290	0	0	0	242	0	0	0	0	220	0	0	0	56	0	844	
6:15 AM	24	287	0	0	0	216	0	0	0	0	301	0	0	0	82	0	910	
6:30 AM	29	317	0	0	0	220	0	0	0	0	354	0	0	0	85	0	1005	
6:45 AM	20	296	0	0	0	286	0	0	0	0	400	0	0	0	105	0	1107	3866
7:00 AM	26	295	0	0	0	303	0	0	0	0	335	0	0	0	78	0	1037	4059
7:15 AM	43	303	0	0	0	254	0	0	0	0	332	0	0	0	95	0	1027	4176
7:30 AM	45	268	0	0	0	283	0	0	0	0	348	0	0	0	106	0	1050	4221
7:45 AM	44	225	0	0	0	220	0	0	0	0	346	0	0	0	135	0	970	4084
8:00 AM	45	229	0	0	0	221	0	0	0	0	341	0	0	0	119	0	955	4002
8:15 AM	38	256	0	0	0	218	0	0	0	0	319	0	0	0	121	0	952	3927
8:30 AM	51	213	0	0	0	220	0	0	0	0	319	0	0	0	120	0	923	3800
8:45 AM	47	202	0	0	0	213	0	0	0	0	290	0	0	0	117	0	869	3699

Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	80	1184	0	0	0	1144	0	0	0	0	1600	0	0	0	420	0	4428
Heavy Trucks	8	24	0		0	12	0		0	0	44		0	0	12		100
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

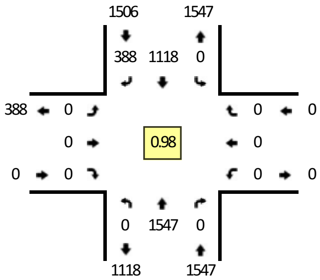
Comments:

Report generated on 11/4/2019 3:22 PM | SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

Type of peak hour being reported: System Peak — Method for determining peak hour: Total Entering Volume

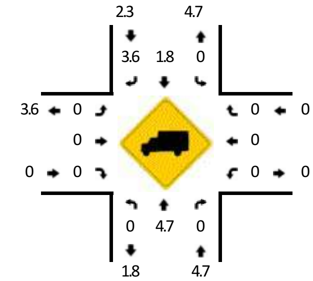
LOCATION: Kunia Rd -- H1 WB On North — **QC JOB #:** 15105707

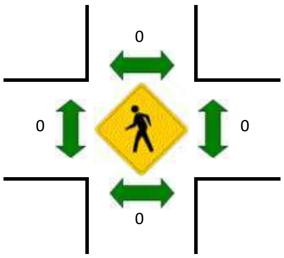
CITY/STATE: Royal Kunia, HI — **DATE:** Tue, Oct 22 2019

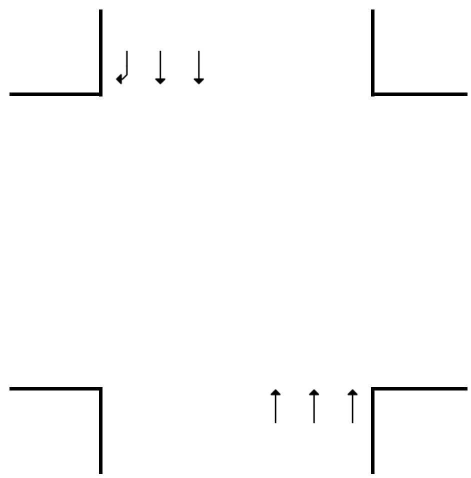


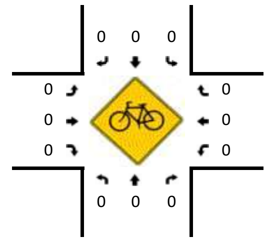
Peak-Hour: 6:45 AM -- 7:45 AM

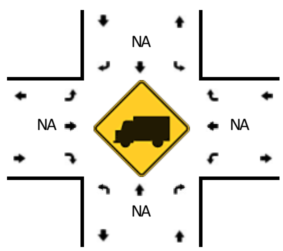
Peak 15-Min: 6:45 AM -- 7:00 AM

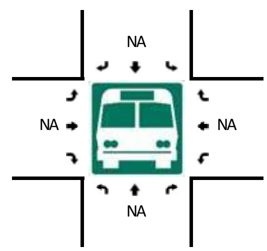












15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				H1 WB On North (Eastbound)				H1 WB On North (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
6:00 AM	0	341	0	0	0	243	68	0	0	0	0	0	0	0	0	0	652	
6:15 AM	0	371	0	0	0	216	64	0	0	0	0	0	0	0	0	0	651	
6:30 AM	0	400	0	0	0	226	90	0	0	0	0	0	0	0	0	0	716	
6:45 AM	0	405	0	0	0	280	93	0	0	0	0	0	0	0	0	0	778	2797
7:00 AM	0	366	0	0	0	304	89	0	0	0	0	0	0	0	0	0	759	2904
7:15 AM	0	399	0	0	0	255	106	0	0	0	0	0	0	0	0	0	760	3013
7:30 AM	0	377	0	0	0	279	100	0	0	0	0	0	0	0	0	0	756	3053
7:45 AM	0	363	0	0	0	217	107	0	0	0	0	0	0	0	0	0	687	2962
8:00 AM	0	354	0	0	0	220	71	0	0	0	0	0	0	0	0	0	645	2848
8:15 AM	0	369	0	0	0	218	74	0	0	0	0	0	0	0	0	0	661	2749
8:30 AM	0	338	0	0	0	220	71	0	0	0	0	0	0	0	0	0	629	2622
8:45 AM	0	320	0	0	0	217	59	0	0	0	0	0	0	0	0	0	596	2531

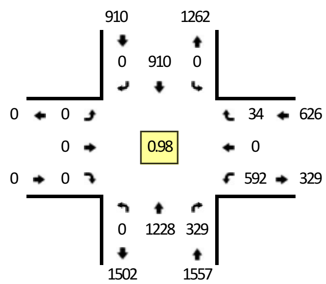
Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	0	1620	0	0	0	1120	372	0	0	0	0	0	0	0	0	0	3112
Heavy Trucks	0	36	0		0	12	4		0	0	0		0	0	0		52
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

Comments:

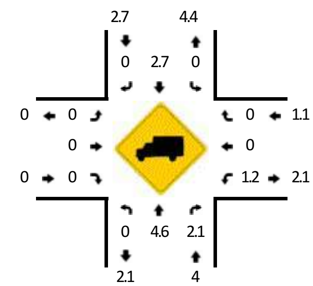
Report generated on 11/4/2019 3:22 PM — SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

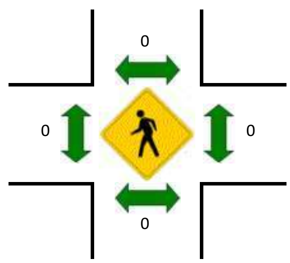
Type of peak hour being reported: System Peak | Method for determining peak hour: Total Entering Volume

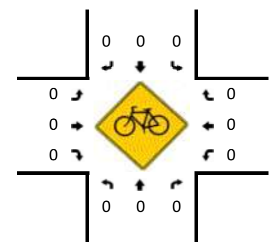
LOCATION: Kunia Rd -- Kupuna Loop (South) | **QC JOB #:** 15105709
CITY/STATE: Royal Kunia, HI | **DATE:** Tue, Oct 22 2019

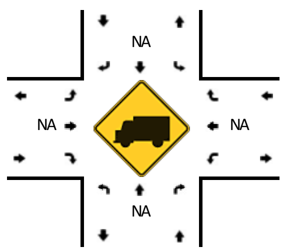


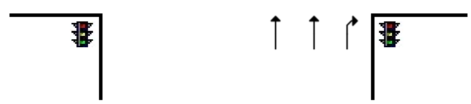
Peak-Hour: 6:45 AM -- 7:45 AM
Peak 15-Min: 6:45 AM -- 7:00 AM

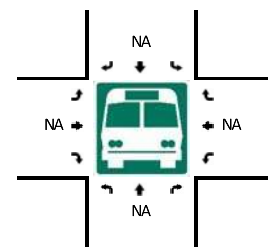












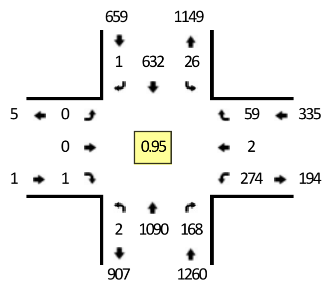
15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				Kupuna Loop (South) (Eastbound)				Kupuna Loop (South) (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
6:00 AM	0	337	47	0	0	188	0	0	0	0	0	0	96	0	7	0	675	
6:15 AM	0	294	51	0	0	176	0	0	0	0	0	0	110	0	6	0	637	
6:30 AM	0	331	56	0	0	189	0	0	0	0	0	0	127	0	10	0	713	
6:45 AM	0	343	74	0	0	233	0	0	0	0	0	0	132	0	11	0	793	2818
7:00 AM	0	295	70	0	0	227	0	0	0	0	0	0	151	0	7	0	750	2893
7:15 AM	0	288	86	0	0	217	0	0	0	0	0	0	174	0	9	0	774	3030
7:30 AM	0	302	99	0	0	233	0	0	0	0	0	0	135	0	7	0	776	3093
7:45 AM	0	245	105	0	0	210	0	0	0	0	0	0	116	0	12	0	688	2988
8:00 AM	0	262	89	0	0	193	0	0	0	0	0	0	117	0	7	0	668	2906
8:15 AM	0	279	90	0	0	182	0	0	0	0	0	0	93	0	9	0	653	2785
8:30 AM	0	259	89	0	0	175	0	0	0	0	0	0	100	0	4	0	627	2636
8:45 AM	0	239	105	0	0	192	0	0	0	0	0	0	93	0	5	0	634	2582

Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	0	1372	296	0	0	932	0	0	0	0	0	0	528	0	44	0	3172
Heavy Trucks	0	32	0		0	12	0		0	0	0		4	0	0		48
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

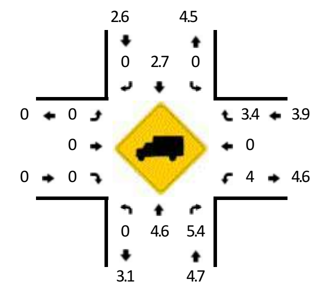
Comments:

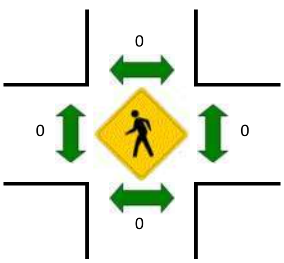
Report generated on 11/4/2019 3:22 PM | SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

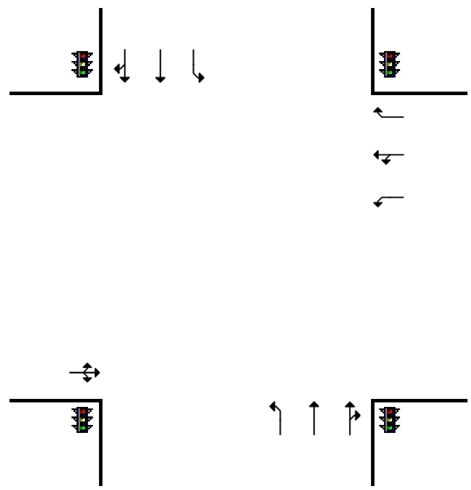
LOCATION: Kunia Rd -- Kupuna Loop (North) **QC JOB #:** 15105711
CITY/STATE: Royal Kunia, HI **DATE:** Tue, Oct 22 2019

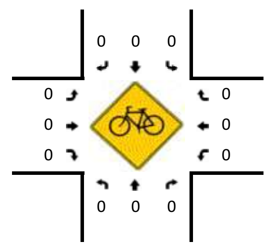


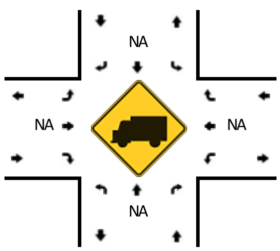
Peak-Hour: 6:45 AM -- 7:45 AM
Peak 15-Min: 6:45 AM -- 7:00 AM

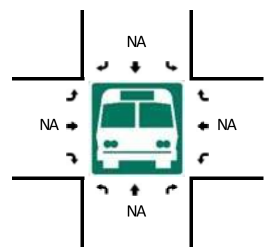












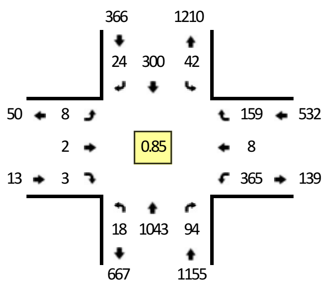
15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				Kupuna Loop (North) (Eastbound)				Kupuna Loop (North) (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
6:00 AM	0	286	34	0	1	120	0	0	0	0	0	0	70	0	10	0	521	
6:15 AM	0	280	33	0	2	120	0	0	0	0	0	0	51	0	16	0	502	
6:30 AM	0	300	30	0	3	153	0	0	0	0	0	0	56	2	21	0	565	
6:45 AM	1	308	37	0	7	173	0	0	0	0	0	0	58	0	12	0	596	2184
7:00 AM	0	273	37	0	5	158	1	0	0	0	0	0	72	1	17	0	564	2227
7:15 AM	0	268	43	0	5	156	0	0	0	0	0	0	86	1	14	0	573	2298
7:30 AM	1	241	51	0	9	145	0	0	0	0	1	0	58	0	16	0	522	2255
7:45 AM	4	202	69	1	7	153	0	0	1	0	0	0	57	0	12	0	506	2165
8:00 AM	1	209	64	0	3	126	0	0	0	0	0	0	56	0	13	0	472	2073
8:15 AM	0	215	72	0	9	161	0	0	0	0	0	0	39	0	8	0	504	2004
8:30 AM	2	184	69	0	8	119	0	0	0	0	0	0	61	0	7	0	450	1932
8:45 AM	0	178	50	0	5	112	0	0	0	0	1	0	73	0	8	0	427	1853

Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	4	1232	148	0	28	692	0	0	0	0	0	0	232	0	48	0	2384
Heavy Trucks	0	24	8		0	8	0		0	0	0		4	0	4		48
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

Comments:

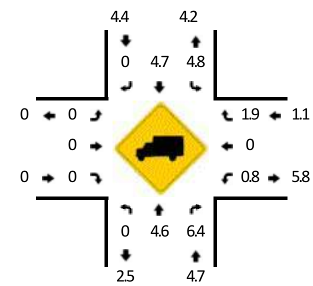
Report generated on 11/4/2019 3:22 PM SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

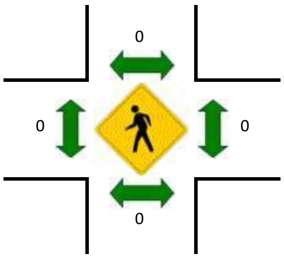
LOCATION: Kunia Rd -- Anonui St **QC JOB #:** 15105713
CITY/STATE: Royal Kunia, HI **DATE:** Tue, Oct 22 2019

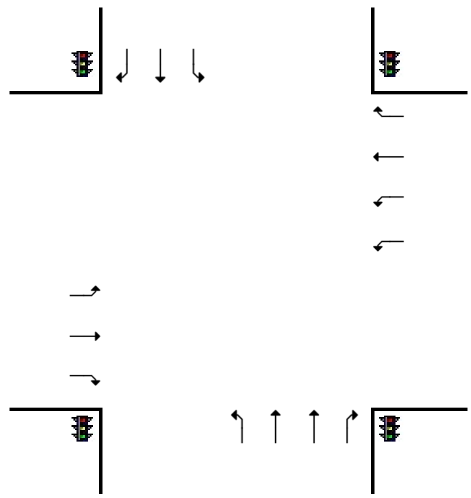


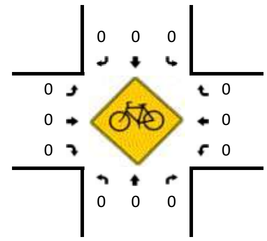
Peak-Hour: 6:45 AM -- 7:45 AM
Peak 15-Min: 6:45 AM -- 7:00 AM

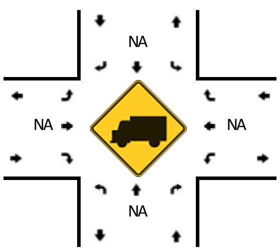
Quality Counts
DATA THAT DRIVES COMMUNITIES

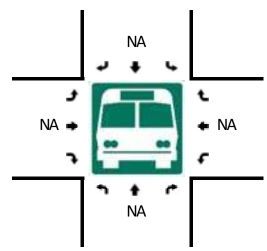












15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				Anonui St (Eastbound)				Anonui St (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
6:00 AM	9	280	13	0	4	30	6	0	1	0	1	0	89	2	22	0	457	
6:15 AM	18	261	17	0	3	39	6	0	0	2	1	0	77	10	29	0	463	
6:30 AM	21	284	23	0	9	58	8	0	1	1	2	0	97	13	38	0	555	
6:45 AM	9	297	21	0	16	91	23	0	6	0	1	0	92	6	48	0	610	2085
7:00 AM	4	265	19	0	7	74	0	0	0	0	0	0	89	1	54	1	514	2142
7:15 AM	3	242	27	0	7	59	0	0	1	1	0	0	104	1	30	0	475	2154
7:30 AM	2	239	27	0	12	76	1	0	1	1	2	0	79	0	27	0	467	2066
7:45 AM	1	173	37	0	18	96	0	0	0	0	1	0	57	0	23	0	406	1862
8:00 AM	1	171	48	0	11	98	0	0	0	1	0	0	52	1	15	0	398	1746
8:15 AM	1	175	41	0	7	79	0	0	0	0	1	0	70	0	18	0	392	1663
8:30 AM	0	182	28	0	5	76	0	0	0	0	1	0	56	0	41	0	389	1585
8:45 AM	1	158	33	0	12	57	5	0	0	0	4	0	51	0	14	1	336	1515

Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	36	1188	84	0	64	364	92	0	24	0	4	0	368	24	192	0	2440
Heavy Trucks	0	32	4		0	4	0		0	0	0		4	0	0		44
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

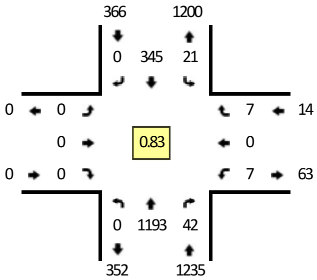
Comments:

Report generated on 11/4/2019 3:22 PM SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

Type of peak hour being reported: System Peak — Method for determining peak hour: Total Entering Volume

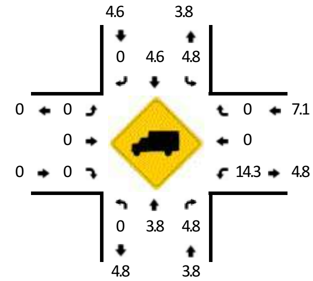
LOCATION: Kunia Rd -- Plantation Rd — **QC JOB #:** 15105715

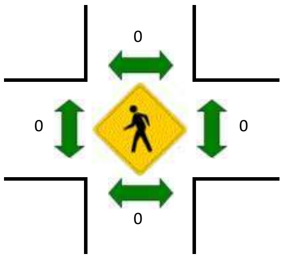
CITY/STATE: Waipahu, HI — **DATE:** Tue, Oct 22 2019

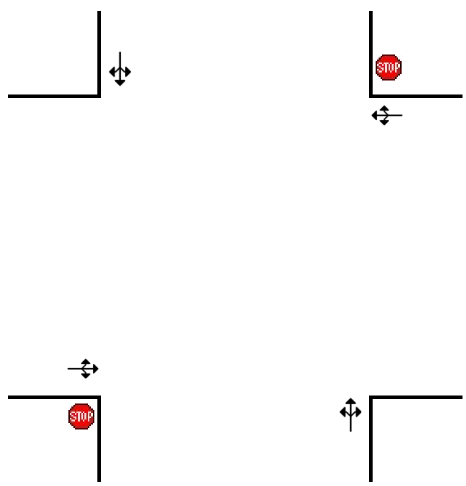


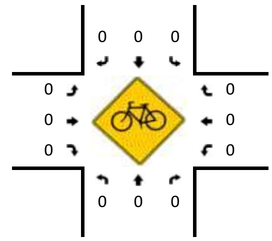
Peak-Hour: 6:45 AM -- 7:45 AM

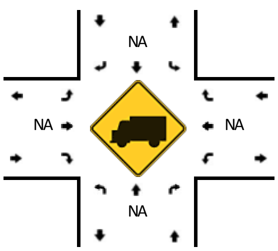
Peak 15-Min: 6:45 AM -- 7:00 AM

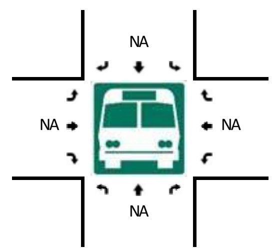












15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				Plantation Rd (Eastbound)				Plantation Rd (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
6:00 AM	0	325	10	0	1	43	0	0	0	0	0	0	2	0	0	0	381	
6:15 AM	1	271	19	0	3	52	0	0	0	0	0	0	0	0	1	0	347	
6:30 AM	0	289	21	1	5	89	0	0	0	0	0	0	1	0	1	0	407	
6:45 AM	0	326	29	0	9	117	0	0	0	0	0	0	1	0	2	0	484	1619
7:00 AM	0	310	10	0	9	67	0	0	0	0	0	0	4	0	1	0	401	1639
7:15 AM	0	285	1	0	2	70	0	0	0	0	0	0	0	0	1	0	359	1651
7:30 AM	0	272	2	0	1	91	0	0	0	0	0	0	2	0	3	0	371	1615
7:45 AM	1	199	1	0	1	121	0	0	0	0	0	0	2	0	0	0	325	1456
8:00 AM	0	188	1	0	2	88	1	0	0	0	0	0	7	0	0	0	287	1342
8:15 AM	0	189	4	0	0	82	0	0	0	0	0	0	2	0	1	0	278	1261
8:30 AM	0	217	6	0	0	86	0	0	0	0	0	0	1	0	1	0	311	1201
8:45 AM	0	162	5	0	0	61	0	0	0	0	0	0	0	0	0	0	228	1104

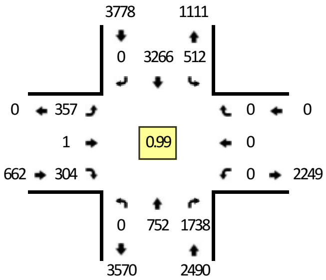
Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	0	1304	116	0	36	468	0	0	0	0	0	0	4	0	8	0	1936
Heavy Trucks	0	36	4		0	8	0		0	0	0		0	0	0		48
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

Comments:

Report generated on 11/4/2019 3:22 PM — SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

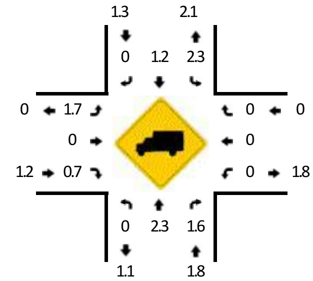
Type of peak hour being reported: System Peak | Method for determining peak hour: Total Entering Volume

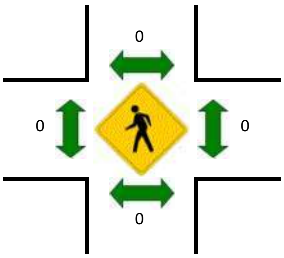
LOCATION: Kunia Rd -- H1 EB Ramps | **QC JOB #:** 15105702
CITY/STATE: Waipahu, HI | **DATE:** Tue, Oct 22 2019

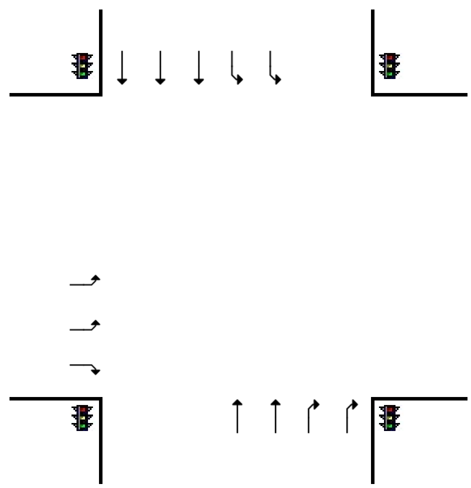


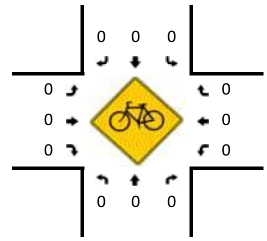
Peak-Hour: 4:00 PM -- 5:00 PM
Peak 15-Min: 4:00 PM -- 4:15 PM

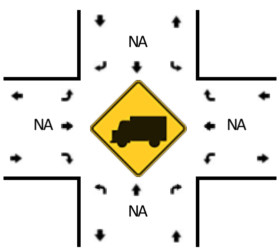
Quality Counts
DATA THAT DRIVES COMMUNITIES

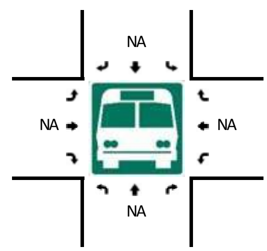












15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				H1 EB Ramps (Eastbound)				H1 EB Ramps (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
3:00 PM	0	172	467	0	115	713	0	1	93	0	57	0	0	0	0	0	1618	
3:15 PM	0	181	423	0	128	819	0	1	74	1	72	0	0	0	0	0	1699	
3:30 PM	0	210	511	0	117	849	0	0	99	0	83	0	0	0	0	0	1869	
3:45 PM	0	196	410	0	114	870	0	0	98	0	64	0	0	0	0	0	1752	6938
4:00 PM	0	189	451	0	131	813	0	2	88	0	83	0	0	0	0	0	1757	7077
4:15 PM	0	179	407	0	138	866	0	0	80	0	70	0	0	0	0	0	1740	7118
4:30 PM	0	188	449	0	107	760	0	0	107	1	72	0	0	0	0	0	1684	6933
4:45 PM	0	196	431	0	134	827	0	0	82	0	79	0	0	0	0	0	1749	6930
5:00 PM	0	176	374	0	112	794	0	0	77	0	59	0	0	0	0	0	1592	6765
5:15 PM	0	162	423	0	135	795	0	0	104	0	59	0	0	0	0	0	1678	6703
5:30 PM	0	207	409	0	120	752	0	0	82	0	50	0	0	0	0	0	1620	6639
5:45 PM	0	147	379	0	125	784	0	0	75	0	48	0	0	0	0	0	1558	6448

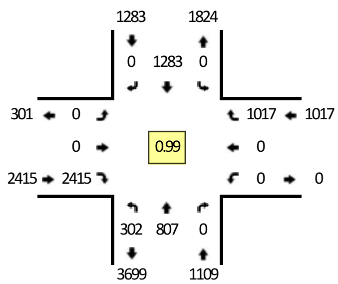
Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	0	756	1804	0	524	3252	0	8	352	0	332	0	0	0	0	0	7028
Heavy Trucks	0	28	32		24	28	0		0	0	4		0	0	0		116
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

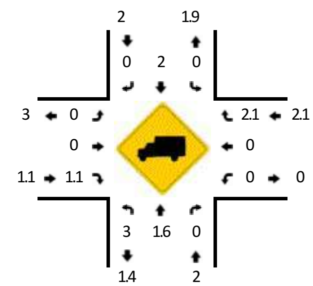
Comments:

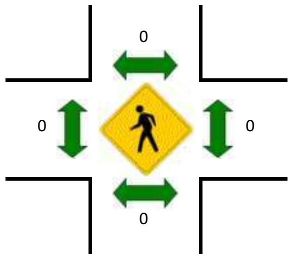
Report generated on 11/4/2019 3:22 PM | SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

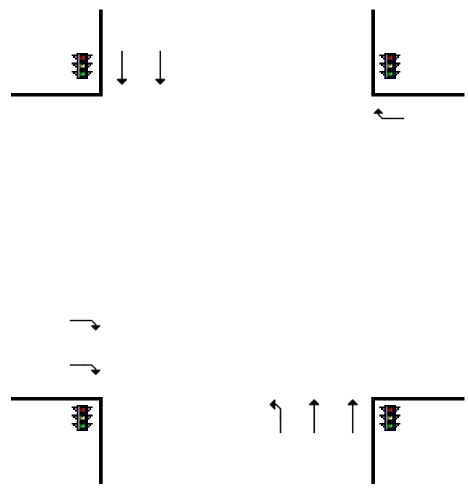
LOCATION: Kunia Rd -- H1 WB Off South **QC JOB #:** 15105706
CITY/STATE: Waipahu, HI **DATE:** Tue, Oct 22 2019

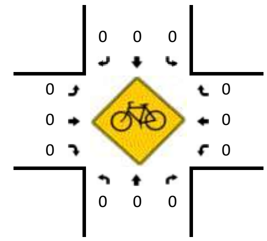
Peak-Hour: 4:00 PM -- 5:00 PM
Peak 15-Min: 4:15 PM -- 4:30 PM

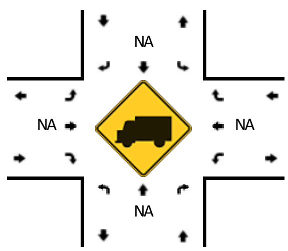


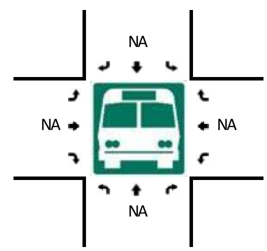












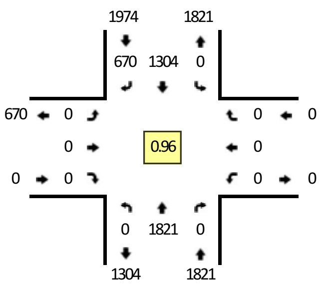
15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				H1 WB Off South (Eastbound)				H1 WB Off South (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
3:00 PM	62	209	0	0	0	240	0	0	0	0	624	0	0	0	212	0	1347	
3:15 PM	73	195	0	0	0	260	0	0	0	0	639	0	0	0	277	0	1444	
3:30 PM	78	223	0	1	0	314	0	0	0	0	642	0	0	0	228	0	1486	
3:45 PM	72	214	0	0	0	322	0	0	0	0	651	0	0	0	252	0	1511	5788
4:00 PM	83	210	0	0	0	287	0	0	0	0	615	0	0	0	237	0	1432	5873
4:15 PM	70	173	0	1	0	350	0	0	0	0	633	0	0	0	247	0	1474	5903
4:30 PM	82	217	0	0	0	324	0	0	0	0	576	0	0	0	268	0	1467	5884
4:45 PM	66	207	0	0	0	322	0	0	0	0	591	0	0	0	265	0	1451	5824
5:00 PM	77	178	0	0	0	309	0	0	0	0	568	0	0	0	240	0	1372	5764
5:15 PM	63	211	0	0	0	329	0	0	0	0	598	0	0	0	209	0	1410	5700
5:30 PM	71	202	0	0	0	356	0	0	0	0	561	0	0	0	234	0	1424	5657
5:45 PM	69	179	0	0	0	304	0	0	0	0	600	0	0	0	216	0	1368	5574

Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	280	692	0	4	0	1400	0	0	0	0	2532	0	0	0	988	0	5896
Heavy Trucks	4	8	0		0	32	0		0	0	36		0	0	16		96
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

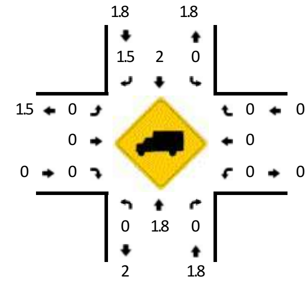
Comments:

Report generated on 11/4/2019 3:22 PM SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

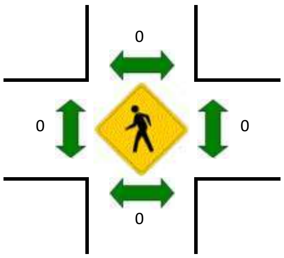
LOCATION: Kunia Rd -- H1 WB On North
QC JOB #: 15105708
CITY/STATE: Royal Kunia, HI
DATE: Tue, Oct 22 2019

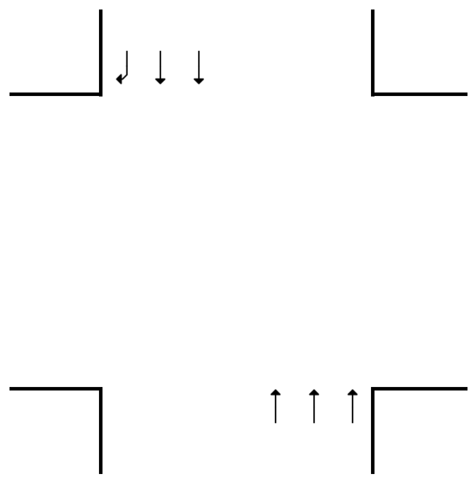


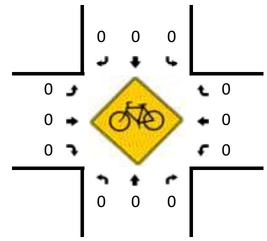
Peak-Hour: 4:00 PM -- 5:00 PM
Peak 15-Min: 4:30 PM -- 4:45 PM

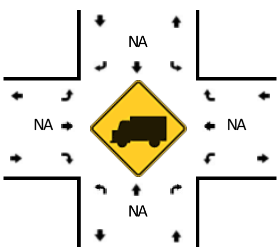


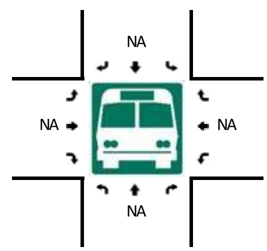
Quality Counts
DATA THAT DRIVES COMMUNITIES











15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				H1 WB On North (Eastbound)				H1 WB On North (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
3:00 PM	0	421	0	0	0	239	108	0	0	0	0	0	0	0	0	0	768	
3:15 PM	0	469	0	0	0	270	132	0	0	0	0	0	0	0	0	0	871	
3:30 PM	0	450	0	0	0	312	142	0	0	0	0	0	0	0	0	0	904	
3:45 PM	0	471	0	0	0	321	166	0	0	0	0	0	0	0	0	0	958	3501
4:00 PM	0	445	0	0	0	294	149	0	0	0	0	0	0	0	0	0	888	3621
4:15 PM	0	421	0	0	0	358	177	0	0	0	0	0	0	0	0	0	956	3706
4:30 PM	0	479	0	0	0	330	180	0	0	0	0	0	0	0	0	0	989	3791
4:45 PM	0	476	0	0	0	322	164	0	0	0	0	0	0	0	0	0	962	3795
5:00 PM	0	418	0	0	0	318	159	0	0	0	0	0	0	0	0	0	895	3802
5:15 PM	0	426	0	0	0	330	160	0	0	0	0	0	0	0	0	0	916	3762
5:30 PM	0	436	0	0	0	355	159	0	0	0	0	0	0	0	0	0	950	3723
5:45 PM	0	390	0	0	0	307	115	0	0	0	0	0	0	0	0	0	812	3573

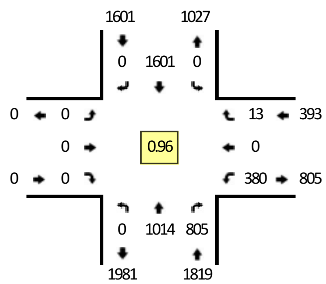
Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	0	1916	0	0	0	1320	720	0	0	0	0	0	0	0	0	0	3956
Heavy Trucks	0	56	0		0	16	12		0	0	0		0	0	0		84
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

Comments:

Type of peak hour being reported: System Peak | Method for determining peak hour: Total Entering Volume

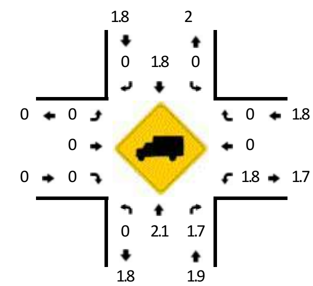
LOCATION: Kunia Rd -- Kupuna Loop (South)
CITY/STATE: Royal Kunia, HI

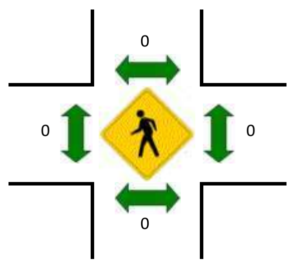
QC JOB #: 15105710
DATE: Tue, Oct 22 2019

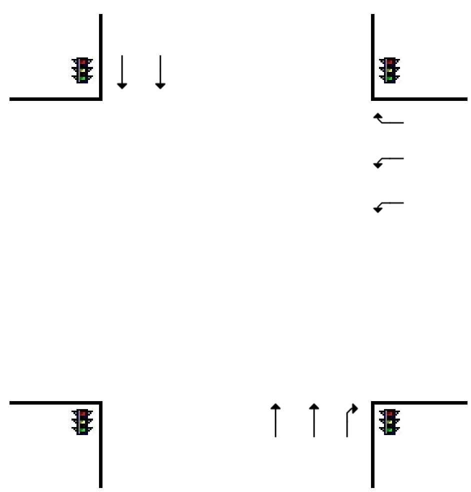


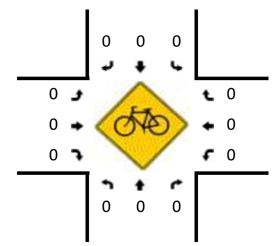
Peak-Hour: 4:00 PM -- 5:00 PM
Peak 15-Min: 4:45 PM -- 5:00 PM

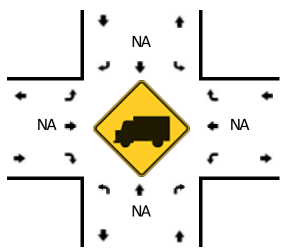
Quality Counts
DATA THAT DRIVES COMMUNITIES

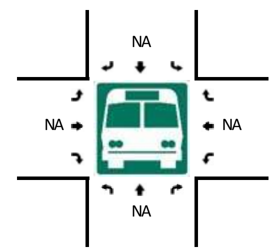












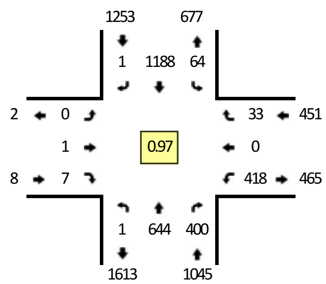
15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				Kupuna Loop (South) (Eastbound)				Kupuna Loop (South) (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
3:00 PM	0	228	172	0	0	271	0	0	0	0	0	0	80	0	0	0	751	
3:15 PM	0	233	213	0	0	290	0	0	0	0	0	0	98	0	0	0	834	
3:30 PM	0	254	203	0	0	358	0	0	0	0	0	0	72	0	3	0	890	
3:45 PM	0	270	218	0	0	410	0	0	0	0	0	0	80	0	5	0	983	3458
4:00 PM	0	263	179	0	0	343	0	0	0	0	0	0	95	0	1	0	881	3588
4:15 PM	0	227	201	0	0	429	0	0	0	0	0	0	101	0	4	0	962	3716
4:30 PM	0	257	200	0	0	425	0	0	0	0	0	0	89	0	4	0	975	3801
4:45 PM	0	267	225	0	0	404	0	0	0	0	0	0	95	0	4	0	995	3813
5:00 PM	0	234	195	0	0	388	0	0	0	0	0	0	95	0	6	0	918	3850
5:15 PM	0	253	184	0	0	393	0	0	0	0	0	0	97	0	2	0	929	3817
5:30 PM	0	232	170	0	0	423	0	0	0	0	0	0	77	0	2	0	904	3746
5:45 PM	0	219	182	0	0	372	0	0	0	0	0	0	85	0	4	0	862	3613

Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	0	1068	900	0	0	1616	0	0	0	0	0	0	380	0	16	0	3980
Heavy Trucks	0	4	20		0	16	0		0	0	0		8	0	0		48
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

Comments:

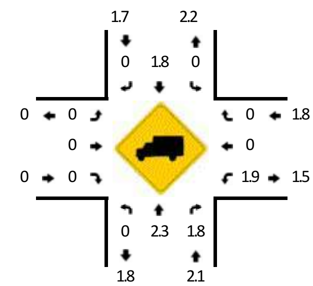
Report generated on 11/4/2019 3:22 PM | SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

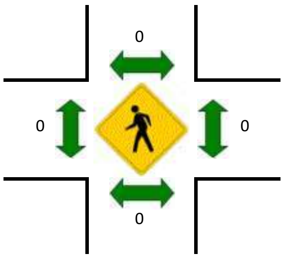
LOCATION: Kunia Rd -- Kupuna Loop (North) | **QC JOB #:** 15105712
CITY/STATE: Royal Kunia, HI | **DATE:** Tue, Oct 22 2019

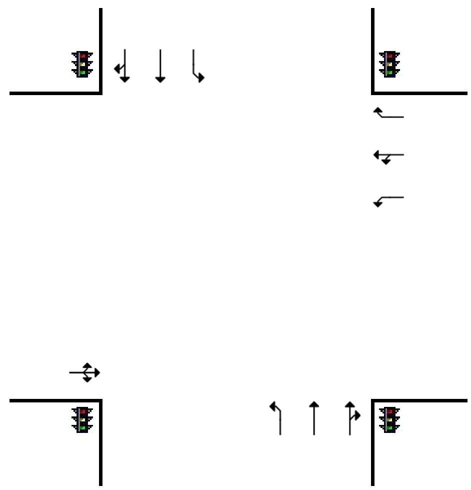


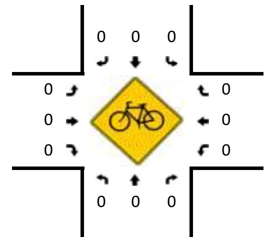
Peak-Hour: 4:00 PM -- 5:00 PM
Peak 15-Min: 4:30 PM -- 4:45 PM

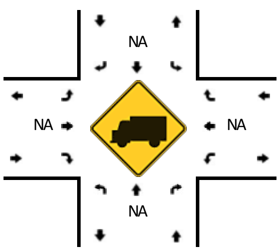
Quality Counts
DATA THAT DRIVES COMMUNITIES

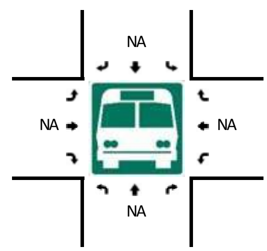












15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				Kupuna Loop (North) (Eastbound)				Kupuna Loop (North) (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
3:00 PM	1	120	99	0	12	163	0	0	0	0	0	0	106	0	11	0	512	
3:15 PM	0	150	101	0	14	206	0	0	0	0	3	0	92	0	14	0	580	
3:30 PM	0	157	83	0	23	257	0	0	0	1	2	0	123	0	8	0	654	
3:45 PM	0	156	112	1	16	293	0	0	0	1	1	0	99	0	13	0	692	2438
4:00 PM	1	169	98	0	15	264	0	0	0	0	2	0	96	0	9	0	654	2580
4:15 PM	0	155	87	0	13	320	0	0	0	1	1	0	113	0	10	0	700	2700
4:30 PM	0	151	107	0	20	301	1	0	0	0	4	0	118	0	10	0	712	2758
4:45 PM	0	169	108	0	16	303	0	0	0	0	0	0	91	0	4	0	691	2757
5:00 PM	0	134	95	0	24	276	0	0	0	0	0	0	110	0	13	0	652	2755
5:15 PM	0	160	99	0	21	292	0	0	1	1	0	0	115	0	5	0	694	2749
5:30 PM	1	142	95	0	18	304	0	0	0	0	0	0	117	0	3	0	680	2717
5:45 PM	0	124	87	0	16	236	0	0	0	0	0	0	114	0	8	0	585	2611

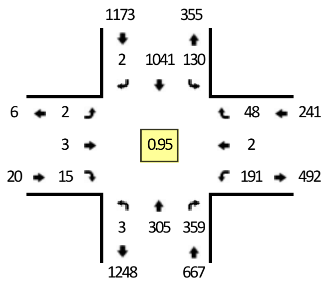
Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	0	604	428	0	80	1204	4	0	0	0	16	0	472	0	40	0	2848
Heavy Trucks	0	20	12		0	16	0		0	0	0		12	0	0		60
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

Comments:

Report generated on 11/4/2019 3:22 PM | SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

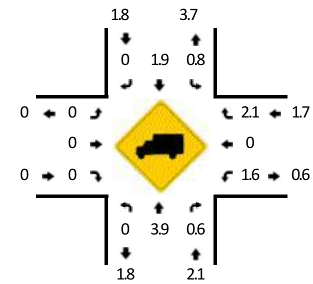
Type of peak hour being reported: System Peak | Method for determining peak hour: Total Entering Volume

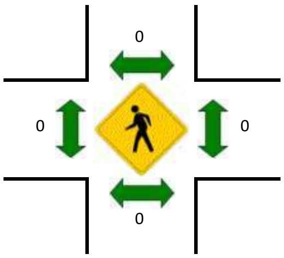
LOCATION: Kunia Rd -- Anonui St | **QC JOB #:** 15105714
CITY/STATE: Royal Kunia, HI | **DATE:** Tue, Oct 22 2019

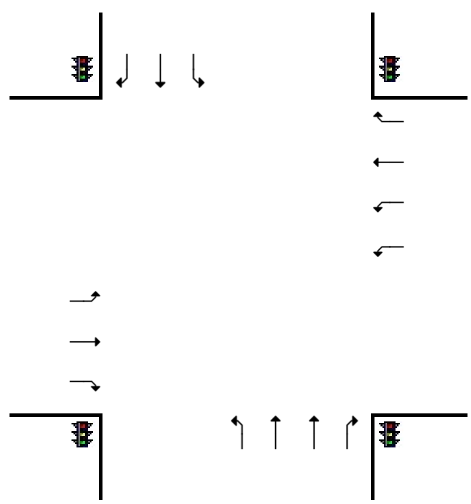


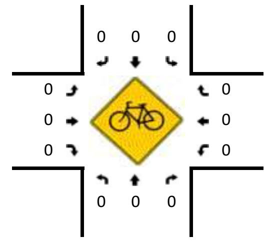
Peak-Hour: 4:00 PM -- 5:00 PM
Peak 15-Min: 4:45 PM -- 5:00 PM

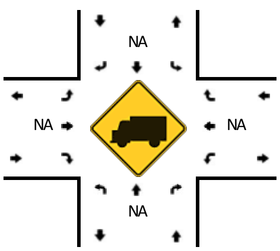
Quality Counts
DATA THAT DRIVES COMMUNITIES

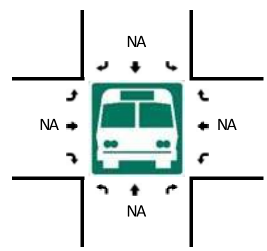












15-Min Count Period Beginning At	Kunia Rd (Northbound)				Kunia Rd (Southbound)				Anonui St (Eastbound)				Anonui St (Westbound)				Total	Hourly Totals
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U		
3:00 PM	1	65	72	0	18	131	0	0	0	0	2	0	55	0	9	0	353	
3:15 PM	2	68	88	0	22	161	4	0	1	0	12	0	42	1	11	0	412	
3:30 PM	1	90	74	0	22	205	1	0	36	14	50	0	50	1	9	0	553	
3:45 PM	1	94	83	0	40	243	1	0	2	2	10	0	46	0	10	0	532	1850
4:00 PM	0	74	91	1	29	228	0	0	2	1	5	0	45	1	13	0	490	1987
4:15 PM	1	76	80	0	27	258	0	0	0	2	1	0	61	0	9	0	515	2090
4:30 PM	1	76	97	0	31	278	1	0	0	0	5	0	44	0	11	0	544	2081
4:45 PM	0	79	91	0	43	277	1	0	0	0	4	0	41	1	15	0	552	2101
5:00 PM	0	74	78	0	27	235	1	0	0	0	2	0	56	0	18	0	491	2102
5:15 PM	0	72	101	0	23	273	0	0	1	2	2	0	45	0	9	0	528	2115
5:30 PM	0	62	80	0	44	249	0	0	1	0	0	0	64	0	17	0	517	2088
5:45 PM	4	55	77	0	24	215	0	0	0	0	2	0	51	0	10	1	439	1975

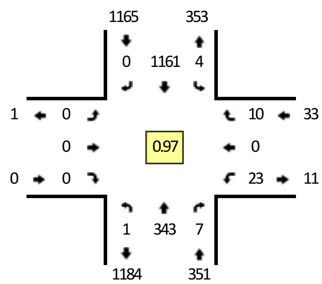
Peak 15-Min Flowrates	Northbound				Southbound				Eastbound				Westbound				Total
	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	Left	Thru	Right	U	
All Vehicles	0	316	364	0	172	1108	4	0	0	0	16	0	164	4	60	0	2208
Heavy Trucks	0	4	0		0	20	0		0	0	0		4	0	4		32
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

Comments:

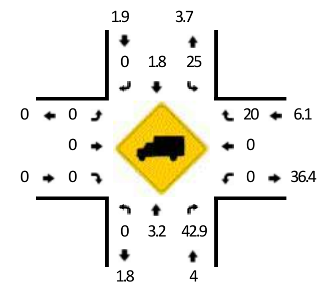
Report generated on 11/4/2019 3:22 PM | SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

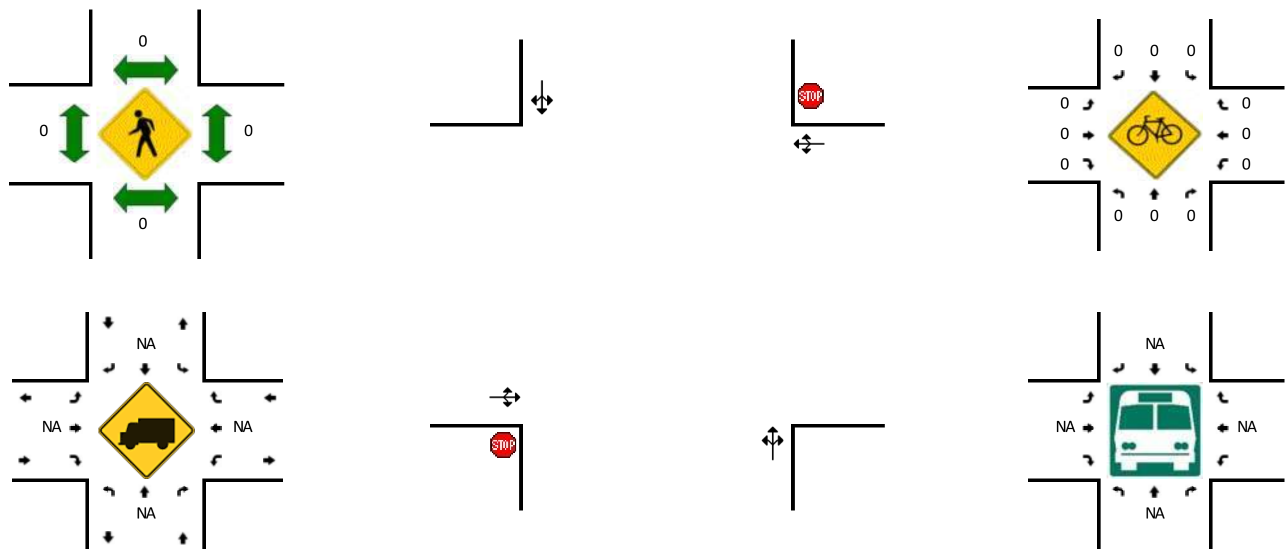
Type of peak hour being reported: System Peak — Method for determining peak hour: Total Entering Volume

LOCATION: Kunia Rd -- Plantation Rd — **QC JOB #:** 15105716
CITY/STATE: Waipahu, HI — **DATE:** Tue, Oct 22 2019



Peak-Hour: 4:00 PM -- 5:00 PM
Peak 15-Min: 4:30 PM -- 4:45 PM





15-Min Count Period Beginning At	Kunia Rd (Northbound) Left	Thru	Right	U	Kunia Rd (Southbound) Left	Thru	Right	U	Plantation Rd (Eastbound) Left	Thru	Right	U	Plantation Rd (Westbound) Left	Thru	Right	U	Total	Hourly Totals
3:00 PM	1	73	1	0	2	149	0	0	0	0	0	0	2	0	0	0	228	
3:15 PM	0	77	0	2	1	186	0	0	0	0	0	0	1	0	1	0	268	
3:30 PM	0	133	3	0	0	263	0	0	0	0	0	0	3	0	1	0	403	
3:45 PM	0	108	0	0	1	242	0	0	0	0	0	0	4	0	2	0	357	1256
4:00 PM	0	88	4	0	1	280	0	0	0	0	0	0	2	0	2	0	377	1405
4:15 PM	1	82	2	0	0	292	0	0	0	0	0	0	5	0	2	0	384	1521
4:30 PM	0	88	1	0	1	300	0	0	0	0	0	0	3	0	5	0	398	1516
4:45 PM	0	85	0	0	2	289	0	0	0	0	0	0	13	0	1	0	390	1549
5:00 PM	1	92	2	1	0	270	1	0	2	0	1	0	7	0	6	0	383	1555
5:15 PM	0	82	5	0	3	297	0	0	0	0	1	0	5	0	0	0	393	1564
5:30 PM	0	72	0	0	0	260	0	0	0	0	0	0	16	0	7	0	355	1521
5:45 PM	0	69	3	0	1	213	0	0	1	0	2	0	19	0	5	0	313	1444

Peak 15-Min Flowrates	Northbound Left	Thru	Right	U	Southbound Left	Thru	Right	U	Eastbound Left	Thru	Right	U	Westbound Left	Thru	Right	U	Total
All Vehicles	0	352	4	0	4	1200	0	0	0	0	0	0	12	0	20	0	1592
Heavy Trucks	0	12	4		0	8	0		0	0	0		0	0	8		32
Pedestrians		0				0				0				0			0
Bicycles	0	0	0		0	0	0		0	0	0		0	0	0		0
Railroad																	
Stopped Buses																	

Comments:

Report generated on 11/4/2019 3:22 PM — SOURCE: Quality Counts, LLC (http://www.qualitycounts.net) 1-877-580-2212

ATTACHMENT B: LEVEL OF SERVICE ANALYSIS WORKSHEETS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	557	0	282	0	0	0	0	798	2581	631	1887	0
Future Volume (veh/h)	557	0	282	0	0	0	0	798	2581	631	1887	0
Initial Q (Qb), veh	0	0	0				0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00				1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No						No			No	
Adj Sat Flow, veh/h/ln	1796	0	1796				0	1856	1870	1870	1870	0
Adj Flow Rate, veh/h	586	0	0				0	840	1664	664	1986	0
Peak Hour Factor	0.95	0.95	0.95				0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	7	0	7				0	3	2	2	2	0
Cap, veh/h	627	0					0	1842	1458	735	3884	0
Arrive On Green	0.19	0.00	0.00				0.00	0.52	0.52	0.21	0.76	0.00
Sat Flow, veh/h	3319	0	1522				0	3618	2790	3456	5274	0
Grp Volume(v), veh/h	586	0	0				0	840	1664	664	1986	0
Grp Sat Flow(s),veh/h/ln	1659	0	1522				0	1763	1395	1728	1702	0
Q Serve(g_s), s	31.0	0.0	0.0				0.0	26.6	93.1	33.4	27.1	0.0
Cycle Q Clear(g_c), s	31.0	0.0	0.0				0.0	26.6	93.1	33.4	27.1	0.0
Prop In Lane	1.00		1.00				0.00		1.00	1.00		0.00
Lane Grp Cap(c), veh/h	627	0					0	1842	1458	735	3884	0
V/C Ratio(X)	0.94	0.00					0.00	0.46	1.14	0.90	0.51	0.00
Avail Cap(c_a), veh/h	661	0					0	1842	1458	1271	3884	0
HCM Platoon Ratio	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00				0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	71.2	0.0	0.0				0.0	26.7	42.5	68.3	8.4	0.0
Incr Delay (d2), s/veh	20.1	0.0	0.0				0.0	0.8	72.4	5.1	0.5	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	15.1	0.0	0.0				0.0	11.5	46.0	15.3	9.6	0.0
Unsig. Movement Delay, s/veh			0.00									
LnGrp Delay(d),s/veh	91.3	0.0	0.0				0.0	27.5	114.9	73.4	8.8	0.0
LnGrp LOS	F	A	A				A	C	F	E	A	A
Approach Vol, veh/h		854	A					2504			2650	
Approach Delay, s/veh		62.6						85.6			25.0	
Approach LOS		E						F			C	

Timer - Assigned Phs	1	2		4		6
Phs Duration (G+Y+Rc), s	42.4	97.6		38.1		140.0
Change Period (Y+Rc), s	4.5	4.5		4.5		4.5
Max Green Setting (Gmax), s	65.5	65.5		35.5		135.5
Max Q Clear Time (g_c+I1), s	35.4	95.1		33.0		29.1
Green Ext Time (p_c), s	2.6	0.0		0.7		32.4

Intersection Summary	
HCM 6th Ctrl Delay	55.6
HCM 6th LOS	E

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [EBR] is included in calculations of the approach delay and intersection delay.

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	1415	134	1162	1126	388
Future Volume (veh/h)	0	1415	134	1162	1126	388
Initial Q (Qb), veh			0	0	0	0
Ped-Bike Adj(A_pbT)			1.00			1.00
Parking Bus, Adj			1.00	1.00	1.00	1.00
Work Zone On Approach				No	No	
Adj Sat Flow, veh/h/ln			1811	1841	1870	1870
Adj Flow Rate, veh/h			141	1223	1185	0
Peak Hour Factor			0.95	0.95	0.95	0.95
Percent Heavy Veh, %			6	4	2	2
Cap, veh/h			192	3010	2169	
Arrive On Green			0.11	0.86	0.61	0.00
Sat Flow, veh/h			1725	3589	3741	0
Grp Volume(v), veh/h			141	1223	1185	0
Grp Sat Flow(s),veh/h/ln			1725	1749	1777	0
Q Serve(g_s), s			2.6	2.4	6.3	0.0
Cycle Q Clear(g_c), s			2.6	2.4	6.3	0.0
Prop In Lane			1.00			0.00
Lane Grp Cap(c), veh/h			192	3010	2169	
V/C Ratio(X)			0.74	0.41	0.55	
Avail Cap(c_a), veh/h			1361	9256	6105	
HCM Platoon Ratio			1.00	1.00	1.00	1.00
Upstream Filter(I)			1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh			13.9	0.5	3.7	0.0
Incr Delay (d2), s/veh			5.4	0.1	0.2	0.0
Initial Q Delay(d3),s/veh			0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln			1.0	0.0	0.4	0.0
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh			19.3	0.6	3.9	0.0
LnGrp LOS			B	A	A	
Approach Vol, veh/h				1364	1185	A
Approach Delay, s/veh				2.5	3.9	
Approach LOS				A	A	

Timer - Assigned Phs		2			5	6
Phs Duration (G+Y+Rc), s		32.3			8.1	24.2
Change Period (Y+Rc), s		4.5			4.5	4.5
Max Green Setting (Gmax), s		85.5			25.5	55.5
Max Q Clear Time (g_c+I1), s		4.4			4.6	8.3
Green Ext Time (p_c), s		12.7			0.3	11.4

Intersection Summary						
HCM 6th Ctrl Delay			3.2			
HCM 6th LOS			A			

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	592	34	1228	329	0	910
Future Volume (veh/h)	592	34	1228	329	0	910
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach	No		No			No
Adj Sat Flow, veh/h/ln	1870	1870	1841	1870	0	1870
Adj Flow Rate, veh/h	604	0	1253	0	0	929
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	4	2	0	2
Cap, veh/h	818		2460		0	2499
Arrive On Green	0.24	0.00	0.70	0.00	0.00	0.70
Sat Flow, veh/h	3456	1585	3589	1585	0	3741
Grp Volume(v), veh/h	604	0	1253	0	0	929
Grp Sat Flow(s),veh/h/ln	1728	1585	1749	1585	0	1777
Q Serve(g_s), s	24.3	0.0	24.8	0.0	0.0	15.8
Cycle Q Clear(g_c), s	24.3	0.0	24.8	0.0	0.0	15.8
Prop In Lane	1.00	1.00		1.00	0.00	
Lane Grp Cap(c), veh/h	818		2460		0	2499
V/C Ratio(X)	0.74		0.51		0.00	0.37
Avail Cap(c_a), veh/h	818		2460		0	2499
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	0.00	1.00
Uniform Delay (d), s/veh	53.0	0.0	10.3	0.0	0.0	8.9
Incr Delay (d2), s/veh	5.9	0.0	0.8	0.0	0.0	0.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	11.3	0.0	9.3	0.0	0.0	6.0
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh	58.9	0.0	11.0	0.0	0.0	9.4
LnGrp LOS	E		B		A	A
Approach Vol, veh/h	604	A	1253	A		929
Approach Delay, s/veh	58.9		11.0			9.4
Approach LOS	E		B			A

Timer - Assigned Phs	2	6	8
Phs Duration (G+Y+Rc), s	110.0	110.0	40.0
Change Period (Y+Rc), s	4.5	4.5	4.5
Max Green Setting (Gmax), s	105.5	105.5	35.5
Max Q Clear Time (g_c+I1), s	26.8	17.8	26.3
Green Ext Time (p_c), s	13.2	8.1	1.7

Intersection Summary	
HCM 6th Ctrl Delay	20.9
HCM 6th LOS	C

Notes

Unsignalized Delay for [NBR, WBR] is excluded from calculations of the approach delay and intersection delay.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	1	274	2	59	2	1090	168	26	632	1
Future Volume (veh/h)	0	0	1	274	2	59	2	1090	168	26	632	1
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1841	1870	1856	1870	1841	1841	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	289	0	9	2	1147	171	27	665	1
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	4	2	3	2	4	4	2	2	2
Cap, veh/h	0	2	0	402	0	180	5	2135	317	49	2636	4
Arrive On Green	0.00	0.00	0.00	0.11	0.00	0.11	0.00	0.70	0.70	0.03	0.72	0.72
Sat Flow, veh/h	0	1870	0	3506	0	1572	1781	3054	454	1781	3641	5
Grp Volume(v), veh/h	0	0	0	289	0	9	2	655	663	27	325	341
Grp Sat Flow(s),veh/h/ln	0	1870	0	1753	0	1572	1781	1749	1759	1781	1777	1869
Q Serve(g_s), s	0.0	0.0	0.0	6.8	0.0	0.4	0.1	15.3	15.5	1.3	5.2	5.2
Cycle Q Clear(g_c), s	0.0	0.0	0.0	6.8	0.0	0.4	0.1	15.3	15.5	1.3	5.2	5.2
Prop In Lane	0.00		0.00	1.00		1.00	1.00		0.26	1.00		0.00
Lane Grp Cap(c), veh/h	0	2	0	402	0	180	5	1223	1230	49	1287	1354
V/C Ratio(X)	0.00	0.00	0.00	0.72	0.00	0.05	0.41	0.54	0.54	0.55	0.25	0.25
Avail Cap(c_a), veh/h	0	143	0	1133	0	508	387	1223	1230	387	1287	1354
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	36.4	0.0	33.6	42.4	6.2	6.2	40.8	4.0	4.0
Incr Delay (d2), s/veh	0.0	0.0	0.0	2.4	0.0	0.1	48.1	1.7	1.7	9.1	0.5	0.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	3.0	0.0	0.2	0.1	4.8	4.9	0.7	1.5	1.6
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	38.8	0.0	33.7	90.4	7.8	7.9	49.9	4.4	4.4
LnGrp LOS	A	A	A	D	A	C	F	A	A	D	A	A
Approach Vol, veh/h		0			298			1320			693	
Approach Delay, s/veh		0.0			38.6			8.0			6.2	
Approach LOS					D			A			A	
Timer - Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	6.9	64.0		0.0	4.7	66.1		14.2				
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5				
Max Green Setting (Gmax), s	18.5	59.5		6.5	18.5	59.5		27.5				
Max Q Clear Time (g_c+I1), s	3.3	17.5		0.0	2.1	7.2		8.8				
Green Ext Time (p_c), s	0.0	12.1		0.0	0.0	4.5		1.0				
Intersection Summary												
HCM 6th Ctrl Delay			11.4									
HCM 6th LOS			B									

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱		↰↰	↑	↱	↰	↑↑	↱	↰	↑	↱
Traffic Volume (veh/h)	8	2	3	1	364	8	159	18	1043	94	42	300	24
Future Volume (veh/h)	8	2	3	1	364	8	159	18	1043	94	42	300	24
Initial Q (Qb), veh	0	0	0		0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00		1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No				No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870		1870	1870	1870	1870	1841	1811	1841	1841	1870
Adj Flow Rate, veh/h	9	2	0		428	9	38	21	1227	0	49	353	16
Peak Hour Factor	0.85	0.85	0.85		0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Percent Heavy Veh, %	2	2	2		2	2	2	2	4	6	4	4	2
Cap, veh/h	24	25	21		546	296	251	638	2055		313	1112	958
Arrive On Green	0.01	0.01	0.00		0.16	0.16	0.16	0.02	0.59	0.00	0.04	0.60	0.60
Sat Flow, veh/h	1781	1870	1585		3456	1870	1585	1781	3497	1535	1753	1841	1585
Grp Volume(v), veh/h	9	2	0		428	9	38	21	1227	0	49	353	16
Grp Sat Flow(s),veh/h/ln	1781	1870	1585		1728	1870	1585	1781	1749	1535	1753	1841	1585
Q Serve(g_s), s	0.4	0.1	0.0		10.6	0.4	1.8	0.4	19.9	0.0	1.0	8.4	0.4
Cycle Q Clear(g_c), s	0.4	0.1	0.0		10.6	0.4	1.8	0.4	19.9	0.0	1.0	8.4	0.4
Prop In Lane	1.00		1.00		1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	24	25	21		546	296	251	638	2055		313	1112	958
V/C Ratio(X)	0.38	0.08	0.00		0.78	0.03	0.15	0.03	0.60		0.16	0.32	0.02
Avail Cap(c_a), veh/h	449	471	399		986	534	452	927	2055		568	1112	958
HCM Platoon Ratio	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00		1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	43.7	43.5	0.0		36.1	31.8	32.4	7.1	11.7	0.0	8.9	8.7	7.1
Incr Delay (d2), s/veh	9.6	1.3	0.0		2.5	0.0	0.3	0.0	1.3	0.0	0.2	0.8	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.3	0.1	0.0		4.6	0.2	0.7	0.1	7.1	0.0	0.3	3.0	0.1
Unsig. Movement Delay, s/veh													
LnGrp Delay(d),s/veh	53.3	44.9	0.0		38.7	31.9	32.7	7.2	13.0	0.0	9.1	9.4	7.1
LnGrp LOS	D	D	A		D	C	C	A	B		A	A	A
Approach Vol, veh/h		11				475			1248	A		418	
Approach Delay, s/veh		51.8				38.0			12.9			9.3	
Approach LOS		D				D			B			A	

Timer - Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	8.0	57.0		5.7	6.5	58.5		18.6
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5
Max Green Setting (Gmax), s	16.5	52.5		22.5	16.5	52.5		25.5
Max Q Clear Time (g_c+I1), s	3.0	21.9		2.4	2.4	10.4		12.6
Green Ext Time (p_c), s	0.1	10.8		0.0	0.0	2.1		1.5

Intersection Summary	
HCM 6th Ctrl Delay	17.9
HCM 6th LOS	B

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Intersection	
Int Delay, s/veh	0.8

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	0	7	0	7	0	1193	42	21	345	0
Future Vol, veh/h	0	0	0	7	0	7	0	1193	42	21	345	0
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	350	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	83	83	83	83	83	83	83	83	83
Heavy Vehicles, %	3	2	4	14	2	2	2	3	4	4	4	2
Mvmt Flow	0	0	0	8	0	8	0	1437	51	25	416	0

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1933	1954	416	1903	1903	1437	416	0	0	1488	0	0
Stage 1	466	466	-	1437	1437	-	-	-	-	-	-	-
Stage 2	1467	1488	-	466	466	-	-	-	-	-	-	-
Critical Hdwy	7.13	6.52	6.24	7.24	6.52	6.22	4.12	-	-	4.14	-	-
Critical Hdwy Stg 1	6.13	5.52	-	6.24	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.13	5.52	-	6.24	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.527	4.018	3.336	3.626	4.018	3.318	2.218	-	-	2.236	-	-
Pot Cap-1 Maneuver	49	64	632	49	69	163	1143	-	-	446	-	-
Stage 1	575	562	-	156	199	-	-	-	-	-	-	-
Stage 2	158	188	-	555	562	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	44	59	632	46	64	163	1143	-	-	446	-	-
Mov Cap-2 Maneuver	44	59	-	46	64	-	-	-	-	-	-	-
Stage 1	575	521	-	156	199	-	-	-	-	-	-	-
Stage 2	150	188	-	514	521	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	69.7	0	0.8
HCM LOS	A	F		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1143	-	-	-	72	446	-	-
HCM Lane V/C Ratio	-	-	-	-	0.234	0.057	-	-
HCM Control Delay (s)	0	-	-	0	69.7	13.6	0	-
HCM Lane LOS	A	-	-	A	F	B	A	-
HCM 95th %tile Q(veh)	0	-	-	-	0.8	0.2	-	-

Intersection	
Int Delay, s/veh	0.2

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	5	5	5	1195	356	5
Future Vol, veh/h	5	5	5	1195	356	5
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	83	83	83	83	83	83
Heavy Vehicles, %	3	4	3	3	4	4
Mvmt Flow	6	6	6	1440	429	6

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1884	432	435	0	-	0
Stage 1	432	-	-	-	-	-
Stage 2	1452	-	-	-	-	-
Critical Hdwy	6.43	6.24	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.336	2.227	-	-	-
Pot Cap-1 Maneuver	77	619	1119	-	-	-
Stage 1	652	-	-	-	-	-
Stage 2	214	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	75	619	1119	-	-	-
Mov Cap-2 Maneuver	75	-	-	-	-	-
Stage 1	634	-	-	-	-	-
Stage 2	214	-	-	-	-	-

Approach	EB		NB		SB	
HCM Control Delay, s	34.5		0		0	
HCM LOS	D					

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1119	-	134	-	-
HCM Lane V/C Ratio	0.005	-	0.09	-	-
HCM Control Delay (s)	8.2	0	34.5	-	-
HCM Lane LOS	A	A	D	-	-
HCM 95th %tile Q(veh)	0	-	0.3	-	-

Intersection						
Int Delay, s/veh	0.8					

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	10	10	40	1165	331	20
Future Vol, veh/h	10	10	40	1165	331	20
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	83	83	83	83	83	83
Heavy Vehicles, %	3	4	3	3	4	4
Mvmt Flow	12	12	48	1404	399	24

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1911	411	423	0	-	0
Stage 1	411	-	-	-	-	-
Stage 2	1500	-	-	-	-	-
Critical Hdwy	6.43	6.24	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.336	2.227	-	-	-
Pot Cap-1 Maneuver	74	636	1131	-	-	-
Stage 1	667	-	-	-	-	-
Stage 2	203	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	60	636	1131	-	-	-
Mov Cap-2 Maneuver	60	-	-	-	-	-
Stage 1	538	-	-	-	-	-
Stage 2	203	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	46.7	0.3	0
HCM LOS	E		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1131	-	110	-	-
HCM Lane V/C Ratio	0.043	-	0.219	-	-
HCM Control Delay (s)	8.3	0	46.7	-	-
HCM Lane LOS	A	A	E	-	-
HCM 95th %tile Q(veh)	0.1	-	0.8	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBU	SBL	SBT
Lane Configurations												
Traffic Volume (veh/h)	358	0	304	0	0	0	0	752	1738	2	510	3266
Future Volume (veh/h)	358	0	304	0	0	0	0	752	1738	2	510	3266
Initial Q (Qb), veh	0	0	0				0	0	0		0	0
Ped-Bike Adj(A_pbT)	1.00		1.00				1.00		1.00		1.00	
Parking Bus, Adj	1.00	1.00	1.00				1.00	1.00	1.00		1.00	1.00
Work Zone On Approach		No						No				No
Adj Sat Flow, veh/h/ln	1870	0	1870				0	1870	1870		1870	1870
Adj Flow Rate, veh/h	362	0	0				0	760	0		515	3299
Peak Hour Factor	0.99	0.99	0.99				0.99	0.99	0.99		0.99	0.99
Percent Heavy Veh, %	2	0	2				0	2	2		2	2
Cap, veh/h	422	0					0	2226			585	4203
Arrive On Green	0.12	0.00	0.00				0.00	0.63	0.00		0.17	0.82
Sat Flow, veh/h	3456	0	1585				0	3647	2790		3456	5274
Grp Volume(v), veh/h	362	0	0				0	760	0		515	3299
Grp Sat Flow(s),veh/h/ln	1728	0	1585				0	1777	1395		1728	1702
Q Serve(g_s), s	16.9	0.0	0.0				0.0	16.7	0.0		23.9	53.1
Cycle Q Clear(g_c), s	16.9	0.0	0.0				0.0	16.7	0.0		23.9	53.1
Prop In Lane	1.00		1.00				0.00		1.00		1.00	
Lane Grp Cap(c), veh/h	422	0					0	2226			585	4203
V/C Ratio(X)	0.86	0.00					0.00	0.34			0.88	0.78
Avail Cap(c_a), veh/h	745	0					0	2226			1375	4203
HCM Platoon Ratio	1.00	1.00	1.00				1.00	1.00	1.00		1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00				0.00	1.00	0.00		1.00	1.00
Uniform Delay (d), s/veh	70.8	0.0	0.0				0.0	14.6	0.0		66.7	7.3
Incr Delay (d2), s/veh	5.1	0.0	0.0				0.0	0.4	0.0		4.5	1.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0				0.0	0.0	0.0		0.0	0.0
%ile BackOfQ(50%),veh/ln	7.9	0.0	0.0				0.0	6.9	0.0		10.9	16.0
Unsig. Movement Delay, s/veh			0.00									
LnGrp Delay(d),s/veh	76.0	0.0	0.0				0.0	15.0	0.0		71.2	8.8
LnGrp LOS	E	A	A				A	B			E	A
Approach Vol, veh/h		640	A					760	A			3814
Approach Delay, s/veh		43.0						15.0				17.2
Approach LOS		D						B				B

Timer - Assigned Phs	1	2		4		6
Phs Duration (G+Y+Rc), s	32.4	107.6		24.6		140.0
Change Period (Y+Rc), s	4.5	4.5		4.5		4.5
Max Green Setting (Gmax), s	65.5	65.5		35.5		135.5
Max Q Clear Time (g_c+I1), s	25.9	18.7		18.9		55.1
Green Ext Time (p_c), s	1.9	6.1		1.2		71.5

Intersection Summary	
HCM 6th Ctrl Delay	20.1
HCM 6th LOS	C

Notes

User approved ignoring U-Turning movement.
Unsignalized Delay for [EBR] is included in calculations of the approach delay and intersection delay.
Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Movement	SBR
Lane Configurations	
Traffic Volume (veh/h)	0
Future Volume (veh/h)	0
Initial Q (Qb), veh	0
Ped-Bike Adj(A_pbT)	1.00
Parking Bus, Adj	1.00
Work Zone On Approach	
Adj Sat Flow, veh/h/ln	0
Adj Flow Rate, veh/h	0
Peak Hour Factor	0.99
Percent Heavy Veh, %	0
Cap, veh/h	0
Arrive On Green	0.00
Sat Flow, veh/h	0
Grp Volume(v), veh/h	0
Grp Sat Flow(s),veh/h/ln	0
Q Serve(g_s), s	0.0
Cycle Q Clear(g_c), s	0.0
Prop In Lane	0.00
Lane Grp Cap(c), veh/h	0
V/C Ratio(X)	0.00
Avail Cap(c_a), veh/h	0
HCM Platoon Ratio	1.00
Upstream Filter(I)	0.00
Uniform Delay (d), s/veh	0.0
Incr Delay (d2), s/veh	0.0
Initial Q Delay(d3),s/veh	0.0
%ile BackOfQ(50%),veh/ln	0.0
Unsig. Movement Delay, s/veh	
LnGrp Delay(d),s/veh	0.0
LnGrp LOS	A
Approach Vol, veh/h	
Approach Delay, s/veh	
Approach LOS	
Timer - Assigned Phs	

Movement	EBL	EBR	NBU	NBL	NBT	SBT	SBR
Lane Configurations							
Traffic Volume (veh/h)	0	2415	1	301	807	1304	670
Future Volume (veh/h)	0	2415	1	301	807	1304	670
Initial Q (Qb), veh				0	0	0	0
Ped-Bike Adj(A_pbT)				1.00			1.00
Parking Bus, Adj				1.00	1.00	1.00	1.00
Work Zone On Approach					No	No	
Adj Sat Flow, veh/h/ln				1870	1870	1870	1870
Adj Flow Rate, veh/h				304	815	1317	0
Peak Hour Factor				0.99	0.99	0.99	0.99
Percent Heavy Veh, %				2	2	2	2
Cap, veh/h				388	3199	2070	
Arrive On Green				0.22	0.90	0.58	0.00
Sat Flow, veh/h				1781	3647	3741	0
Grp Volume(v), veh/h				304	815	1317	0
Grp Sat Flow(s),veh/h/ln				1781	1777	1777	0
Q Serve(g_s), s				7.3	1.3	11.1	0.0
Cycle Q Clear(g_c), s				7.3	1.3	11.1	0.0
Prop In Lane				1.00			0.00
Lane Grp Cap(c), veh/h				388	3199	2070	
V/C Ratio(X)				0.78	0.25	0.64	
Avail Cap(c_a), veh/h				1007	6733	4370	
HCM Platoon Ratio				1.00	1.00	1.00	1.00
Upstream Filter(I)				1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh				16.6	0.3	6.2	0.0
Incr Delay (d2), s/veh				3.5	0.0	0.3	0.0
Initial Q Delay(d3),s/veh				0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln				2.8	0.0	2.3	0.0
Unsig. Movement Delay, s/veh							
LnGrp Delay(d),s/veh				20.1	0.3	6.6	0.0
LnGrp LOS				C	A	A	
Approach Vol, veh/h					1119	1317	A
Approach Delay, s/veh					5.7	6.6	
Approach LOS					A	A	

Timer - Assigned Phs	2	5	6
Phs Duration (G+Y+Rc), s	45.1	14.3	30.8
Change Period (Y+Rc), s	4.5	4.5	4.5
Max Green Setting (Gmax), s	85.5	25.5	55.5
Max Q Clear Time (g_c+I1), s	3.3	9.3	13.1
Green Ext Time (p_c), s	6.8	0.8	13.2

Intersection Summary	
HCM 6th Ctrl Delay	6.2
HCM 6th LOS	A

Notes

User approved ignoring U-Turning movement.
Unsignalized Delay for [EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	380	13	1014	805	0	1601
Future Volume (veh/h)	380	13	1014	805	0	1601
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach	No		No			No
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870
Adj Flow Rate, veh/h	396	0	1056	0	0	1668
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	0	2
Cap, veh/h	818		2499		0	2499
Arrive On Green	0.24	0.00	0.70	0.00	0.00	0.70
Sat Flow, veh/h	3456	1585	3647	1585	0	3741
Grp Volume(v), veh/h	396	0	1056	0	0	1668
Grp Sat Flow(s),veh/h/ln	1728	1585	1777	1585	0	1777
Q Serve(g_s), s	14.8	0.0	18.8	0.0	0.0	39.4
Cycle Q Clear(g_c), s	14.8	0.0	18.8	0.0	0.0	39.4
Prop In Lane	1.00	1.00		1.00	0.00	
Lane Grp Cap(c), veh/h	818		2499		0	2499
V/C Ratio(X)	0.48		0.42		0.00	0.67
Avail Cap(c_a), veh/h	818		2499		0	2499
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	0.00	1.00
Uniform Delay (d), s/veh	49.4	0.0	9.4	0.0	0.0	12.4
Incr Delay (d2), s/veh	2.0	0.0	0.5	0.0	0.0	1.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	6.7	0.0	7.1	0.0	0.0	15.0
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh	51.4	0.0	9.9	0.0	0.0	13.9
LnGrp LOS	D		A		A	B
Approach Vol, veh/h	396	A	1056	A		1668
Approach Delay, s/veh	51.4		9.9			13.9
Approach LOS	D		A			B

Timer - Assigned Phs		2				6		8
Phs Duration (G+Y+Rc), s		110.0				110.0		40.0
Change Period (Y+Rc), s		4.5				4.5		4.5
Max Green Setting (Gmax), s		105.5				105.5		35.5
Max Q Clear Time (g_c+I1), s		20.8				41.4		16.8
Green Ext Time (p_c), s		9.9				22.3		1.4

Intersection Summary			
HCM 6th Ctrl Delay			17.3
HCM 6th LOS			B

Notes

Unsignalized Delay for [NBR, WBR] is excluded from calculations of the approach delay and intersection delay.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	1	7	418	0	33	1	644	400	64	1188	1
Future Volume (veh/h)	0	1	7	418	0	33	1	644	400	64	1188	1
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	1	0	431	0	6	1	664	355	66	1225	1
Peak Hour Factor	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	0	3	0	541	0	241	2	1371	733	86	2405	2
Arrive On Green	0.00	0.00	0.00	0.15	0.00	0.15	0.00	0.61	0.61	0.05	0.66	0.66
Sat Flow, veh/h	0	1870	0	3563	0	1585	1781	2237	1195	1781	3644	3
Grp Volume(v), veh/h	0	1	0	431	0	6	1	527	492	66	597	629
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	0	1585	1781	1777	1655	1781	1777	1870
Q Serve(g_s), s	0.0	0.1	0.0	11.3	0.0	0.3	0.1	15.9	15.9	3.6	16.7	16.7
Cycle Q Clear(g_c), s	0.0	0.1	0.0	11.3	0.0	0.3	0.1	15.9	15.9	3.6	16.7	16.7
Prop In Lane	0.00		0.00	1.00		1.00	1.00		0.72	1.00		0.00
Lane Grp Cap(c), veh/h	0	3	0	541	0	241	2	1089	1015	86	1173	1234
V/C Ratio(X)	0.00	0.39	0.00	0.80	0.00	0.02	0.41	0.48	0.48	0.77	0.51	0.51
Avail Cap(c_a), veh/h	0	125	0	1009	0	449	340	1089	1015	340	1173	1234
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	1.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	0.0	48.4	0.0	39.7	0.0	35.0	48.4	10.3	10.3	45.6	8.5	8.5
Incr Delay (d2), s/veh	0.0	76.0	0.0	2.7	0.0	0.0	84.0	1.5	1.7	13.2	1.6	1.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.1	0.0	5.2	0.0	0.1	0.1	6.0	5.6	1.9	6.0	6.2
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	124.4	0.0	42.5	0.0	35.1	132.4	11.9	12.0	58.8	10.0	10.0
LnGrp LOS	A	F	A	D	A	D	F	B	B	E	B	A
Approach Vol, veh/h		1			437			1020			1292	
Approach Delay, s/veh		124.4			42.4			12.1			12.5	
Approach LOS		F			D			B			B	
Timer - Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	9.2	64.0		4.6	4.6	68.6		19.2				
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5				
Max Green Setting (Gmax), s	18.5	59.5		6.5	18.5	59.5		27.5				
Max Q Clear Time (g_c+I1), s	5.6	17.9		2.1	2.1	18.7		13.3				
Green Ext Time (p_c), s	0.1	8.3		0.0	0.0	10.4		1.4				

Intersection Summary	
HCM 6th Ctrl Delay	17.1
HCM 6th LOS	B

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations													
Traffic Volume (veh/h)	2	3	15	191	2	48	1	2	305	359	130	1041	2
Future Volume (veh/h)	2	3	15	191	2	48	1	2	305	359	130	1041	2
Initial Q (Qb), veh	0	0	0	0	0	0		0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00		1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No				No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870		1870	1856	1870	1870	1870	1870
Adj Flow Rate, veh/h	2	3	0	201	2	6		2	321	0	137	1096	1
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95		0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	2	2	2		2	3	2	2	2	2
Cap, veh/h	12	12	10	303	164	139		216	2227		819	1284	1088
Arrive On Green	0.01	0.01	0.00	0.09	0.09	0.09		0.00	0.63	0.00	0.06	0.69	0.69
Sat Flow, veh/h	1781	1870	1585	3456	1870	1585		1781	3526	1585	1781	1870	1585
Grp Volume(v), veh/h	2	3	0	201	2	6		2	321	0	137	1096	1
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1728	1870	1585		1781	1763	1585	1781	1870	1585
Q Serve(g_s), s	0.1	0.1	0.0	4.7	0.1	0.3		0.0	3.1	0.0	2.0	36.9	0.0
Cycle Q Clear(g_c), s	0.1	0.1	0.0	4.7	0.1	0.3		0.0	3.1	0.0	2.0	36.9	0.0
Prop In Lane	1.00		1.00	1.00		1.00		1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	12	12	10	303	164	139		216	2227		819	1284	1088
V/C Ratio(X)	0.17	0.24	0.00	0.66	0.01	0.04		0.01	0.14		0.17	0.85	0.00
Avail Cap(c_a), veh/h	482	506	429	1060	574	486		565	2227		1070	1284	1088
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00		1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	41.1	41.1	0.0	36.7	34.6	34.7		11.9	6.2	0.0	3.9	9.9	4.1
Incr Delay (d2), s/veh	6.8	10.0	0.0	2.5	0.0	0.1		0.0	0.1	0.0	0.1	7.3	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.1	0.1	0.0	2.1	0.0	0.1		0.0	1.0	0.0	0.5	12.4	0.0
Unsig. Movement Delay, s/veh													
LnGrp Delay(d),s/veh	47.8	51.0	0.0	39.2	34.7	34.9		11.9	6.3	0.0	4.0	17.2	4.1
LnGrp LOS	D	D	A	D	C	C		B	A		A	B	A
Approach Vol, veh/h		5			209				323	A		1234	
Approach Delay, s/veh		49.8			39.1				6.4			15.7	
Approach LOS		D			D				A			B	

Timer - Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	9.3	57.0		5.0	4.7	61.6		11.8
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5
Max Green Setting (Gmax), s	16.5	52.5		22.5	16.5	52.5		25.5
Max Q Clear Time (g_c+I1), s	4.0	5.1		2.1	2.0	38.9		6.7
Green Ext Time (p_c), s	0.2	2.2		0.0	0.0	6.9		0.7

Intersection Summary	
HCM 6th Ctrl Delay	16.9
HCM 6th LOS	B

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Intersection	
Int Delay, s/veh	1

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	0	23	0	10	1	343	7	4	1161	0
Future Vol, veh/h	0	0	0	23	0	10	1	343	7	4	1161	0
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	350	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	97	97	97	97	97	97	97	97	97	97	97	97
Heavy Vehicles, %	3	2	2	2	2	20	2	3	42	25	2	2
Mvmt Flow	0	0	0	24	0	10	1	354	7	4	1197	0

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1570	1568	1197	1561	1561	354	1197	0	0	361	0	0
Stage 1	1205	1205	-	356	356	-	-	-	-	-	-	-
Stage 2	365	363	-	1205	1205	-	-	-	-	-	-	-
Critical Hdwy	7.13	6.52	6.22	7.12	6.52	6.4	4.12	-	-	4.35	-	-
Critical Hdwy Stg 1	6.13	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.13	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.527	4.018	3.318	3.518	4.018	3.48	2.218	-	-	2.425	-	-
Pot Cap-1 Maneuver	89	111	226	91	112	651	583	-	-	1081	-	-
Stage 1	223	257	-	661	629	-	-	-	-	-	-	-
Stage 2	652	625	-	225	257	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	87	110	226	90	111	651	583	-	-	1081	-	-
Mov Cap-2 Maneuver	87	110	-	90	111	-	-	-	-	-	-	-
Stage 1	223	254	-	660	628	-	-	-	-	-	-	-
Stage 2	640	624	-	223	254	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	45.5	0	0
HCM LOS	A	E		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	583	-	-	-	122	1081	-	-
HCM Lane V/C Ratio	0.002	-	-	-	0.279	0.004	-	-
HCM Control Delay (s)	11.2	0	-	0	45.5	8.3	0	-
HCM Lane LOS	B	A	-	A	E	A	A	-
HCM 95th %tile Q(veh)	0	-	-	-	1.1	0	-	-

Intersection	
Int Delay, s/veh	0.2

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	5	5	5	348	1155	5
Future Vol, veh/h	5	5	5	348	1155	5
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	97	97	97	97	97	97
Heavy Vehicles, %	3	2	3	3	2	2
Mvmt Flow	5	5	5	359	1191	5

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1563	1194	1196	0	-	0
Stage 1	1194	-	-	-	-	-
Stage 2	369	-	-	-	-	-
Critical Hdwy	6.43	6.22	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.318	2.227	-	-	-
Pot Cap-1 Maneuver	122	227	580	-	-	-
Stage 1	286	-	-	-	-	-
Stage 2	697	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	121	227	580	-	-	-
Mov Cap-2 Maneuver	121	-	-	-	-	-
Stage 1	283	-	-	-	-	-
Stage 2	697	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	29.4	0.2	0
HCM LOS	D		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	580	-	158	-	-
HCM Lane V/C Ratio	0.009	-	0.065	-	-
HCM Control Delay (s)	11.3	0	29.4	-	-
HCM Lane LOS	B	A	D	-	-
HCM 95th %tile Q(veh)	0	-	0.2	-	-

Intersection						
Int Delay, s/veh	0.7					

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	10	23	7	351	1133	4
Future Vol, veh/h	10	23	7	351	1133	4
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	97	97	97	97	97	97
Heavy Vehicles, %	3	2	3	3	2	2
Mvmt Flow	10	24	7	362	1168	4

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1546	1170	1172	0	-	0
Stage 1	1170	-	-	-	-	-
Stage 2	376	-	-	-	-	-
Critical Hdwy	6.43	6.22	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.318	2.227	-	-	-
Pot Cap-1 Maneuver	125	235	592	-	-	-
Stage 1	294	-	-	-	-	-
Stage 2	692	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	123	235	592	-	-	-
Mov Cap-2 Maneuver	123	-	-	-	-	-
Stage 1	290	-	-	-	-	-
Stage 2	692	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	29	0.2	0
HCM LOS	D		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	592	-	184	-	-
HCM Lane V/C Ratio	0.012	-	0.185	-	-
HCM Control Delay (s)	11.2	0	29	-	-
HCM Lane LOS	B	A	D	-	-
HCM 95th %tile Q(veh)	0	-	0.7	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	635	0	300	0	0	0	0	885	2660	664	1950	0
Future Volume (veh/h)	635	0	300	0	0	0	0	885	2660	664	1950	0
Initial Q (Qb), veh	0	0	0				0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00				1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No						No			No	
Adj Sat Flow, veh/h/ln	1796	0	1796				0	1856	1870	1870	1870	0
Adj Flow Rate, veh/h	668	0	0				0	932	1747	699	2053	0
Peak Hour Factor	0.95	0.95	0.95				0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	7	0	7				0	3	2	2	2	0
Cap, veh/h	655	0					0	1779	1408	771	3844	0
Arrive On Green	0.20	0.00	0.00				0.00	0.50	0.50	0.22	0.75	0.00
Sat Flow, veh/h	3319	0	1522				0	3618	2790	3456	5274	0
Grp Volume(v), veh/h	668	0	0				0	932	1747	699	2053	0
Grp Sat Flow(s),veh/h/ln	1659	0	1522				0	1763	1395	1728	1702	0
Q Serve(g_s), s	35.5	0.0	0.0				0.0	32.0	90.8	35.5	29.9	0.0
Cycle Q Clear(g_c), s	35.5	0.0	0.0				0.0	32.0	90.8	35.5	29.9	0.0
Prop In Lane	1.00		1.00				0.00		1.00	1.00		0.00
Lane Grp Cap(c), veh/h	655	0					0	1779	1408	771	3844	0
V/C Ratio(X)	1.02	0.00					0.00	0.52	1.24	0.91	0.53	0.00
Avail Cap(c_a), veh/h	655	0					0	1779	1408	1257	3844	0
HCM Platoon Ratio	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00				0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	72.3	0.0	0.0				0.0	30.0	44.6	68.1	9.2	0.0
Incr Delay (d2), s/veh	40.5	0.0	0.0				0.0	1.1	114.6	6.0	0.5	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	19.0	0.0	0.0				0.0	14.0	53.2	16.3	10.8	0.0
Unsig. Movement Delay, s/veh			0.00									
LnGrp Delay(d),s/veh	112.7	0.0	0.0				0.0	31.1	159.2	74.1	9.7	0.0
LnGrp LOS	F	A	A				A	C	F	E	A	A
Approach Vol, veh/h		955	A					2679			2752	
Approach Delay, s/veh		78.8						114.6			26.1	
Approach LOS		E						F			C	
Timer - Assigned Phs	1	2		4		6						
Phs Duration (G+Y+Rc), s	44.7	95.3		40.0		140.0						
Change Period (Y+Rc), s	4.5	4.5		4.5		4.5						
Max Green Setting (Gmax), s	65.5	65.5		35.5		135.5						
Max Q Clear Time (g_c+I1), s	37.5	92.8		37.5		31.9						
Green Ext Time (p_c), s	2.7	0.0		0.0		34.9						
Intersection Summary												
HCM 6th Ctrl Delay			71.1									
HCM 6th LOS			E									

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [EBR] is included in calculations of the approach delay and intersection delay.

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	1460	140	1309	1174	400
Future Volume (veh/h)	0	1460	140	1309	1174	400
Initial Q (Qb), veh			0	0	0	0
Ped-Bike Adj(A_pbT)			1.00			1.00
Parking Bus, Adj			1.00	1.00	1.00	1.00
Work Zone On Approach				No	No	
Adj Sat Flow, veh/h/ln			1811	1841	1870	1870
Adj Flow Rate, veh/h			147	1378	1236	0
Peak Hour Factor			0.95	0.95	0.95	0.95
Percent Heavy Veh, %			6	4	2	2
Cap, veh/h			197	3033	2205	
Arrive On Green			0.11	0.87	0.62	0.00
Sat Flow, veh/h			1725	3589	3741	0
Grp Volume(v), veh/h			147	1378	1236	0
Grp Sat Flow(s),veh/h/ln			1725	1749	1777	0
Q Serve(g_s), s			2.8	2.9	6.9	0.0
Cycle Q Clear(g_c), s			2.8	2.9	6.9	0.0
Prop In Lane			1.00			0.00
Lane Grp Cap(c), veh/h			197	3033	2205	
V/C Ratio(X)			0.75	0.45	0.56	
Avail Cap(c_a), veh/h			1297	8819	5817	
HCM Platoon Ratio			1.00	1.00	1.00	1.00
Upstream Filter(I)			1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh			14.5	0.5	3.7	0.0
Incr Delay (d2), s/veh			5.6	0.1	0.2	0.0
Initial Q Delay(d3),s/veh			0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln			1.1	0.0	0.5	0.0
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh			20.1	0.6	4.0	0.0
LnGrp LOS			C	A	A	
Approach Vol, veh/h				1525	1236	A
Approach Delay, s/veh				2.5	4.0	
Approach LOS				A	A	

Timer - Assigned Phs		2			5	6
Phs Duration (G+Y+Rc), s		33.9			8.4	25.5
Change Period (Y+Rc), s		4.5			4.5	4.5
Max Green Setting (Gmax), s		85.5			25.5	55.5
Max Q Clear Time (g_c+I1), s		4.9			4.8	8.9
Green Ext Time (p_c), s		15.8			0.4	12.2

Intersection Summary			
HCM 6th Ctrl Delay			3.1
HCM 6th LOS			A

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	610	40	1564	340	0	944
Future Volume (veh/h)	610	40	1564	340	0	944
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach	No		No			No
Adj Sat Flow, veh/h/ln	1870	1870	1841	1870	0	1870
Adj Flow Rate, veh/h	622	0	1596	0	0	963
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	4	2	0	2
Cap, veh/h	818		2460		0	2499
Arrive On Green	0.24	0.00	0.70	0.00	0.00	0.70
Sat Flow, veh/h	3456	1585	3589	1585	0	3741
Grp Volume(v), veh/h	622	0	1596	0	0	963
Grp Sat Flow(s),veh/h/ln	1728	1585	1749	1585	0	1777
Q Serve(g_s), s	25.1	0.0	37.4	0.0	0.0	16.5
Cycle Q Clear(g_c), s	25.1	0.0	37.4	0.0	0.0	16.5
Prop In Lane	1.00	1.00		1.00	0.00	
Lane Grp Cap(c), veh/h	818		2460		0	2499
V/C Ratio(X)	0.76		0.65		0.00	0.39
Avail Cap(c_a), veh/h	818		2460		0	2499
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	0.00	1.00
Uniform Delay (d), s/veh	53.3	0.0	12.1	0.0	0.0	9.1
Incr Delay (d2), s/veh	6.6	0.0	1.3	0.0	0.0	0.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	11.8	0.0	14.0	0.0	0.0	6.3
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh	59.9	0.0	13.5	0.0	0.0	9.5
LnGrp LOS	E		B		A	A
Approach Vol, veh/h	622	A	1596	A		963
Approach Delay, s/veh	59.9		13.5			9.5
Approach LOS	E		B			A

Timer - Assigned Phs	2	6	8
Phs Duration (G+Y+Rc), s	110.0	110.0	40.0
Change Period (Y+Rc), s	4.5	4.5	4.5
Max Green Setting (Gmax), s	105.5	105.5	35.5
Max Q Clear Time (g_c+I1), s	39.4	18.5	27.1
Green Ext Time (p_c), s	20.6	8.6	1.7

Intersection Summary	
HCM 6th Ctrl Delay	21.4
HCM 6th LOS	C

Notes

Unsignalized Delay for [NBR, WBR] is excluded from calculations of the approach delay and intersection delay.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	10	290	10	70	10	1424	180	30	664	10
Future Volume (veh/h)	0	0	10	290	10	70	10	1424	180	30	664	10
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1841	1870	1856	1870	1841	1841	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	313	0	11	11	1499	184	32	699	10
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	4	2	3	2	4	4	2	2	2
Cap, veh/h	0	2	0	427	0	191	24	2168	263	55	2540	36
Arrive On Green	0.00	0.00	0.00	0.12	0.00	0.12	0.01	0.69	0.69	0.03	0.71	0.71
Sat Flow, veh/h	0	1870	0	3506	0	1572	1781	3140	381	1781	3587	51
Grp Volume(v), veh/h	0	0	0	313	0	11	11	827	856	32	346	363
Grp Sat Flow(s),veh/h/ln	0	1870	0	1753	0	1572	1781	1749	1772	1781	1777	1861
Q Serve(g_s), s	0.0	0.0	0.0	7.4	0.0	0.5	0.5	23.9	24.9	1.5	6.1	6.1
Cycle Q Clear(g_c), s	0.0	0.0	0.0	7.4	0.0	0.5	0.5	23.9	24.9	1.5	6.1	6.1
Prop In Lane	0.00		0.00	1.00		1.00	1.00		0.22	1.00		0.03
Lane Grp Cap(c), veh/h	0	2	0	427	0	191	24	1208	1224	55	1258	1318
V/C Ratio(X)	0.00	0.00	0.00	0.73	0.00	0.06	0.46	0.69	0.70	0.58	0.28	0.28
Avail Cap(c_a), veh/h	0	141	0	1119	0	502	382	1208	1224	382	1258	1318
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	36.5	0.0	33.5	42.2	7.8	8.0	41.2	4.6	4.6
Incr Delay (d2), s/veh	0.0	0.0	0.0	2.5	0.0	0.1	13.1	3.2	3.3	9.2	0.5	0.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	3.3	0.0	0.2	0.3	7.8	8.2	0.8	1.9	1.9
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	38.9	0.0	33.6	55.3	11.0	11.3	50.4	5.1	5.1
LnGrp LOS	A	A	A	D	A	C	E	B	B	D	A	A
Approach Vol, veh/h		0			324			1694			741	
Approach Delay, s/veh		0.0			38.8			11.4			7.0	
Approach LOS					D			B			A	

Timer - Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.2	64.0		0.0	5.7	65.5		15.0
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5
Max Green Setting (Gmax), s	18.5	59.5		6.5	18.5	59.5		27.5
Max Q Clear Time (g_c+I1), s	3.5	26.9		0.0	2.5	8.1		9.4
Green Ext Time (p_c), s	0.0	16.6		0.0	0.0	4.8		1.1

Intersection Summary	
HCM 6th Ctrl Delay	13.5
HCM 6th LOS	B

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰↰	↑	↱	↰	↑↑	↱	↰	↑	↱
Traffic Volume (veh/h)	10	10	10	380	10	170	20	1374	100	50	314	30
Future Volume (veh/h)	10	10	10	380	10	170	20	1374	100	50	314	30
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1841	1811	1841	1841	1870
Adj Flow Rate, veh/h	12	12	1	447	12	36	24	1616	0	59	369	19
Peak Hour Factor	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Percent Heavy Veh, %	2	2	2	2	2	2	2	4	6	4	4	2
Cap, veh/h	46	48	41	563	305	258	608	2003		216	1086	935
Arrive On Green	0.03	0.03	0.03	0.16	0.16	0.16	0.02	0.57	0.00	0.04	0.59	0.59
Sat Flow, veh/h	1781	1870	1585	3456	1870	1585	1781	3497	1535	1753	1841	1585
Grp Volume(v), veh/h	12	12	1	447	12	36	24	1616	0	59	369	19
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1728	1870	1585	1781	1749	1535	1753	1841	1585
Q Serve(g_s), s	0.6	0.6	0.1	11.4	0.5	1.8	0.5	33.6	0.0	1.2	9.4	0.5
Cycle Q Clear(g_c), s	0.6	0.6	0.1	11.4	0.5	1.8	0.5	33.6	0.0	1.2	9.4	0.5
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	46	48	41	563	305	258	608	2003		216	1086	935
V/C Ratio(X)	0.26	0.25	0.02	0.79	0.04	0.14	0.04	0.81		0.27	0.34	0.02
Avail Cap(c_a), veh/h	437	459	389	961	520	441	884	2003		457	1086	935
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	43.8	43.8	43.5	36.9	32.3	32.9	7.9	15.6	0.0	14.7	9.6	7.8
Incr Delay (d2), s/veh	3.0	2.7	0.2	2.6	0.1	0.2	0.0	3.6	0.0	0.7	0.8	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.3	0.3	0.0	5.0	0.2	0.7	0.2	12.7	0.0	0.5	3.4	0.1
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	46.8	46.5	43.8	39.5	32.4	33.1	7.9	19.2	0.0	15.3	10.5	7.8
LnGrp LOS	D	D	D	D	C	C	A	B		B	B	A
Approach Vol, veh/h		25			495			1640	A		447	
Approach Delay, s/veh		46.5			38.9			19.0			11.0	
Approach LOS		D			D			B			B	
Timer - Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	8.4	57.0		6.9	6.8	58.6		19.4				
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5				
Max Green Setting (Gmax), s	16.5	52.5		22.5	16.5	52.5		25.5				
Max Q Clear Time (g_c+I1), s	3.2	35.6		2.6	2.5	11.4		13.4				
Green Ext Time (p_c), s	0.1	10.9		0.0	0.0	2.2		1.5				

Intersection Summary		
HCM 6th Ctrl Delay		21.7
HCM 6th LOS		C

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Intersection	
Int Delay, s/veh	5.3

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	0	14	0	10	74	1385	115	45	360	17
Future Vol, veh/h	0	0	0	14	0	10	74	1385	115	45	360	17
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	350	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	83	83	83	83	83	83	83	83	83
Heavy Vehicles, %	3	2	4	14	2	2	2	3	4	4	4	2
Mvmt Flow	0	0	0	17	0	12	89	1669	139	54	434	20

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	2475	2538	444	2399	2409	1669	454	0	0	1808	0	0
Stage 1	552	552	-	1847	1847	-	-	-	-	-	-	-
Stage 2	1923	1986	-	552	562	-	-	-	-	-	-	-
Critical Hdwy	7.13	6.52	6.24	7.24	6.52	6.22	4.12	-	-	4.14	-	-
Critical Hdwy Stg 1	6.13	5.52	-	6.24	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.13	5.52	-	6.24	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.527	4.018	3.336	3.626	4.018	3.318	2.218	-	-	2.236	-	-
Pot Cap-1 Maneuver	20	27	610	21	33	119	1107	-	-	335	-	-
Stage 1	516	515	-	89	125	-	-	-	-	-	-	-
Stage 2	86	106	-	497	510	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	15	21	610	18	26	119	1107	-	-	335	-	-
Mov Cap-2 Maneuver	15	21	-	18	26	-	-	-	-	-	-	-
Stage 1	516	404	-	89	125	-	-	-	-	-	-	-
Stage 2	77	106	-	390	400	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	$ 385.5	0.4	1.9
HCM LOS	A	F		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1107	-	-	-	28	335	-	-
HCM Lane V/C Ratio	0.081	-	-	-	1.033	0.162	-	-
HCM Control Delay (s)	8.5	0	-	0	$ 385.5	17.8	0	-
HCM Lane LOS	A	A	-	A	F	C	A	-
HCM 95th %tile Q(veh)	0.3	-	-	-	3.4	0.6	-	-

Notes			
~: Volume exceeds capacity	$: Delay exceeds 300s	+: Computation Not Defined	*: All major volume in platoon

Intersection	
Int Delay, s/veh	89.5

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	10	10	110	1295	402	35
Future Vol, veh/h	10	10	110	1295	402	35
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	83	83	83	83	83	83
Heavy Vehicles, %	3	4	3	3	4	4
Mvmt Flow	12	12	133	1560	484	42

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	2331	505	526	0	-	0
Stage 1	505	-	-	-	-	-
Stage 2	1826	-	-	-	-	-
Critical Hdwy	6.43	6.24	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.336	2.227	-	-	-
Pot Cap-1 Maneuver	40	563	1036	-	-	-
Stage 1	604	-	-	-	-	-
Stage 2	140	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	~ 1	563	1036	-	-	-
Mov Cap-2 Maneuver	~ 1	-	-	-	-	-
Stage 1	22	-	-	-	-	-
Stage 2	140	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	$ 8283.1	0.7	0
HCM LOS	F		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1036	-	2	-	-
HCM Lane V/C Ratio	0.128	-	12.048	-	-
HCM Control Delay (s)	9	0	$ 8283.1	-	-
HCM Lane LOS	A	A	F	-	-
HCM 95th %tile Q(veh)	0.4	-	4.7	-	-

Notes			
~: Volume exceeds capacity	$: Delay exceeds 300s	+: Computation Not Defined	*: All major volume in platoon

Intersection						
Int Delay, s/veh	3.1					

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	10	10	105	1200	407	43
Future Vol, veh/h	10	10	105	1200	407	43
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	83	83	83	83	83	83
Heavy Vehicles, %	3	4	3	3	4	4
Mvmt Flow	12	12	127	1446	490	52

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	2216	516	542	0	-	0
Stage 1	516	-	-	-	-	-
Stage 2	1700	-	-	-	-	-
Critical Hdwy	6.43	6.24	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.336	2.227	-	-	-
Pot Cap-1 Maneuver	48	555	1022	-	-	-
Stage 1	597	-	-	-	-	-
Stage 2	161	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	18	555	1022	-	-	-
Mov Cap-2 Maneuver	18	-	-	-	-	-
Stage 1	220	-	-	-	-	-
Stage 2	161	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	229.5	0.7	0
HCM LOS	F		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1022	-	35	-	-
HCM Lane V/C Ratio	0.124	-	0.688	-	-
HCM Control Delay (s)	9	0	229.5	-	-
HCM Lane LOS	A	A	F	-	-
HCM 95th %tile Q(veh)	0.4	-	2.4	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	370	10	320	0	0	0	0	780	1800	715	3425	0
Future Volume (veh/h)	370	10	320	0	0	0	0	780	1800	715	3425	0
Initial Q (Qb), veh	0	0	0				0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00				1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No						No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870				0	1870	1870	1870	1870	0
Adj Flow Rate, veh/h	374	10	0				0	788	0	722	3460	0
Peak Hour Factor	0.99	0.99	0.99				0.99	0.99	0.99	0.99	0.99	0.99
Percent Heavy Veh, %	2	2	2				0	2	2	2	2	0
Cap, veh/h	434	0					0	1992		802	4187	0
Arrive On Green	0.13	0.13	0.00				0.00	0.56	0.00	0.23	0.82	0.00
Sat Flow, veh/h	3456	0	1585				0	3647	2790	3456	5274	0
Grp Volume(v), veh/h	374	0	0				0	788	0	722	3460	0
Grp Sat Flow(s),veh/h/ln	1728	0	1585				0	1777	1395	1728	1702	0
Q Serve(g_s), s	17.5	0.0	0.0				0.0	20.7	0.0	33.5	62.5	0.0
Cycle Q Clear(g_c), s	17.5	0.0	0.0				0.0	20.7	0.0	33.5	62.5	0.0
Prop In Lane	1.00		1.00				0.00		1.00	1.00		0.00
Lane Grp Cap(c), veh/h	434	0					0	1992		802	4187	0
V/C Ratio(X)	0.86	0.00					0.00	0.40		0.90	0.83	0.00
Avail Cap(c_a), veh/h	742	0					0	1992		1370	4187	0
HCM Platoon Ratio	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00				0.00	1.00	0.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	70.8	0.0	0.0				0.0	20.5	0.0	61.6	8.3	0.0
Incr Delay (d2), s/veh	5.3	0.0	0.0				0.0	0.6	0.0	4.8	2.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	8.2	0.0	0.0				0.0	8.8	0.0	15.2	19.2	0.0
Unsig. Movement Delay, s/veh			0.00									
LnGrp Delay(d),s/veh	76.1	0.0	0.0				0.0	21.1	0.0	66.4	10.3	0.0
LnGrp LOS	E	A	A				A	C		E	B	A
Approach Vol, veh/h		668	A					788	A		4182	
Approach Delay, s/veh		42.6						21.1			20.0	
Approach LOS		D						C			B	

Timer - Assigned Phs	1	2		4		6
Phs Duration (G+Y+Rc), s	42.8	97.2		25.3		140.0
Change Period (Y+Rc), s	4.5	4.5		4.5		4.5
Max Green Setting (Gmax), s	65.5	65.5		35.5		135.5
Max Q Clear Time (g_c+I1), s	35.5	22.7		19.5		64.5
Green Ext Time (p_c), s	2.8	6.3		1.2		66.0

Intersection Summary	
HCM 6th Ctrl Delay	22.8
HCM 6th LOS	C

Notes

User approved ignoring U-Turning movement.
Unsignalized Delay for [EBR] is included in calculations of the approach delay and intersection delay.
Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	2490	320	840	1589	755
Future Volume (veh/h)	0	2490	320	840	1589	755
Initial Q (Qb), veh			0	0	0	0
Ped-Bike Adj(A_pbT)			1.00			1.00
Parking Bus, Adj			1.00	1.00	1.00	1.00
Work Zone On Approach				No	No	
Adj Sat Flow, veh/h/ln			1870	1870	1870	1870
Adj Flow Rate, veh/h			323	848	1605	0
Peak Hour Factor			0.99	0.99	0.99	0.99
Percent Heavy Veh, %			2	2	2	2
Cap, veh/h			391	3282	2230	
Arrive On Green			0.22	0.92	0.63	0.00
Sat Flow, veh/h			1781	3647	3741	0
Grp Volume(v), veh/h			323	848	1605	0
Grp Sat Flow(s),veh/h/ln			1781	1777	1777	0
Q Serve(g_s), s			10.2	1.4	18.0	0.0
Cycle Q Clear(g_c), s			10.2	1.4	18.0	0.0
Prop In Lane			1.00			0.00
Lane Grp Cap(c), veh/h			391	3282	2230	
V/C Ratio(X)			0.83	0.26	0.72	
Avail Cap(c_a), veh/h			773	5170	3356	
HCM Platoon Ratio			1.00	1.00	1.00	1.00
Upstream Filter(I)			1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh			21.9	0.2	7.4	0.0
Incr Delay (d2), s/veh			4.5	0.0	0.4	0.0
Initial Q Delay(d3),s/veh			0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln			4.3	0.0	4.5	0.0
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh			26.4	0.3	7.9	0.0
LnGrp LOS			C	A	A	
Approach Vol, veh/h				1171	1605	A
Approach Delay, s/veh				7.5	7.9	
Approach LOS				A	A	

Timer - Assigned Phs		2			5	6
Phs Duration (G+Y+Rc), s		58.8			17.4	41.4
Change Period (Y+Rc), s		4.5			4.5	4.5
Max Green Setting (Gmax), s		85.5			25.5	55.5
Max Q Clear Time (g_c+I1), s		3.4			12.2	20.0
Green Ext Time (p_c), s		7.1			0.8	16.8

Intersection Summary			
HCM 6th Ctrl Delay			7.7
HCM 6th LOS			A

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	400	20	1054	830	0	1944
Future Volume (veh/h)	400	20	1054	830	0	1944
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach	No		No			No
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870
Adj Flow Rate, veh/h	417	0	1098	0	0	2025
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	0	2
Cap, veh/h	818		2499		0	2499
Arrive On Green	0.24	0.00	0.70	0.00	0.00	0.70
Sat Flow, veh/h	3456	1585	3647	1585	0	3741
Grp Volume(v), veh/h	417	0	1098	0	0	2025
Grp Sat Flow(s),veh/h/ln	1728	1585	1777	1585	0	1777
Q Serve(g_s), s	15.7	0.0	19.9	0.0	0.0	58.9
Cycle Q Clear(g_c), s	15.7	0.0	19.9	0.0	0.0	58.9
Prop In Lane	1.00	1.00		1.00	0.00	
Lane Grp Cap(c), veh/h	818		2499		0	2499
V/C Ratio(X)	0.51		0.44		0.00	0.81
Avail Cap(c_a), veh/h	818		2499		0	2499
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	0.00	1.00
Uniform Delay (d), s/veh	49.7	0.0	9.6	0.0	0.0	15.3
Incr Delay (d2), s/veh	2.3	0.0	0.6	0.0	0.0	3.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	7.2	0.0	7.5	0.0	0.0	22.8
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh	52.0	0.0	10.1	0.0	0.0	18.3
LnGrp LOS	D		B		A	B
Approach Vol, veh/h	417	A	1098	A		2025
Approach Delay, s/veh	52.0		10.1			18.3
Approach LOS	D		B			B

Timer - Assigned Phs	2	6	8
Phs Duration (G+Y+Rc), s	110.0	110.0	40.0
Change Period (Y+Rc), s	4.5	4.5	4.5
Max Green Setting (Gmax), s	105.5	105.5	35.5
Max Q Clear Time (g_c+I1), s	21.9	60.9	17.7
Green Ext Time (p_c), s	10.5	27.0	1.4

Intersection Summary	
HCM 6th Ctrl Delay	19.7
HCM 6th LOS	B

Notes

Unsignalized Delay for [NBR, WBR] is excluded from calculations of the approach delay and intersection delay.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	10	10	440	0	40	10	674	420	70	1524	10
Future Volume (veh/h)	0	10	10	440	0	40	10	674	420	70	1524	10
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	10	0	454	0	7	10	695	374	72	1571	10
Peak Hour Factor	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	0	23	0	562	0	250	22	1332	716	94	2308	15
Arrive On Green	0.00	0.01	0.00	0.16	0.00	0.16	0.01	0.60	0.60	0.05	0.64	0.64
Sat Flow, veh/h	0	1870	0	3563	0	1585	1781	2231	1200	1781	3620	23
Grp Volume(v), veh/h	0	10	0	454	0	7	10	553	516	72	771	810
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	0	1585	1781	1777	1654	1781	1777	1866
Q Serve(g_s), s	0.0	0.5	0.0	12.3	0.0	0.4	0.6	18.2	18.2	4.0	27.7	27.7
Cycle Q Clear(g_c), s	0.0	0.5	0.0	12.3	0.0	0.4	0.6	18.2	18.2	4.0	27.7	27.7
Prop In Lane	0.00		0.00	1.00		1.00	1.00		0.73	1.00		0.01
Lane Grp Cap(c), veh/h	0	23	0	562	0	250	22	1061	988	94	1133	1190
V/C Ratio(X)	0.00	0.44	0.00	0.81	0.00	0.03	0.46	0.52	0.52	0.77	0.68	0.68
Avail Cap(c_a), veh/h	0	122	0	983	0	437	331	1061	988	331	1133	1190
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	1.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	0.0	48.9	0.0	40.5	0.0	35.5	48.9	11.8	11.8	46.6	11.6	11.6
Incr Delay (d2), s/veh	0.0	12.8	0.0	2.8	0.0	0.0	14.6	1.8	2.0	12.2	3.3	3.2
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.3	0.0	5.6	0.0	0.1	0.3	7.0	6.6	2.1	10.5	11.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	61.7	0.0	43.4	0.0	35.6	63.5	13.6	13.7	58.8	14.9	14.7
LnGrp LOS	A	E	A	D	A	D	E	B	B	E	B	B
Approach Vol, veh/h		10			461			1079			1653	
Approach Delay, s/veh		61.7			43.2			14.1			16.7	
Approach LOS		E			D			B			B	

Timer - Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	9.8	64.0		5.7	5.7	68.0		20.2
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5
Max Green Setting (Gmax), s	18.5	59.5		6.5	18.5	59.5		27.5
Max Q Clear Time (g_c+I1), s	6.0	20.2		2.5	2.6	29.7		14.3
Green Ext Time (p_c), s	0.1	8.8		0.0	0.0	14.2		1.5

Intersection Summary			
HCM 6th Ctrl Delay			19.8
HCM 6th LOS			B

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	10	20	200	10	50	10	324	370	140	1374	10
Future Volume (veh/h)	10	10	20	200	10	50	10	324	370	140	1374	10
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1856	1870	1870	1870	1870
Adj Flow Rate, veh/h	11	11	1	211	11	6	11	341	0	147	1446	7
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	2	2	2	2	3	2	2	2	2
Cap, veh/h	44	46	39	314	170	144	108	2173		784	1234	1046
Arrive On Green	0.02	0.02	0.02	0.09	0.09	0.09	0.01	0.62	0.00	0.06	0.66	0.66
Sat Flow, veh/h	1781	1870	1585	3456	1870	1585	1781	3526	1585	1781	1870	1585
Grp Volume(v), veh/h	11	11	1	211	11	6	11	341	0	147	1446	7
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1728	1870	1585	1781	1763	1585	1781	1870	1585
Q Serve(g_s), s	0.5	0.5	0.1	5.0	0.5	0.3	0.2	3.5	0.0	2.4	56.2	0.1
Cycle Q Clear(g_c), s	0.5	0.5	0.1	5.0	0.5	0.3	0.2	3.5	0.0	2.4	56.2	0.1
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	44	46	39	314	170	144	108	2173		784	1234	1046
V/C Ratio(X)	0.25	0.24	0.03	0.67	0.06	0.04	0.10	0.16		0.19	1.17	0.01
Avail Cap(c_a), veh/h	471	494	419	1035	560	475	430	2173		1028	1234	1046
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	40.8	40.8	40.5	37.5	35.4	35.3	22.1	6.9	0.0	4.7	14.5	5.0
Incr Delay (d2), s/veh	2.9	2.6	0.3	2.5	0.2	0.1	0.4	0.2	0.0	0.1	86.2	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.3	0.3	0.0	2.2	0.2	0.1	0.1	1.2	0.0	0.6	45.9	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	43.7	43.4	40.8	40.0	35.6	35.5	22.5	7.1	0.0	4.8	100.7	5.0
LnGrp LOS	D	D	D	D	D	D	C	A		A	F	A
Approach Vol, veh/h		23			228			352	A		1600	
Approach Delay, s/veh		43.4			39.7			7.6			91.5	
Approach LOS		D			D			A			F	

Timer - Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	9.3	57.0		6.6	5.6	60.7		12.2
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5
Max Green Setting (Gmax), s	16.5	52.5		22.5	16.5	52.5		25.5
Max Q Clear Time (g_c+I1), s	4.4	5.5		2.5	2.2	58.2		7.0
Green Ext Time (p_c), s	0.3	2.4		0.0	0.0	0.0		0.7

Intersection Summary		
HCM 6th Ctrl Delay		72.2
HCM 6th LOS		E

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Intersection	
Int Delay, s/veh	82.9

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	17	0	74	95	0	25	10	360	14	10	1355	0
Future Vol, veh/h	17	0	74	95	0	25	10	360	14	10	1355	0
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	350	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	97	97	97	97	97	97	97	97	97	97	97	97
Heavy Vehicles, %	3	2	2	2	2	20	2	3	42	25	2	2
Mvmt Flow	18	0	76	98	0	26	10	371	14	10	1397	0

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1828	1822	1397	1846	1808	371	1397	0	0	385	0	0
Stage 1	1417	1417	-	391	391	-	-	-	-	-	-	-
Stage 2	411	405	-	1455	1417	-	-	-	-	-	-	-
Critical Hdwy	7.13	6.52	6.22	7.12	6.52	6.4	4.12	-	-	4.35	-	-
Critical Hdwy Stg 1	6.13	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.13	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.527	4.018	3.318	3.518	4.018	3.48	2.218	-	-	2.425	-	-
Pot Cap-1 Maneuver	59	77	173	~ 57	79	637	489	-	-	1058	-	-
Stage 1	169	203	-	633	607	-	-	-	-	-	-	-
Stage 2	616	598	-	162	203	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	54	72	173	~ 30	74	637	489	-	-	1058	-	-
Mov Cap-2 Maneuver	54	72	-	~ 30	74	-	-	-	-	-	-	-
Stage 1	165	194	-	617	591	-	-	-	-	-	-	-
Stage 2	576	582	-	~ 87	194	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	94.4	$ 1281.1	0.3	0.1
HCM LOS	F	F		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	489	-	-	123	37	1058	-	-
HCM Lane V/C Ratio	0.021	-	-	0.763	3.344	0.01	-	-
HCM Control Delay (s)	12.5	0	-	94.4	$ 1281.1	8.4	0	-
HCM Lane LOS	B	A	-	F	F	A	A	-
HCM 95th %tile Q(veh)	0.1	-	-	4.4	14.1	0	-	-

Notes			
~: Volume exceeds capacity	$: Delay exceeds 300s	+: Computation Not Defined	*: All major volume in platoon

Intersection	
Int Delay, s/veh	9.1

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	35	110	10	377	1245	10
Future Vol, veh/h	35	110	10	377	1245	10
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	97	97	97	97	97	97
Heavy Vehicles, %	3	2	3	3	2	2
Mvmt Flow	36	113	10	389	1284	10

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1698	1289	1294	0	-	0
Stage 1	1289	-	-	-	-	-
Stage 2	409	-	-	-	-	-
Critical Hdwy	6.43	6.22	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.318	2.227	-	-	-
Pot Cap-1 Maneuver	101	200	532	-	-	-
Stage 1	257	-	-	-	-	-
Stage 2	668	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	99	200	532	-	-	-
Mov Cap-2 Maneuver	99	-	-	-	-	-
Stage 1	251	-	-	-	-	-
Stage 2	668	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	111.1	0.3	0
HCM LOS	F		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	532	-	160	-	-
HCM Lane V/C Ratio	0.019	-	0.934	-	-
HCM Control Delay (s)	11.9	0	111.1	-	-
HCM Lane LOS	B	A	F	-	-
HCM 95th %tile Q(veh)	0.1	-	6.9	-	-

Intersection						
Int Delay, s/veh	3.5					

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	23	85	10	412	1170	10
Future Vol, veh/h	23	85	10	412	1170	10
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	97	97	97	97	97	97
Heavy Vehicles, %	3	2	3	3	2	2
Mvmt Flow	24	88	10	425	1206	10

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1656	1211	1216	0	-	0
Stage 1	1211	-	-	-	-	-
Stage 2	445	-	-	-	-	-
Critical Hdwy	6.43	6.22	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.318	2.227	-	-	-
Pot Cap-1 Maneuver	107	222	570	-	-	-
Stage 1	281	-	-	-	-	-
Stage 2	644	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	105	222	570	-	-	-
Mov Cap-2 Maneuver	105	-	-	-	-	-
Stage 1	275	-	-	-	-	-
Stage 2	644	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	53.5	0.3	0
HCM LOS	F		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	570	-	179	-	-
HCM Lane V/C Ratio	0.018	-	0.622	-	-
HCM Control Delay (s)	11.4	0	53.5	-	-
HCM Lane LOS	B	A	F	-	-
HCM 95th %tile Q(veh)	0.1	-	3.5	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	582	0	300	0	0	0	0	842	2690	660	1970	0
Future Volume (veh/h)	582	0	300	0	0	0	0	842	2690	660	1970	0
Initial Q (Qb), veh	0	0	0				0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00				1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No						No			No	
Adj Sat Flow, veh/h/ln	1796	0	1796				0	1856	1870	1870	1870	0
Adj Flow Rate, veh/h	613	0	0				0	886	1779	695	2074	0
Peak Hour Factor	0.95	0.95	0.95				0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	7	0	7				0	3	2	2	2	0
Cap, veh/h	647	0					0	1791	1417	767	3855	0
Arrive On Green	0.19	0.00	0.00				0.00	0.51	0.51	0.22	0.76	0.00
Sat Flow, veh/h	3319	0	1522				0	3618	2790	3456	5274	0
Grp Volume(v), veh/h	613	0	0				0	886	1779	695	2074	0
Grp Sat Flow(s),veh/h/ln	1659	0	1522				0	1763	1395	1728	1702	0
Q Serve(g_s), s	32.7	0.0	0.0				0.0	29.6	91.2	35.2	30.1	0.0
Cycle Q Clear(g_c), s	32.7	0.0	0.0				0.0	29.6	91.2	35.2	30.1	0.0
Prop In Lane	1.00		1.00				0.00		1.00	1.00		0.00
Lane Grp Cap(c), veh/h	647	0					0	1791	1417	767	3855	0
V/C Ratio(X)	0.95	0.00					0.00	0.49	1.26	0.91	0.54	0.00
Avail Cap(c_a), veh/h	656	0					0	1791	1417	1261	3855	0
HCM Platoon Ratio	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00				0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	71.4	0.0	0.0				0.0	29.0	44.2	68.0	9.1	0.0
Incr Delay (d2), s/veh	22.9	0.0	0.0				0.0	1.0	120.9	5.9	0.5	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	16.1	0.0	0.0				0.0	12.9	54.7	16.1	10.8	0.0
Unsig. Movement Delay, s/veh			0.00									
LnGrp Delay(d),s/veh	94.3	0.0	0.0				0.0	30.0	165.0	73.9	9.6	0.0
LnGrp LOS	F	A	A				A	C	F	E	A	A
Approach Vol, veh/h		900	A					2665			2769	
Approach Delay, s/veh		64.2						120.1			25.7	
Approach LOS		E						F			C	
Timer - Assigned Phs	1	2		4		6						
Phs Duration (G+Y+Rc), s	44.3	95.7		39.5		140.0						
Change Period (Y+Rc), s	4.5	4.5		4.5		4.5						
Max Green Setting (Gmax), s	65.5	65.5		35.5		135.5						
Max Q Clear Time (g_c+I1), s	37.2	93.2		34.7		32.1						
Green Ext Time (p_c), s	2.7	0.0		0.2		35.8						
Intersection Summary												
HCM 6th Ctrl Delay			70.9									
HCM 6th LOS			E									

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [EBR] is included in calculations of the approach delay and intersection delay.

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	1480	140	1214	1180	410
Future Volume (veh/h)	0	1480	140	1214	1180	410
Initial Q (Qb), veh			0	0	0	0
Ped-Bike Adj(A_pbT)			1.00			1.00
Parking Bus, Adj			1.00	1.00	1.00	1.00
Work Zone On Approach				No	No	
Adj Sat Flow, veh/h/ln			1811	1841	1870	1870
Adj Flow Rate, veh/h			147	1278	1242	0
Peak Hour Factor			0.95	0.95	0.95	0.95
Percent Heavy Veh, %			6	4	2	2
Cap, veh/h			197	3036	2210	
Arrive On Green			0.11	0.87	0.62	0.00
Sat Flow, veh/h			1725	3589	3741	0
Grp Volume(v), veh/h			147	1278	1242	0
Grp Sat Flow(s),veh/h/ln			1725	1749	1777	0
Q Serve(g_s), s			2.8	2.6	6.9	0.0
Cycle Q Clear(g_c), s			2.8	2.6	6.9	0.0
Prop In Lane			1.00			0.00
Lane Grp Cap(c), veh/h			197	3036	2210	
V/C Ratio(X)			0.75	0.42	0.56	
Avail Cap(c_a), veh/h			1291	8774	5787	
HCM Platoon Ratio			1.00	1.00	1.00	1.00
Upstream Filter(I)			1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh			14.6	0.5	3.7	0.0
Incr Delay (d2), s/veh			5.6	0.1	0.2	0.0
Initial Q Delay(d3),s/veh			0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln			1.2	0.0	0.5	0.0
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh			20.2	0.6	4.0	0.0
LnGrp LOS			C	A	A	
Approach Vol, veh/h				1425	1242	A
Approach Delay, s/veh				2.6	4.0	
Approach LOS				A	A	
Timer - Assigned Phs		2			5	6
Phs Duration (G+Y+Rc), s		34.1			8.4	25.7
Change Period (Y+Rc), s		4.5			4.5	4.5
Max Green Setting (Gmax), s		85.5			25.5	55.5
Max Q Clear Time (g_c+I1), s		4.6			4.8	8.9
Green Ext Time (p_c), s		13.7			0.4	12.3
Intersection Summary						
HCM 6th Ctrl Delay			3.2			
HCM 6th LOS			A			

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	620	40	1288	350	0	950
Future Volume (veh/h)	620	40	1288	350	0	950
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach	No		No			No
Adj Sat Flow, veh/h/ln	1870	1870	1841	1870	0	1870
Adj Flow Rate, veh/h	633	0	1314	0	0	969
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	4	2	0	2
Cap, veh/h	818		2460		0	2499
Arrive On Green	0.24	0.00	0.70	0.00	0.00	0.70
Sat Flow, veh/h	3456	1585	3589	1585	0	3741
Grp Volume(v), veh/h	633	0	1314	0	0	969
Grp Sat Flow(s),veh/h/ln	1728	1585	1749	1585	0	1777
Q Serve(g_s), s	25.7	0.0	26.8	0.0	0.0	16.7
Cycle Q Clear(g_c), s	25.7	0.0	26.8	0.0	0.0	16.7
Prop In Lane	1.00	1.00		1.00	0.00	
Lane Grp Cap(c), veh/h	818		2460		0	2499
V/C Ratio(X)	0.77		0.53		0.00	0.39
Avail Cap(c_a), veh/h	818		2460		0	2499
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	0.00	1.00
Uniform Delay (d), s/veh	53.5	0.0	10.6	0.0	0.0	9.1
Incr Delay (d2), s/veh	7.0	0.0	0.8	0.0	0.0	0.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	12.1	0.0	10.0	0.0	0.0	6.3
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh	60.5	0.0	11.4	0.0	0.0	9.5
LnGrp LOS	E		B		A	A
Approach Vol, veh/h	633	A	1314	A		969
Approach Delay, s/veh	60.5		11.4			9.5
Approach LOS	E		B			A

Timer - Assigned Phs	2	6	8
Phs Duration (G+Y+Rc), s	110.0	110.0	40.0
Change Period (Y+Rc), s	4.5	4.5	4.5
Max Green Setting (Gmax), s	105.5	105.5	35.5
Max Q Clear Time (g_c+I1), s	28.8	18.7	27.7
Green Ext Time (p_c), s	14.4	8.7	1.6

Intersection Summary	
HCM 6th Ctrl Delay	21.5
HCM 6th LOS	C

Notes

Unsignalized Delay for [NBR, WBR] is excluded from calculations of the approach delay and intersection delay.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	10	290	10	70	10	1148	180	30	660	10
Future Volume (veh/h)	0	0	10	290	10	70	10	1148	180	30	660	10
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1841	1870	1856	1870	1841	1841	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	313	0	11	11	1208	182	32	695	10
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	4	2	3	2	4	4	2	2	2
Cap, veh/h	0	2	0	427	0	191	24	2106	316	55	2540	37
Arrive On Green	0.00	0.00	0.00	0.12	0.00	0.12	0.01	0.69	0.69	0.03	0.71	0.71
Sat Flow, veh/h	0	1870	0	3506	0	1572	1781	3050	457	1781	3586	52
Grp Volume(v), veh/h	0	0	0	313	0	11	11	690	700	32	344	361
Grp Sat Flow(s),veh/h/ln	0	1870	0	1753	0	1572	1781	1749	1758	1781	1777	1861
Q Serve(g_s), s	0.0	0.0	0.0	7.4	0.0	0.5	0.5	17.4	17.6	1.5	6.0	6.0
Cycle Q Clear(g_c), s	0.0	0.0	0.0	7.4	0.0	0.5	0.5	17.4	17.6	1.5	6.0	6.0
Prop In Lane	0.00		0.00	1.00		1.00	1.00		0.26	1.00		0.03
Lane Grp Cap(c), veh/h	0	2	0	427	0	191	24	1208	1214	55	1258	1318
V/C Ratio(X)	0.00	0.00	0.00	0.73	0.00	0.06	0.46	0.57	0.58	0.58	0.27	0.27
Avail Cap(c_a), veh/h	0	141	0	1119	0	502	382	1208	1214	382	1258	1318
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	36.5	0.0	33.5	42.2	6.8	6.9	41.2	4.6	4.6
Incr Delay (d2), s/veh	0.0	0.0	0.0	2.5	0.0	0.1	13.1	2.0	2.0	9.2	0.5	0.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	3.3	0.0	0.2	0.3	5.6	5.7	0.8	1.8	1.9
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	38.9	0.0	33.6	55.3	8.8	8.8	50.4	5.1	5.1
LnGrp LOS	A	A	A	D	A	C	E	A	A	D	A	A
Approach Vol, veh/h		0			324			1401			737	
Approach Delay, s/veh		0.0			38.8			9.2			7.0	
Approach LOS					D			A			A	
Timer - Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	7.2	64.0		0.0	5.7	65.5		15.0				
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5				
Max Green Setting (Gmax), s	18.5	59.5		6.5	18.5	59.5		27.5				
Max Q Clear Time (g_c+I1), s	3.5	19.6		0.0	2.5	8.0		9.4				
Green Ext Time (p_c), s	0.0	13.1		0.0	0.0	4.8		1.1				
Intersection Summary												
HCM 6th Ctrl Delay			12.4									
HCM 6th LOS			B									

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰↰	↑	↱	↰	↑↑	↱	↰	↑	↱
Traffic Volume (veh/h)	10	10	10	380	10	170	20	1098	100	50	320	30
Future Volume (veh/h)	10	10	10	380	10	170	20	1098	100	50	320	30
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1841	1811	1841	1841	1870
Adj Flow Rate, veh/h	12	12	1	447	12	36	24	1292	0	59	376	19
Peak Hour Factor	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Percent Heavy Veh, %	2	2	2	2	2	2	2	4	6	4	4	2
Cap, veh/h	46	48	41	563	305	258	603	2003		288	1086	935
Arrive On Green	0.03	0.03	0.03	0.16	0.16	0.16	0.02	0.57	0.00	0.04	0.59	0.59
Sat Flow, veh/h	1781	1870	1585	3456	1870	1585	1781	3497	1535	1753	1841	1585
Grp Volume(v), veh/h	12	12	1	447	12	36	24	1292	0	59	376	19
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1728	1870	1585	1781	1749	1535	1753	1841	1585
Q Serve(g_s), s	0.6	0.6	0.1	11.4	0.5	1.8	0.5	22.9	0.0	1.2	9.6	0.5
Cycle Q Clear(g_c), s	0.6	0.6	0.1	11.4	0.5	1.8	0.5	22.9	0.0	1.2	9.6	0.5
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	46	48	41	563	305	258	603	2003		288	1086	935
V/C Ratio(X)	0.26	0.25	0.02	0.79	0.04	0.14	0.04	0.65		0.20	0.35	0.02
Avail Cap(c_a), veh/h	437	459	389	961	520	441	879	2003		530	1086	935
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	43.8	43.8	43.5	36.9	32.3	32.9	7.9	13.3	0.0	10.4	9.7	7.8
Incr Delay (d2), s/veh	3.0	2.7	0.2	2.6	0.1	0.2	0.0	1.6	0.0	0.3	0.9	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.3	0.3	0.0	5.0	0.2	0.7	0.2	8.4	0.0	0.4	3.5	0.1
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	46.8	46.5	43.8	39.5	32.4	33.1	7.9	14.9	0.0	10.7	10.5	7.8
LnGrp LOS	D	D	D	D	C	C	A	B		B	B	A
Approach Vol, veh/h		25			495			1316	A		454	
Approach Delay, s/veh		46.5			38.9			14.8			10.5	
Approach LOS		D			D			B			B	

Timer - Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	8.4	57.0		6.9	6.8	58.6		19.4
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5
Max Green Setting (Gmax), s	16.5	52.5		22.5	16.5	52.5		25.5
Max Q Clear Time (g_c+I1), s	3.2	24.9		2.6	2.5	11.6		13.4
Green Ext Time (p_c), s	0.1	11.1		0.0	0.0	2.3		1.5

Intersection Summary	
HCM 6th Ctrl Delay	19.5
HCM 6th LOS	B

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Intersection	
Int Delay, s/veh	1.5

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	0	10	0	10	4	1250	54	31	360	1
Future Vol, veh/h	0	0	0	10	0	10	4	1250	54	31	360	1
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	350	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	83	83	83	83	83	83	83	83	83
Heavy Vehicles, %	3	2	4	14	2	2	2	3	4	4	4	2
Mvmt Flow	0	0	0	12	0	12	5	1506	65	37	434	1

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	2064	2090	435	2025	2025	1506	435	0	0	1571	0	0
Stage 1	509	509	-	1516	1516	-	-	-	-	-	-	-
Stage 2	1555	1581	-	509	509	-	-	-	-	-	-	-
Critical Hdwy	7.13	6.52	6.24	7.24	6.52	6.22	4.12	-	-	4.14	-	-
Critical Hdwy Stg 1	6.13	5.52	-	6.24	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.13	5.52	-	6.24	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.527	4.018	3.336	3.626	4.018	3.318	2.218	-	-	2.236	-	-
Pot Cap-1 Maneuver	40	53	617	40	58	149	1125	-	-	414	-	-
Stage 1	545	538	-	140	182	-	-	-	-	-	-	-
Stage 2	141	169	-	525	538	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	33	45	617	35	49	149	1125	-	-	414	-	-
Mov Cap-2 Maneuver	33	45	-	35	49	-	-	-	-	-	-	-
Stage 1	525	475	-	135	175	-	-	-	-	-	-	-
Stage 2	125	163	-	463	475	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	108.2	0	1.2
HCM LOS	A	F		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1125	-	-	-	57	414	-	-
HCM Lane V/C Ratio	0.004	-	-	-	0.423	0.09	-	-
HCM Control Delay (s)	8.2	0	-	0	108.2	14.6	0	-
HCM Lane LOS	A	A	-	A	F	B	A	-
HCM 95th %tile Q(veh)	0	-	-	-	1.6	0.3	-	-

Intersection						
Int Delay, s/veh	0.6					

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	10	10	10	1250	382	10
Future Vol, veh/h	10	10	10	1250	382	10
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	83	83	83	83	83	83
Heavy Vehicles, %	3	4	3	3	4	4
Mvmt Flow	12	12	12	1506	460	12

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1996	466	472	0	-	0
Stage 1	466	-	-	-	-	-
Stage 2	1530	-	-	-	-	-
Critical Hdwy	6.43	6.24	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.336	2.227	-	-	-
Pot Cap-1 Maneuver	66	592	1085	-	-	-
Stage 1	630	-	-	-	-	-
Stage 2	196	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	62	592	1085	-	-	-
Mov Cap-2 Maneuver	62	-	-	-	-	-
Stage 1	587	-	-	-	-	-
Stage 2	196	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	45.7	0.1	0
HCM LOS	E		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1085	-	112	-	-
HCM Lane V/C Ratio	0.011	-	0.215	-	-
HCM Control Delay (s)	8.4	0	45.7	-	-
HCM Lane LOS	A	A	E	-	-
HCM 95th %tile Q(veh)	0	-	0.8	-	-

Intersection						
Int Delay, s/veh	1					

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	10	10	50	1210	352	30
Future Vol, veh/h	10	10	50	1210	352	30
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	83	83	83	83	83	83
Heavy Vehicles, %	3	4	3	3	4	4
Mvmt Flow	12	12	60	1458	424	36

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	2020	442	460	0	-	0
Stage 1	442	-	-	-	-	-
Stage 2	1578	-	-	-	-	-
Critical Hdwy	6.43	6.24	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.336	2.227	-	-	-
Pot Cap-1 Maneuver	64	611	1096	-	-	-
Stage 1	646	-	-	-	-	-
Stage 2	186	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	46	611	1096	-	-	-
Mov Cap-2 Maneuver	46	-	-	-	-	-
Stage 1	460	-	-	-	-	-
Stage 2	186	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	62.4	0.3	0
HCM LOS	F		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1096	-	86	-	-
HCM Lane V/C Ratio	0.055	-	0.28	-	-
HCM Control Delay (s)	8.5	0	62.4	-	-
HCM Lane LOS	A	A	F	-	-
HCM 95th %tile Q(veh)	0.2	-	1	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	380	10	320	0	0	0	0	790	1810	544	3402	0
Future Volume (veh/h)	380	10	320	0	0	0	0	790	1810	544	3402	0
Initial Q (Qb), veh	0	0	0				0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00				1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No						No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870				0	1870	1870	1870	1870	0
Adj Flow Rate, veh/h	384	10	0				0	798	0	549	3436	0
Peak Hour Factor	0.99	0.99	0.99				0.99	0.99	0.99	0.99	0.99	0.99
Percent Heavy Veh, %	2	2	2				0	2	2	2	2	0
Cap, veh/h	444	0					0	2170		620	4173	0
Arrive On Green	0.13	0.13	0.00				0.00	0.61	0.00	0.18	0.82	0.00
Sat Flow, veh/h	3456	0	1585				0	3647	2790	3456	5274	0
Grp Volume(v), veh/h	384	0	0				0	798	0	549	3436	0
Grp Sat Flow(s),veh/h/ln	1728	0	1585				0	1777	1395	1728	1702	0
Q Serve(g_s), s	18.1	0.0	0.0				0.0	18.7	0.0	25.7	62.4	0.0
Cycle Q Clear(g_c), s	18.1	0.0	0.0				0.0	18.7	0.0	25.7	62.4	0.0
Prop In Lane	1.00		1.00				0.00		1.00	1.00		0.00
Lane Grp Cap(c), veh/h	444	0					0	2170		620	4173	0
V/C Ratio(X)	0.86	0.00					0.00	0.37		0.88	0.82	0.00
Avail Cap(c_a), veh/h	740	0					0	2170		1365	4173	0
HCM Platoon Ratio	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00				0.00	1.00	0.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	70.8	0.0	0.0				0.0	16.2	0.0	66.3	8.5	0.0
Incr Delay (d2), s/veh	5.8	0.0	0.0				0.0	0.5	0.0	4.4	2.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	8.4	0.0	0.0				0.0	7.8	0.0	11.7	19.4	0.0
Unsig. Movement Delay, s/veh			0.00									
LnGrp Delay(d),s/veh	76.6	0.0	0.0				0.0	16.7	0.0	70.8	10.4	0.0
LnGrp LOS	E	A	A				A	B		E	B	A
Approach Vol, veh/h		678	A					798	A		3985	
Approach Delay, s/veh		43.4						16.7			18.7	
Approach LOS		D						B			B	

Timer - Assigned Phs	1	2		4		6
Phs Duration (G+Y+Rc), s	34.3	105.7		25.8		140.0
Change Period (Y+Rc), s	4.5	4.5		4.5		4.5
Max Green Setting (Gmax), s	65.5	65.5		35.5		135.5
Max Q Clear Time (g_c+I1), s	27.7	20.7		20.1		64.4
Green Ext Time (p_c), s	2.1	6.4		1.2		65.9

Intersection Summary			
HCM 6th Ctrl Delay			21.5
HCM 6th LOS			C

Notes

User approved ignoring U-Turning movement.
Unsignalized Delay for [EBR] is included in calculations of the approach delay and intersection delay.
Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	2520	320	840	1362	702
Future Volume (veh/h)	0	2520	320	840	1362	702
Initial Q (Qb), veh			0	0	0	0
Ped-Bike Adj(A_pbT)			1.00			1.00
Parking Bus, Adj			1.00	1.00	1.00	1.00
Work Zone On Approach				No	No	
Adj Sat Flow, veh/h/ln			1870	1870	1870	1870
Adj Flow Rate, veh/h			323	848	1376	0
Peak Hour Factor			0.99	0.99	0.99	0.99
Percent Heavy Veh, %			2	2	2	2
Cap, veh/h			404	3225	2092	
Arrive On Green			0.23	0.91	0.59	0.00
Sat Flow, veh/h			1781	3647	3741	0
Grp Volume(v), veh/h			323	848	1376	0
Grp Sat Flow(s),veh/h/ln			1781	1777	1777	0
Q Serve(g_s), s			8.3	1.4	12.7	0.0
Cycle Q Clear(g_c), s			8.3	1.4	12.7	0.0
Prop In Lane			1.00			0.00
Lane Grp Cap(c), veh/h			404	3225	2092	
V/C Ratio(X)			0.80	0.26	0.66	
Avail Cap(c_a), veh/h			933	6238	4049	
HCM Platoon Ratio			1.00	1.00	1.00	1.00
Upstream Filter(I)			1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh			17.8	0.3	6.7	0.0
Incr Delay (d2), s/veh			3.7	0.0	0.4	0.0
Initial Q Delay(d3),s/veh			0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln			3.3	0.0	2.9	0.0
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh			21.5	0.3	7.1	0.0
LnGrp LOS			C	A	A	
Approach Vol, veh/h				1171	1376	A
Approach Delay, s/veh				6.2	7.1	
Approach LOS				A	A	

Timer - Assigned Phs		2			5	6
Phs Duration (G+Y+Rc), s		48.7			15.5	33.2
Change Period (Y+Rc), s		4.5			4.5	4.5
Max Green Setting (Gmax), s		85.5			25.5	55.5
Max Q Clear Time (g_c+I1), s		3.4			10.3	14.7
Green Ext Time (p_c), s		7.1			0.8	14.0

Intersection Summary				
HCM 6th Ctrl Delay			6.7	
HCM 6th LOS			A	

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	400	20	1060	840	0	1678
Future Volume (veh/h)	400	20	1060	840	0	1678
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach	No		No			No
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870
Adj Flow Rate, veh/h	417	0	1104	0	0	1748
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	0	2
Cap, veh/h	818		2499		0	2499
Arrive On Green	0.24	0.00	0.70	0.00	0.00	0.70
Sat Flow, veh/h	3456	1585	3647	1585	0	3741
Grp Volume(v), veh/h	417	0	1104	0	0	1748
Grp Sat Flow(s),veh/h/ln	1728	1585	1777	1585	0	1777
Q Serve(g_s), s	15.7	0.0	20.1	0.0	0.0	43.1
Cycle Q Clear(g_c), s	15.7	0.0	20.1	0.0	0.0	43.1
Prop In Lane	1.00	1.00		1.00	0.00	
Lane Grp Cap(c), veh/h	818		2499		0	2499
V/C Ratio(X)	0.51		0.44		0.00	0.70
Avail Cap(c_a), veh/h	818		2499		0	2499
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	0.00	1.00
Uniform Delay (d), s/veh	49.7	0.0	9.6	0.0	0.0	13.0
Incr Delay (d2), s/veh	2.3	0.0	0.6	0.0	0.0	1.7
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	7.2	0.0	7.6	0.0	0.0	16.5
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh	52.0	0.0	10.1	0.0	0.0	14.6
LnGrp LOS	D		B		A	B
Approach Vol, veh/h	417	A	1104	A		1748
Approach Delay, s/veh	52.0		10.1			14.6
Approach LOS	D		B			B

Timer - Assigned Phs	2	6	8
Phs Duration (G+Y+Rc), s	110.0	110.0	40.0
Change Period (Y+Rc), s	4.5	4.5	4.5
Max Green Setting (Gmax), s	105.5	105.5	35.5
Max Q Clear Time (g_c+I1), s	22.1	45.1	17.7
Green Ext Time (p_c), s	10.6	24.0	1.4

Intersection Summary	
HCM 6th Ctrl Delay	17.9
HCM 6th LOS	B

Notes

Unsignalized Delay for [NBR, WBR] is excluded from calculations of the approach delay and intersection delay.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	10	10	440	0	40	10	680	420	70	1248	10
Future Volume (veh/h)	0	10	10	440	0	40	10	680	420	70	1248	10
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	10	0	454	0	7	10	701	375	72	1287	10
Peak Hour Factor	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	0	23	0	562	0	250	22	1335	714	94	2304	18
Arrive On Green	0.00	0.01	0.00	0.16	0.00	0.16	0.01	0.60	0.60	0.05	0.64	0.64
Sat Flow, veh/h	0	1870	0	3563	0	1585	1781	2237	1195	1781	3614	28
Grp Volume(v), veh/h	0	10	0	454	0	7	10	557	519	72	633	664
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	0	1585	1781	1777	1655	1781	1777	1865
Q Serve(g_s), s	0.0	0.5	0.0	12.3	0.0	0.4	0.6	18.3	18.4	4.0	20.0	20.0
Cycle Q Clear(g_c), s	0.0	0.5	0.0	12.3	0.0	0.4	0.6	18.3	18.4	4.0	20.0	20.0
Prop In Lane	0.00		0.00	1.00		1.00	1.00		0.72	1.00		0.02
Lane Grp Cap(c), veh/h	0	23	0	562	0	250	22	1061	988	94	1133	1189
V/C Ratio(X)	0.00	0.44	0.00	0.81	0.00	0.03	0.46	0.52	0.53	0.77	0.56	0.56
Avail Cap(c_a), veh/h	0	122	0	983	0	437	331	1061	988	331	1133	1189
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	1.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	0.0	48.9	0.0	40.5	0.0	35.5	48.9	11.8	11.8	46.6	10.2	10.2
Incr Delay (d2), s/veh	0.0	12.8	0.0	2.8	0.0	0.0	14.6	1.9	2.0	12.2	2.0	1.9
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.3	0.0	5.6	0.0	0.1	0.3	7.1	6.6	2.1	7.4	7.8
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	61.7	0.0	43.4	0.0	35.6	63.5	13.7	13.8	58.8	12.2	12.1
LnGrp LOS	A	E	A	D	A	D	E	B	B	E	B	B
Approach Vol, veh/h		10			461			1086			1369	
Approach Delay, s/veh		61.7			43.2			14.2			14.6	
Approach LOS		E			D			B			B	

Timer - Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	9.8	64.0		5.7	5.7	68.0		20.2
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5
Max Green Setting (Gmax), s	18.5	59.5		6.5	18.5	59.5		27.5
Max Q Clear Time (g_c+I1), s	6.0	20.4		2.5	2.6	22.0		14.3
Green Ext Time (p_c), s	0.1	8.9		0.0	0.0	11.2		1.5

Intersection Summary			
HCM 6th Ctrl Delay			19.1
HCM 6th LOS			B

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	10	20	200	10	50	10	320	380	140	1098	10
Future Volume (veh/h)	10	10	20	200	10	50	10	320	380	140	1098	10
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1856	1870	1870	1870	1870
Adj Flow Rate, veh/h	11	11	1	211	11	6	11	337	0	147	1156	11
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	2	2	2	2	3	2	2	2	2
Cap, veh/h	44	46	39	314	170	144	161	2173		787	1234	1046
Arrive On Green	0.02	0.02	0.02	0.09	0.09	0.09	0.01	0.62	0.00	0.06	0.66	0.66
Sat Flow, veh/h	1781	1870	1585	3456	1870	1585	1781	3526	1585	1781	1870	1585
Grp Volume(v), veh/h	11	11	1	211	11	6	11	337	0	147	1156	11
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1728	1870	1585	1781	1763	1585	1781	1870	1585
Q Serve(g_s), s	0.5	0.5	0.1	5.0	0.5	0.3	0.2	3.5	0.0	2.4	46.9	0.2
Cycle Q Clear(g_c), s	0.5	0.5	0.1	5.0	0.5	0.3	0.2	3.5	0.0	2.4	46.9	0.2
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	44	46	39	314	170	144	161	2173		787	1234	1046
V/C Ratio(X)	0.25	0.24	0.03	0.67	0.06	0.04	0.07	0.16		0.19	0.94	0.01
Avail Cap(c_a), veh/h	471	494	419	1035	560	475	482	2173		1030	1234	1046
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	40.8	40.8	40.5	37.5	35.4	35.3	17.1	6.9	0.0	4.7	12.9	5.0
Incr Delay (d2), s/veh	2.9	2.6	0.3	2.5	0.2	0.1	0.2	0.2	0.0	0.1	14.4	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.3	0.3	0.0	2.2	0.2	0.1	0.1	1.2	0.0	0.6	18.5	0.1
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	43.7	43.4	40.8	40.0	35.6	35.5	17.3	7.1	0.0	4.8	27.3	5.0
LnGrp LOS	D	D	D	D	D	D	B	A		A	C	A
Approach Vol, veh/h		23			228			348	A		1314	
Approach Delay, s/veh		43.4			39.7			7.4			24.6	
Approach LOS		D			D			A			C	

Timer - Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	9.3	57.0		6.6	5.6	60.7		12.2
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5
Max Green Setting (Gmax), s	16.5	52.5		22.5	16.5	52.5		25.5
Max Q Clear Time (g_c+I1), s	4.4	5.5		2.5	2.2	48.9		7.0
Green Ext Time (p_c), s	0.3	2.3		0.0	0.0	2.6		0.7

Intersection Summary	
HCM 6th Ctrl Delay	23.5
HCM 6th LOS	C

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Intersection	
Int Delay, s/veh	2.3

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	1	0	4	34	0	11	10	360	10	10	1210	0
Future Vol, veh/h	1	0	4	34	0	11	10	360	10	10	1210	0
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	350	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	97	97	97	97	97	97	97	97	97	97	97	97
Heavy Vehicles, %	3	2	2	2	2	20	2	3	42	25	2	2
Mvmt Flow	1	0	4	35	0	11	10	371	10	10	1247	0

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1669	1668	1247	1660	1658	371	1247	0	0	381	0	0
Stage 1	1267	1267	-	391	391	-	-	-	-	-	-	-
Stage 2	402	401	-	1269	1267	-	-	-	-	-	-	-
Critical Hdwy	7.13	6.52	6.22	7.12	6.52	6.4	4.12	-	-	4.35	-	-
Critical Hdwy Stg 1	6.13	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.13	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.527	4.018	3.318	3.518	4.018	3.48	2.218	-	-	2.425	-	-
Pot Cap-1 Maneuver	76	96	212	78	98	637	558	-	-	1062	-	-
Stage 1	206	240	-	633	607	-	-	-	-	-	-	-
Stage 2	623	601	-	206	240	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	72	91	212	73	93	637	558	-	-	1062	-	-
Mov Cap-2 Maneuver	72	91	-	73	93	-	-	-	-	-	-	-
Stage 1	201	233	-	618	593	-	-	-	-	-	-	-
Stage 2	598	587	-	196	233	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	29.3	77.3	0.3	0.1
HCM LOS	D	F		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	558	-	-	153	93	1062	-	-
HCM Lane V/C Ratio	0.018	-	-	0.034	0.499	0.01	-	-
HCM Control Delay (s)	11.6	0	-	29.3	77.3	8.4	0	-
HCM Lane LOS	B	A	-	D	F	A	A	-
HCM 95th %tile Q(veh)	0.1	-	-	0.1	2.2	0	-	-

Intersection	
Int Delay, s/veh	0.5

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	10	10	10	372	1210	10
Future Vol, veh/h	10	10	10	372	1210	10
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	97	97	97	97	97	97
Heavy Vehicles, %	3	2	3	3	2	2
Mvmt Flow	10	10	10	384	1247	10

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1656	1252	1257	0	-	0
Stage 1	1252	-	-	-	-	-
Stage 2	404	-	-	-	-	-
Critical Hdwy	6.43	6.22	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.318	2.227	-	-	-
Pot Cap-1 Maneuver	107	210	550	-	-	-
Stage 1	268	-	-	-	-	-
Stage 2	672	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	105	210	550	-	-	-
Mov Cap-2 Maneuver	105	-	-	-	-	-
Stage 1	262	-	-	-	-	-
Stage 2	672	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	35.1	0.3	0
HCM LOS	E		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	550	-	140	-	-
HCM Lane V/C Ratio	0.019	-	0.147	-	-
HCM Control Delay (s)	11.7	0	35.1	-	-
HCM Lane LOS	B	A	E	-	-
HCM 95th %tile Q(veh)	0.1	-	0.5	-	-

Intersection	
Int Delay, s/veh	0.9

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	10	30	10	372	1180	10
Future Vol, veh/h	10	30	10	372	1180	10
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	97	97	97	97	97	97
Heavy Vehicles, %	3	2	3	3	2	2
Mvmt Flow	10	31	10	384	1216	10

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1625	1221	1226	0	-	0
Stage 1	1221	-	-	-	-	-
Stage 2	404	-	-	-	-	-
Critical Hdwy	6.43	6.22	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.318	2.227	-	-	-
Pot Cap-1 Maneuver	112	219	565	-	-	-
Stage 1	277	-	-	-	-	-
Stage 2	672	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	110	219	565	-	-	-
Mov Cap-2 Maneuver	110	-	-	-	-	-
Stage 1	271	-	-	-	-	-
Stage 2	672	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	31.6	0.3	0
HCM LOS	D		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	565	-	176	-	-
HCM Lane V/C Ratio	0.018	-	0.234	-	-
HCM Control Delay (s)	11.5	0	31.6	-	-
HCM Lane LOS	B	A	D	-	-
HCM 95th %tile Q(veh)	0.1	-	0.9	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	583	0	300	0	0	0	0	843	2690	660	1970	0
Future Volume (veh/h)	583	0	300	0	0	0	0	843	2690	660	1970	0
Initial Q (Qb), veh	0	0	0				0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00				1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No						No			No	
Adj Sat Flow, veh/h/ln	1796	0	1796				0	1856	1870	1870	1870	0
Adj Flow Rate, veh/h	614	0	0				0	887	1779	695	2074	0
Peak Hour Factor	0.95	0.95	0.95				0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	7	0	7				0	3	2	2	2	0
Cap, veh/h	647	0					0	1790	1417	767	3854	0
Arrive On Green	0.20	0.00	0.00				0.00	0.51	0.51	0.22	0.75	0.00
Sat Flow, veh/h	3319	0	1522				0	3618	2790	3456	5274	0
Grp Volume(v), veh/h	614	0	0				0	887	1779	695	2074	0
Grp Sat Flow(s),veh/h/ln	1659	0	1522				0	1763	1395	1728	1702	0
Q Serve(g_s), s	32.8	0.0	0.0				0.0	29.7	91.2	35.2	30.1	0.0
Cycle Q Clear(g_c), s	32.8	0.0	0.0				0.0	29.7	91.2	35.2	30.1	0.0
Prop In Lane	1.00		1.00				0.00		1.00	1.00		0.00
Lane Grp Cap(c), veh/h	647	0					0	1790	1417	767	3854	0
V/C Ratio(X)	0.95	0.00					0.00	0.50	1.26	0.91	0.54	0.00
Avail Cap(c_a), veh/h	656	0					0	1790	1417	1261	3854	0
HCM Platoon Ratio	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00				0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	71.4	0.0	0.0				0.0	29.1	44.2	68.0	9.1	0.0
Incr Delay (d2), s/veh	23.1	0.0	0.0				0.0	1.0	121.1	5.9	0.5	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	16.2	0.0	0.0				0.0	12.9	54.7	16.1	10.8	0.0
Unsig. Movement Delay, s/veh			0.00									
LnGrp Delay(d),s/veh	94.4	0.0	0.0				0.0	30.0	165.3	73.9	9.6	0.0
LnGrp LOS	F	A	A				A	C	F	E	A	A
Approach Vol, veh/h		901	A					2666			2769	
Approach Delay, s/veh		64.3						120.3			25.8	
Approach LOS		E						F			C	

Timer - Assigned Phs	1	2		4		6
Phs Duration (G+Y+Rc), s	44.3	95.7		39.5		140.0
Change Period (Y+Rc), s	4.5	4.5		4.5		4.5
Max Green Setting (Gmax), s	65.5	65.5		35.5		135.5
Max Q Clear Time (g_c+I1), s	37.2	93.2		34.8		32.1
Green Ext Time (p_c), s	2.7	0.0		0.2		35.8

Intersection Summary	
HCM 6th Ctrl Delay	71.0
HCM 6th LOS	E

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [EBR] is included in calculations of the approach delay and intersection delay.

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	1480	140	1216	1180	410
Future Volume (veh/h)	0	1480	140	1216	1180	410
Initial Q (Qb), veh			0	0	0	0
Ped-Bike Adj(A_pbT)			1.00			1.00
Parking Bus, Adj			1.00	1.00	1.00	1.00
Work Zone On Approach				No	No	
Adj Sat Flow, veh/h/ln			1811	1841	1870	1870
Adj Flow Rate, veh/h			147	1280	1242	0
Peak Hour Factor			0.95	0.95	0.95	0.95
Percent Heavy Veh, %			6	4	2	2
Cap, veh/h			197	3036	2210	
Arrive On Green			0.11	0.87	0.62	0.00
Sat Flow, veh/h			1725	3589	3741	0
Grp Volume(v), veh/h			147	1280	1242	0
Grp Sat Flow(s),veh/h/ln			1725	1749	1777	0
Q Serve(g_s), s			2.8	2.6	6.9	0.0
Cycle Q Clear(g_c), s			2.8	2.6	6.9	0.0
Prop In Lane			1.00			0.00
Lane Grp Cap(c), veh/h			197	3036	2210	
V/C Ratio(X)			0.75	0.42	0.56	
Avail Cap(c_a), veh/h			1291	8774	5787	
HCM Platoon Ratio			1.00	1.00	1.00	1.00
Upstream Filter(I)			1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh			14.6	0.5	3.7	0.0
Incr Delay (d2), s/veh			5.6	0.1	0.2	0.0
Initial Q Delay(d3),s/veh			0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln			1.2	0.0	0.5	0.0
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh			20.2	0.6	4.0	0.0
LnGrp LOS			C	A	A	
Approach Vol, veh/h				1427	1242	A
Approach Delay, s/veh				2.6	4.0	
Approach LOS				A	A	

Timer - Assigned Phs		2			5	6
Phs Duration (G+Y+Rc), s		34.1			8.4	25.7
Change Period (Y+Rc), s		4.5			4.5	4.5
Max Green Setting (Gmax), s		85.5			25.5	55.5
Max Q Clear Time (g_c+I1), s		4.6			4.8	8.9
Green Ext Time (p_c), s		13.8			0.4	12.3

Intersection Summary			
HCM 6th Ctrl Delay			3.2
HCM 6th LOS			A

Notes

User approved ignoring U-Turning movement.
Unsignalized Delay for [EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	620	40	1292	350	0	950
Future Volume (veh/h)	620	40	1292	350	0	950
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach	No		No			No
Adj Sat Flow, veh/h/ln	1870	1870	1841	1870	0	1870
Adj Flow Rate, veh/h	633	0	1318	0	0	969
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	4	2	0	2
Cap, veh/h	818		2460		0	2499
Arrive On Green	0.24	0.00	0.70	0.00	0.00	0.70
Sat Flow, veh/h	3456	1585	3589	1585	0	3741
Grp Volume(v), veh/h	633	0	1318	0	0	969
Grp Sat Flow(s),veh/h/ln	1728	1585	1749	1585	0	1777
Q Serve(g_s), s	25.7	0.0	26.9	0.0	0.0	16.7
Cycle Q Clear(g_c), s	25.7	0.0	26.9	0.0	0.0	16.7
Prop In Lane	1.00	1.00		1.00	0.00	
Lane Grp Cap(c), veh/h	818		2460		0	2499
V/C Ratio(X)	0.77		0.54		0.00	0.39
Avail Cap(c_a), veh/h	818		2460		0	2499
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	0.00	1.00
Uniform Delay (d), s/veh	53.5	0.0	10.6	0.0	0.0	9.1
Incr Delay (d2), s/veh	7.0	0.0	0.8	0.0	0.0	0.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	12.1	0.0	10.1	0.0	0.0	6.3
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh	60.5	0.0	11.4	0.0	0.0	9.5
LnGrp LOS	E		B		A	A
Approach Vol, veh/h	633	A	1318	A		969
Approach Delay, s/veh	60.5		11.4			9.5
Approach LOS	E		B			A

Timer - Assigned Phs	2	6	8
Phs Duration (G+Y+Rc), s	110.0	110.0	40.0
Change Period (Y+Rc), s	4.5	4.5	4.5
Max Green Setting (Gmax), s	105.5	105.5	35.5
Max Q Clear Time (g_c+I1), s	28.9	18.7	27.7
Green Ext Time (p_c), s	14.5	8.7	1.6

Intersection Summary	
HCM 6th Ctrl Delay	21.4
HCM 6th LOS	C

Notes

Unsignalized Delay for [NBR, WBR] is excluded from calculations of the approach delay and intersection delay.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	10	290	10	70	10	1152	180	30	660	10
Future Volume (veh/h)	0	0	10	290	10	70	10	1152	180	30	660	10
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1841	1870	1856	1870	1841	1841	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	313	0	11	11	1213	182	32	695	10
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	4	2	3	2	4	4	2	2	2
Cap, veh/h	0	2	0	427	0	191	24	2107	315	55	2540	37
Arrive On Green	0.00	0.00	0.00	0.12	0.00	0.12	0.01	0.69	0.69	0.03	0.71	0.71
Sat Flow, veh/h	0	1870	0	3506	0	1572	1781	3052	456	1781	3586	52
Grp Volume(v), veh/h	0	0	0	313	0	11	11	693	702	32	344	361
Grp Sat Flow(s),veh/h/ln	0	1870	0	1753	0	1572	1781	1749	1759	1781	1777	1861
Q Serve(g_s), s	0.0	0.0	0.0	7.4	0.0	0.5	0.5	17.5	17.7	1.5	6.0	6.0
Cycle Q Clear(g_c), s	0.0	0.0	0.0	7.4	0.0	0.5	0.5	17.5	17.7	1.5	6.0	6.0
Prop In Lane	0.00		0.00	1.00		1.00	1.00		0.26	1.00		0.03
Lane Grp Cap(c), veh/h	0	2	0	427	0	191	24	1208	1214	55	1258	1318
V/C Ratio(X)	0.00	0.00	0.00	0.73	0.00	0.06	0.46	0.57	0.58	0.58	0.27	0.27
Avail Cap(c_a), veh/h	0	141	0	1119	0	502	382	1208	1214	382	1258	1318
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	36.5	0.0	33.5	42.2	6.8	6.9	41.2	4.6	4.6
Incr Delay (d2), s/veh	0.0	0.0	0.0	2.5	0.0	0.1	13.1	2.0	2.0	9.2	0.5	0.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	3.3	0.0	0.2	0.3	5.6	5.7	0.8	1.8	1.9
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	38.9	0.0	33.6	55.3	8.8	8.9	50.4	5.1	5.1
LnGrp LOS	A	A	A	D	A	C	E	A	A	D	A	A
Approach Vol, veh/h		0			324			1406			737	
Approach Delay, s/veh		0.0			38.8			9.2			7.0	
Approach LOS					D			A			A	
Timer - Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	7.2	64.0		0.0	5.7	65.5		15.0				
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5				
Max Green Setting (Gmax), s	18.5	59.5		6.5	18.5	59.5		27.5				
Max Q Clear Time (g_c+I1), s	3.5	19.7		0.0	2.5	8.0		9.4				
Green Ext Time (p_c), s	0.0	13.2		0.0	0.0	4.8		1.1				
Intersection Summary												
HCM 6th Ctrl Delay			12.4									
HCM 6th LOS			B									

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰↰	↑	↱	↰	↑↑	↱	↰	↑	↱
Traffic Volume (veh/h)	10	10	10	380	10	170	20	1102	100	50	320	30
Future Volume (veh/h)	10	10	10	380	10	170	20	1102	100	50	320	30
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1841	1811	1841	1841	1870
Adj Flow Rate, veh/h	12	12	1	447	12	36	24	1296	0	59	376	19
Peak Hour Factor	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Percent Heavy Veh, %	2	2	2	2	2	2	2	4	6	4	4	2
Cap, veh/h	46	48	41	563	305	258	603	2003		287	1086	935
Arrive On Green	0.03	0.03	0.03	0.16	0.16	0.16	0.02	0.57	0.00	0.04	0.59	0.59
Sat Flow, veh/h	1781	1870	1585	3456	1870	1585	1781	3497	1535	1753	1841	1585
Grp Volume(v), veh/h	12	12	1	447	12	36	24	1296	0	59	376	19
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1728	1870	1585	1781	1749	1535	1753	1841	1585
Q Serve(g_s), s	0.6	0.6	0.1	11.4	0.5	1.8	0.5	23.1	0.0	1.2	9.6	0.5
Cycle Q Clear(g_c), s	0.6	0.6	0.1	11.4	0.5	1.8	0.5	23.1	0.0	1.2	9.6	0.5
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	46	48	41	563	305	258	603	2003		287	1086	935
V/C Ratio(X)	0.26	0.25	0.02	0.79	0.04	0.14	0.04	0.65		0.21	0.35	0.02
Avail Cap(c_a), veh/h	437	459	389	961	520	441	879	2003		529	1086	935
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	43.8	43.8	43.5	36.9	32.3	32.9	7.9	13.3	0.0	10.4	9.7	7.8
Incr Delay (d2), s/veh	3.0	2.7	0.2	2.6	0.1	0.2	0.0	1.6	0.0	0.3	0.9	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.3	0.3	0.0	5.0	0.2	0.7	0.2	8.4	0.0	0.4	3.5	0.1
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	46.8	46.5	43.8	39.5	32.4	33.1	7.9	14.9	0.0	10.8	10.5	7.8
LnGrp LOS	D	D	D	D	C	C	A	B		B	B	A
Approach Vol, veh/h		25			495			1320	A		454	
Approach Delay, s/veh		46.5			38.9			14.8			10.5	
Approach LOS		D			D			B			B	

Timer - Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	8.4	57.0		6.9	6.8	58.6		19.4
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5
Max Green Setting (Gmax), s	16.5	52.5		22.5	16.5	52.5		25.5
Max Q Clear Time (g_c+I1), s	13.2	25.1		2.6	2.5	11.6		13.4
Green Ext Time (p_c), s	0.1	11.2		0.0	0.0	2.3		1.5

Intersection Summary			
HCM 6th Ctrl Delay			19.5
HCM 6th LOS			B

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Intersection	
Int Delay, s/veh	1.6

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	0	10	0	10	5	1253	54	31	360	1
Future Vol, veh/h	0	0	0	10	0	10	5	1253	54	31	360	1
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	350	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	83	83	83	83	83	83	83	83	83
Heavy Vehicles, %	3	2	4	14	2	2	2	3	4	4	4	2
Mvmt Flow	0	0	0	12	0	12	6	1510	65	37	434	1

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	2070	2096	435	2031	2031	1510	435	0	0	1575	0	0
Stage 1	509	509	-	1522	1522	-	-	-	-	-	-	-
Stage 2	1561	1587	-	509	509	-	-	-	-	-	-	-
Critical Hdwy	7.13	6.52	6.24	7.24	6.52	6.22	4.12	-	-	4.14	-	-
Critical Hdwy Stg 1	6.13	5.52	-	6.24	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.13	5.52	-	6.24	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.527	4.018	3.336	3.626	4.018	3.318	2.218	-	-	2.236	-	-
Pot Cap-1 Maneuver	40	52	617	39	57	148	1125	-	-	413	-	-
Stage 1	545	538	-	139	181	-	-	-	-	-	-	-
Stage 2	140	168	-	525	538	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	32	44	617	34	48	148	1125	-	-	413	-	-
Mov Cap-2 Maneuver	32	44	-	34	48	-	-	-	-	-	-	-
Stage 1	520	475	-	133	173	-	-	-	-	-	-	-
Stage 2	123	160	-	463	475	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	114	0	1.2
HCM LOS	A	F		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1125	-	-	-	55	413	-	-
HCM Lane V/C Ratio	0.005	-	-	-	0.438	0.09	-	-
HCM Control Delay (s)	8.2	0	-	0	114	14.6	0	-
HCM Lane LOS	A	A	-	A	F	B	A	-
HCM 95th %tile Q(veh)	0	-	-	-	1.6	0.3	-	-

Intersection	
Int Delay, s/veh	0.6

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	10	10	11	1252	382	10
Future Vol, veh/h	10	10	11	1252	382	10
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	83	83	83	83	83	83
Heavy Vehicles, %	3	4	3	3	4	4
Mvmt Flow	12	12	13	1508	460	12

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	2000	466	472	0	-	0
Stage 1	466	-	-	-	-	-
Stage 2	1534	-	-	-	-	-
Critical Hdwy	6.43	6.24	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.336	2.227	-	-	-
Pot Cap-1 Maneuver	65	592	1085	-	-	-
Stage 1	630	-	-	-	-	-
Stage 2	195	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	60	592	1085	-	-	-
Mov Cap-2 Maneuver	60	-	-	-	-	-
Stage 1	583	-	-	-	-	-
Stage 2	195	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	47.2	0.1	0
HCM LOS	E		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1085	-	109	-	-
HCM Lane V/C Ratio	0.012	-	0.221	-	-
HCM Control Delay (s)	8.4	0	47.2	-	-
HCM Lane LOS	A	A	E	-	-
HCM 95th %tile Q(veh)	0	-	0.8	-	-

Intersection						
Int Delay, s/veh	1					
Movement	**EBL**	**EBR**	**NBL**	**NBT**	**SBT**	**SBR**
Lane Configurations						
Traffic Vol, veh/h	10	10	52	1210	352	31
Future Vol, veh/h	10	10	52	1210	352	31
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	83	83	83	83	83	83
Heavy Vehicles, %	3	4	3	3	4	4
Mvmt Flow	12	12	63	1458	424	37

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	2027	443	461	0	-	0
Stage 1	443	-	-	-	-	-
Stage 2	1584	-	-	-	-	-
Critical Hdwy	6.43	6.24	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.336	2.227	-	-	-
Pot Cap-1 Maneuver	63	611	1095	-	-	-
Stage 1	645	-	-	-	-	-
Stage 2	184	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	44	611	1095	-	-	-
Mov Cap-2 Maneuver	44	-	-	-	-	-
Stage 1	450	-	-	-	-	-
Stage 2	184	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	66.2	0.3	0
HCM LOS	F		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	1095	-	82	-	-
HCM Lane V/C Ratio	0.057	-	0.294	-	-
HCM Control Delay (s)	8.5	0	66.2	-	-
HCM Lane LOS	A	A	F	-	-
HCM 95th %tile Q(veh)	0.2	-	1.1	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	380	10	320	0	0	0	0	790	1810	546	3403	0
Future Volume (veh/h)	380	10	320	0	0	0	0	790	1810	546	3403	0
Initial Q (Qb), veh	0	0	0				0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00				1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No						No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870				0	1870	1870	1870	1870	0
Adj Flow Rate, veh/h	384	10	0				0	798	0	552	3437	0
Peak Hour Factor	0.99	0.99	0.99				0.99	0.99	0.99	0.99	0.99	0.99
Percent Heavy Veh, %	2	2	2				0	2	2	2	2	0
Cap, veh/h	444	0					0	2166		624	4173	0
Arrive On Green	0.13	0.13	0.00				0.00	0.61	0.00	0.18	0.82	0.00
Sat Flow, veh/h	3456	0	1585				0	3647	2790	3456	5274	0
Grp Volume(v), veh/h	384	0	0				0	798	0	552	3437	0
Grp Sat Flow(s),veh/h/ln	1728	0	1585				0	1777	1395	1728	1702	0
Q Serve(g_s), s	18.1	0.0	0.0				0.0	18.7	0.0	25.8	62.4	0.0
Cycle Q Clear(g_c), s	18.1	0.0	0.0				0.0	18.7	0.0	25.8	62.4	0.0
Prop In Lane	1.00		1.00				0.00		1.00	1.00		0.00
Lane Grp Cap(c), veh/h	444	0					0	2166		624	4173	0
V/C Ratio(X)	0.86	0.00					0.00	0.37		0.89	0.82	0.00
Avail Cap(c_a), veh/h	740	0					0	2166		1365	4173	0
HCM Platoon Ratio	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00				0.00	1.00	0.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	70.8	0.0	0.0				0.0	16.3	0.0	66.3	8.5	0.0
Incr Delay (d2), s/veh	5.8	0.0	0.0				0.0	0.5	0.0	4.4	2.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	8.4	0.0	0.0				0.0	7.8	0.0	11.8	19.4	0.0
Unsig. Movement Delay, s/veh			0.00									
LnGrp Delay(d),s/veh	76.6	0.0	0.0				0.0	16.8	0.0	70.7	10.4	0.0
LnGrp LOS	E	A	A				A	B		E	B	A
Approach Vol, veh/h		678	A					798	A		3989	
Approach Delay, s/veh		43.4						16.8			18.8	
Approach LOS		D						B			B	

Timer - Assigned Phs	1	2		4		6
Phs Duration (G+Y+Rc), s	34.4	105.6		25.8		140.0
Change Period (Y+Rc), s	4.5	4.5		4.5		4.5
Max Green Setting (Gmax), s	65.5	65.5		35.5		135.5
Max Q Clear Time (g_c+I1), s	27.8	20.7		20.1		64.4
Green Ext Time (p_c), s	2.1	6.4		1.2		65.9

Intersection Summary			
HCM 6th Ctrl Delay			21.5
HCM 6th LOS			C

Notes

User approved ignoring U-Turning movement.
Unsignalized Delay for [EBR] is included in calculations of the approach delay and intersection delay.
Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	2520	320	840	1363	703
Future Volume (veh/h)	0	2520	320	840	1363	703
Initial Q (Qb), veh			0	0	0	0
Ped-Bike Adj(A_pbT)			1.00			1.00
Parking Bus, Adj			1.00	1.00	1.00	1.00
Work Zone On Approach				No	No	
Adj Sat Flow, veh/h/ln			1870	1870	1870	1870
Adj Flow Rate, veh/h			323	848	1377	0
Peak Hour Factor			0.99	0.99	0.99	0.99
Percent Heavy Veh, %			2	2	2	2
Cap, veh/h			404	3226	2092	
Arrive On Green			0.23	0.91	0.59	0.00
Sat Flow, veh/h			1781	3647	3741	0
Grp Volume(v), veh/h			323	848	1377	0
Grp Sat Flow(s),veh/h/ln			1781	1777	1777	0
Q Serve(g_s), s			8.4	1.4	12.7	0.0
Cycle Q Clear(g_c), s			8.4	1.4	12.7	0.0
Prop In Lane			1.00			0.00
Lane Grp Cap(c), veh/h			404	3226	2092	
V/C Ratio(X)			0.80	0.26	0.66	
Avail Cap(c_a), veh/h			932	6233	4046	
HCM Platoon Ratio			1.00	1.00	1.00	1.00
Upstream Filter(I)			1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh			17.8	0.3	6.7	0.0
Incr Delay (d2), s/veh			3.7	0.0	0.4	0.0
Initial Q Delay(d3),s/veh			0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln			3.3	0.0	2.9	0.0
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh			21.5	0.3	7.1	0.0
LnGrp LOS			C	A	A	
Approach Vol, veh/h				1171	1377	A
Approach Delay, s/veh				6.2	7.1	
Approach LOS				A	A	

Timer - Assigned Phs		2			5	6
Phs Duration (G+Y+Rc), s		48.7			15.5	33.2
Change Period (Y+Rc), s		4.5			4.5	4.5
Max Green Setting (Gmax), s		85.5			25.5	55.5
Max Q Clear Time (g_c+I1), s		3.4			10.4	14.7
Green Ext Time (p_c), s		7.1			0.8	14.0

Intersection Summary						
HCM 6th Ctrl Delay			6.7			
HCM 6th LOS			A			

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [EBR, SBR] is excluded from calculations of the approach delay and intersection delay.

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	400	20	1060	840	0	1682
Future Volume (veh/h)	400	20	1060	840	0	1682
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach	No		No			No
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870
Adj Flow Rate, veh/h	417	0	1104	0	0	1752
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	0	2
Cap, veh/h	818		2499		0	2499
Arrive On Green	0.24	0.00	0.70	0.00	0.00	0.70
Sat Flow, veh/h	3456	1585	3647	1585	0	3741
Grp Volume(v), veh/h	417	0	1104	0	0	1752
Grp Sat Flow(s),veh/h/ln	1728	1585	1777	1585	0	1777
Q Serve(g_s), s	15.7	0.0	20.1	0.0	0.0	43.3
Cycle Q Clear(g_c), s	15.7	0.0	20.1	0.0	0.0	43.3
Prop In Lane	1.00	1.00		1.00	0.00	
Lane Grp Cap(c), veh/h	818		2499		0	2499
V/C Ratio(X)	0.51		0.44		0.00	0.70
Avail Cap(c_a), veh/h	818		2499		0	2499
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	0.00	1.00
Uniform Delay (d), s/veh	49.7	0.0	9.6	0.0	0.0	13.0
Incr Delay (d2), s/veh	2.3	0.0	0.6	0.0	0.0	1.7
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	7.2	0.0	7.6	0.0	0.0	16.5
Unsig. Movement Delay, s/veh						
LnGrp Delay(d),s/veh	52.0	0.0	10.1	0.0	0.0	14.7
LnGrp LOS	D		B		A	B
Approach Vol, veh/h	417	A	1104	A		1752
Approach Delay, s/veh	52.0		10.1			14.7
Approach LOS	D		B			B

Timer - Assigned Phs	2	6	8
Phs Duration (G+Y+Rc), s	110.0	110.0	40.0
Change Period (Y+Rc), s	4.5	4.5	4.5
Max Green Setting (Gmax), s	105.5	105.5	35.5
Max Q Clear Time (g_c+I1), s	22.1	45.3	17.7
Green Ext Time (p_c), s	10.6	24.1	1.4

Intersection Summary	
HCM 6th Ctrl Delay	17.9
HCM 6th LOS	B

Notes

Unsignalized Delay for [NBR, WBR] is excluded from calculations of the approach delay and intersection delay.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	10	10	440	0	40	10	680	420	70	1252	10
Future Volume (veh/h)	0	10	10	440	0	40	10	680	420	70	1252	10
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	10	0	454	0	7	10	701	375	72	1291	10
Peak Hour Factor	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	0	23	0	562	0	250	22	1335	714	94	2304	18
Arrive On Green	0.00	0.01	0.00	0.16	0.00	0.16	0.01	0.60	0.60	0.05	0.64	0.64
Sat Flow, veh/h	0	1870	0	3563	0	1585	1781	2237	1195	1781	3614	28
Grp Volume(v), veh/h	0	10	0	454	0	7	10	557	519	72	635	666
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	0	1585	1781	1777	1655	1781	1777	1865
Q Serve(g_s), s	0.0	0.5	0.0	12.3	0.0	0.4	0.6	18.3	18.4	4.0	20.1	20.1
Cycle Q Clear(g_c), s	0.0	0.5	0.0	12.3	0.0	0.4	0.6	18.3	18.4	4.0	20.1	20.1
Prop In Lane	0.00		0.00	1.00		1.00	1.00		0.72	1.00		0.02
Lane Grp Cap(c), veh/h	0	23	0	562	0	250	22	1061	988	94	1133	1189
V/C Ratio(X)	0.00	0.44	0.00	0.81	0.00	0.03	0.46	0.52	0.53	0.77	0.56	0.56
Avail Cap(c_a), veh/h	0	122	0	983	0	437	331	1061	988	331	1133	1189
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	1.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	0.0	48.9	0.0	40.5	0.0	35.5	48.9	11.8	11.8	46.6	10.2	10.2
Incr Delay (d2), s/veh	0.0	12.8	0.0	2.8	0.0	0.0	14.6	1.9	2.0	12.2	2.0	1.9
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.3	0.0	5.6	0.0	0.1	0.3	7.1	6.6	2.1	7.5	7.8
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	61.7	0.0	43.4	0.0	35.6	63.5	13.7	13.8	58.8	12.2	12.1
LnGrp LOS	A	E	A	D	A	D	E	B	B	E	B	B
Approach Vol, veh/h		10			461			1086			1373	
Approach Delay, s/veh		61.7			43.2			14.2			14.6	
Approach LOS		E			D			B			B	
Timer - Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	9.8	64.0		5.7	5.7	68.0		20.2				
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5				
Max Green Setting (Gmax), s	18.5	59.5		6.5	18.5	59.5		27.5				
Max Q Clear Time (g_c+I1), s	6.0	20.4		2.5	2.6	22.1		14.3				
Green Ext Time (p_c), s	0.1	8.9		0.0	0.0	11.3		1.5				
Intersection Summary												
HCM 6th Ctrl Delay			19.1									
HCM 6th LOS			B									

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰↰	↑	↱	↰	↑↑	↱	↰	↑	↱
Traffic Volume (veh/h)	10	10	20	200	10	50	10	320	380	140	1102	10
Future Volume (veh/h)	10	10	20	200	10	50	10	320	380	140	1102	10
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1856	1870	1870	1870	1870
Adj Flow Rate, veh/h	11	11	1	211	11	6	11	337	0	147	1160	7
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	2	2	2	2	3	2	2	2	2
Cap, veh/h	44	46	39	314	170	144	159	2173		787	1234	1046
Arrive On Green	0.02	0.02	0.02	0.09	0.09	0.09	0.01	0.62	0.00	0.06	0.66	0.66
Sat Flow, veh/h	1781	1870	1585	3456	1870	1585	1781	3526	1585	1781	1870	1585
Grp Volume(v), veh/h	11	11	1	211	11	6	11	337	0	147	1160	7
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1728	1870	1585	1781	1763	1585	1781	1870	1585
Q Serve(g_s), s	0.5	0.5	0.1	5.0	0.5	0.3	0.2	3.5	0.0	2.4	47.3	0.1
Cycle Q Clear(g_c), s	0.5	0.5	0.1	5.0	0.5	0.3	0.2	3.5	0.0	2.4	47.3	0.1
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	44	46	39	314	170	144	159	2173		787	1234	1046
V/C Ratio(X)	0.25	0.24	0.03	0.67	0.06	0.04	0.07	0.16		0.19	0.94	0.01
Avail Cap(c_a), veh/h	471	494	419	1035	560	475	480	2173		1030	1234	1046
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	40.8	40.8	40.5	37.5	35.4	35.3	17.3	6.9	0.0	4.7	13.0	5.0
Incr Delay (d2), s/veh	2.9	2.6	0.3	2.5	0.2	0.1	0.2	0.2	0.0	0.1	14.8	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.3	0.3	0.0	2.2	0.2	0.1	0.1	1.2	0.0	0.6	18.8	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	43.7	43.4	40.8	40.0	35.6	35.5	17.5	7.1	0.0	4.8	27.7	5.0
LnGrp LOS	D	D	D	D	D	D	B	A		A	C	A
Approach Vol, veh/h		23			228			348	A		1314	
Approach Delay, s/veh		43.4			39.7			7.4			25.1	
Approach LOS		D			D			A			C	

Timer - Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	9.3	57.0		6.6	5.6	60.7		12.2				
Change Period (Y+Rc), s	4.5	4.5		4.5	4.5	4.5		4.5				
Max Green Setting (Gmax), s	16.5	52.5		22.5	16.5	52.5		25.5				
Max Q Clear Time (g_c+I1), s	4.4	5.5		2.5	2.2	49.3		7.0				
Green Ext Time (p_c), s	0.3	2.3		0.0	0.0	2.3		0.7				

Intersection Summary			
HCM 6th Ctrl Delay			23.8
HCM 6th LOS			C

Notes

User approved ignoring U-Turning movement.

Unsignalized Delay for [NBR] is excluded from calculations of the approach delay and intersection delay.

Intersection												
Int Delay, s/veh	2.4											

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥			↰	↱		✥	
Traffic Vol, veh/h	1	0	5	34	0	11	10	360	10	10	1213	0
Future Vol, veh/h	1	0	5	34	0	11	10	360	10	10	1213	0
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	350	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	97	97	97	97	97	97	97	97	97	97	97	97
Heavy Vehicles, %	3	2	2	2	2	20	2	3	42	25	2	2
Mvmt Flow	1	0	5	35	0	11	10	371	10	10	1251	0

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1673	1672	1251	1665	1662	371	1251	0	0	381	0	0
Stage 1	1271	1271	-	391	391	-	-	-	-	-	-	-
Stage 2	402	401	-	1274	1271	-	-	-	-	-	-	-
Critical Hdwy	7.13	6.52	6.22	7.12	6.52	6.4	4.12	-	-	4.35	-	-
Critical Hdwy Stg 1	6.13	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.13	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.527	4.018	3.318	3.518	4.018	3.48	2.218	-	-	2.425	-	-
Pot Cap-1 Maneuver	76	96	211	77	97	637	556	-	-	1062	-	-
Stage 1	205	239	-	633	607	-	-	-	-	-	-	-
Stage 2	623	601	-	205	239	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	72	91	211	72	92	637	556	-	-	1062	-	-
Mov Cap-2 Maneuver	72	91	-	72	92	-	-	-	-	-	-	-
Stage 1	200	232	-	618	593	-	-	-	-	-	-	-
Stage 2	598	587	-	194	232	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	28.4	78.6	0.3	0.1
HCM LOS	D	F		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	556	-	-	160	92	1062	-	-
HCM Lane V/C Ratio	0.019	-	-	0.039	0.504	0.01	-	-
HCM Control Delay (s)	11.6	0	-	28.4	78.6	8.4	0	-
HCM Lane LOS	B	A	-	D	F	A	A	-
HCM 95th %tile Q(veh)	0.1	-	-	0.1	2.2	0	-	-

Intersection	
Int Delay, s/veh	0.5

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	10	11	10	372	1212	10
Future Vol, veh/h	10	11	10	372	1212	10
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	97	97	97	97	97	97
Heavy Vehicles, %	3	2	3	3	2	2
Mvmt Flow	10	11	10	384	1249	10

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1658	1254	1259	0	-	0
Stage 1	1254	-	-	-	-	-
Stage 2	404	-	-	-	-	-
Critical Hdwy	6.43	6.22	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.318	2.227	-	-	-
Pot Cap-1 Maneuver	107	210	549	-	-	-
Stage 1	267	-	-	-	-	-
Stage 2	672	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	105	210	549	-	-	-
Mov Cap-2 Maneuver	105	-	-	-	-	-
Stage 1	261	-	-	-	-	-
Stage 2	672	-	-	-	-	-

Approach	EB	NB	SB
HCM Control Delay, s	34.9	0.3	0
HCM LOS	D		

Minor Lane/Major Mvmt	NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)	549	-	142	-	-
HCM Lane V/C Ratio	0.019	-	0.152	-	-
HCM Control Delay (s)	11.7	0	34.9	-	-
HCM Lane LOS	B	A	D	-	-
HCM 95th %tile Q(veh)	0.1	-	0.5	-	-

Intersection						
Int Delay, s/veh	0.9					

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Vol, veh/h	11	32	10	372	1180	10
Future Vol, veh/h	11	32	10	372	1180	10
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	97	97	97	97	97	97
Heavy Vehicles, %	3	2	3	3	2	2
Mvmt Flow	11	33	10	384	1216	10

Major/Minor	Minor2		Major1		Major2	
Conflicting Flow All	1625	1221	1226	0	-	0
Stage 1	1221	-	-	-	-	-
Stage 2	404	-	-	-	-	-
Critical Hdwy	6.43	6.22	4.13	-	-	-
Critical Hdwy Stg 1	5.43	-	-	-	-	-
Critical Hdwy Stg 2	5.43	-	-	-	-	-
Follow-up Hdwy	3.527	3.318	2.227	-	-	-
Pot Cap-1 Maneuver	112	219	565	-	-	-
Stage 1	277	-	-	-	-	-
Stage 2	672	-	-	-	-	-
Platoon blocked, %				-	-	-
Mov Cap-1 Maneuver	110	219	565	-	-	-
Mov Cap-2 Maneuver	110	-	-	-	-	-
Stage 1	271	-	-	-	-	-
Stage 2	672	-	-	-	-	-

Approach	EB		NB		SB	
HCM Control Delay, s	32.4		0.3		0	
HCM LOS	D					

Minor Lane/Major Mvmt		NBL	NBT	EBLn1	SBT	SBR
Capacity (veh/h)		565	-	175	-	-
HCM Lane V/C Ratio		0.018	-	0.253	-	-
HCM Control Delay (s)		11.5	0	32.4	-	-
HCM Lane LOS		B	A	D	-	-
HCM 95th %tile Q(veh)		0.1	-	1	-	-

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Professional Experience

Director of Development-Hawaii, Longroad Energy (2016-present)

Leading the development of Hawai'i's largest clean energy projects, including Mahi Solar and Storage (120 MW/480MWh) and Pulehu Solar and Storage (40 MW/160MWh) which are scheduled for commercial operation in 2023. Manages work in the following areas:

- Business Development & Finance – Sets the organizations' strategic direction for energy development in Hawai'i. Identifies sites for projects and acquisition opportunities; coordinated all bids to HECO and PPA negotiations; support project financings.
- Community Outreach – Works extensively with local communities to engage stakeholders in areas near planned energy projects, to understand potential community impacts and foster ongoing dialogue with residents that have long-time familial ties to the land, kupuna who know the mo'olelo of the area, and many other individuals, groups and stakeholders.
- Government Affairs – Works with state and city officials to obtain all permits and advance policy initiatives. Maintained relationships with state legislators and staff in DLNR, DEBDT, LUC, PUC; and with Honolulu City Council, Planning Commission and DPP.
- Communication — Manages the Longroad brand in Hawai'i; serving as the local representative of the company through media appearances, media releases, speaking engagements and professional conferences.

Director of Development-Hawaii, First Wind (2007-2016)

Led development of 250 megawatts of wind and solar projects, comprising nearly half of the utility-scale capacity operating in the state of Hawaii to date, totaling more than $1 billion in financed construction. Operating projects developed include:

- Kahuku Wind 30 MW
- Kawailoa Wind 69 MW
- Kaheawa Wind II 21 MW
- Kawailoa Solar 50 MW
- Waipio Solar 47 MW
- Mililani Solar 15 MW

Founder & Owner, Kahuhipa Land Management (2018-present)

Established a new business to provide agricultural land management and sheep ranching to Oʻahu's largest solar energy projects. Currently responsible for all business management, marketing, contracting, financing and back-office functions.

Commissioner, Hawaiian Homes Commission (2015-2019)

Served as a voting member of the executive board that advises and oversees the State Department of Hawaiian Homelands (DHHL) in serving Native Hawaiian beneficiaries. Appointed by the Governor and confirmed by the Senate to oversee DHHL's implementation of its mission to provide land, loans and services to beneficiaries; fiduciary stewardship of lands and financial assets; and delegation of day-to-day management to the Director. Drafted DHHL's investment and spending policy and pushed for the purchase of residential buildings as rentals for beneficiaries, which occurred in 2020.

Co-Founder & Executive Director, College Connections Hawaiʻi (1999-2007)

Created and managed a statewide 501(c)(3) organization to prepare more local students to succeed in post-secondary education, focusing on Native Hawaiian and low-income students across Hawaiʻi.

- Oversaw all daily operations of the organization, including 150 employees, and 2,000 students each year;
- Developed curriculum for multiple educational programs in supplementary instruction in SAT preparation, tutoring and college counseling; conducted teacher and counselor training to improve student outcomes;
- Launched the "Native Hawaiian Scholars Program" to prepare 500 Hawaiian teens to enter and complete college, SAT-prep classes for public school students, and strategic tutoring to provide after-school reading and math tutoring to 900 students per year, including approximately 300 Native Hawaiian children at DOE elementary schools.
- Planned and administered state contracts and federal grants for multiple educational programs, partnering with more than 40 charter, traditional public and private schools.

Educational Specialist, Casey Family Programs, Honolulu, HI (1999-2000)

Managed the educational programs for a statewide private foster care agency, funded by the Casey Family Foundation; Responsibilities were to coordinate with social workers to seek the best educational outcomes for local foster youth, many of whom were Native Hawaiian. Met with teachers, counselors and staff to ensure appropriate educational services were provided to each student. Worked to develop a system to track and improve educational outcomes for youth in the program.

Director, Sylvan Learning Center, Belmont, CA. (1997-98)

Managed a private tutoring center to provide reading and math instruction to students in the Bay Area. Supervised a staff of 15 teachers and other employees, Oversaw implementation of proprietary curriculum and designed a new college counseling module to encourage and guide more students toward post-secondary education. Secured regional accreditation for the center in 1998.

Teacher, Castro Valley High School, Castro Valley, CA. (1995-97)

Taught a full schedule of high school classes in English and Video Production; Secured a vocational teaching certification for pre-professional training in video production; Establish the school's first school-wide weekly news broadcast — written, produced and directed by students.

Communication Specialist, Kamehameha Schools, Honolulu, HI. (1991-93)
Designed and wrote copy for both internal and external KS publications. Part of the team that produced the very first "I MUA" magazine, which remains an important communication resource for the organization.

Education

University of North Carolina at Chapel Hill, NC
Master of Arts in Curriculum and Instruction (1995); Teaching Certification in Secondary Education, English (1995)

Stanford University, Stanford, CA
Bachelor of Arts in Communication (1990)

Kamehameha Schools, Honolulu, HI
Honors Diploma (1986)

Service & Affiliations

- Fellow, Omidyar Fellows Program, Cohort VIII (2020-present)
- Oʻahu Commissioner, Hawaiian Homes Commission, Department of Hawaiian Home Lands (2015-19)
- Fellow, Pacific Century Fellows program (2006-07)
- Hawaiʻi Renewable Energy Alliance
- Board Member, Toddler Program Christian preschool
- Hawaiʻi Association of College Counseling
- Stanford University Alumni Association
- Kamehameha Schools Alumni Association

WRITTEN DIRECT TESTIMONY OF WREN WESCOATT

A. <u>PROJECT DEVELOPMENT</u>.

1. <u>Please state your name and business address for the record.</u>

Wren Wescoatt
Mahi Solar, LLC
c/o Longroad Development Company, LLC
330 Congress Street, 6th Floor
Boston, MA 02210

2. <u>What is your current occupation?</u>

I am the Director of Development in Hawaii for Longroad Energy.

3. <u>How long have you worked as an Energy Developer?</u>

13 years.

4. <u>Did you provide a copy of your resume for these proceedings?</u>

Yes, it has been filed with the Planning Commission as an exhibit.

5. <u>Can you describe for the Planning Commission what it is you do as an Energy Developer ?</u>

I am responsible for the development of solar energy projects in Hawaii for Longroad.

6. <u>Is Mahi Solar, LLC ("*Mahi Solar*") the applicant for this State Special Use Permit ("*SUP*")?</u>

Yes.

7. <u>Are there other Longroad Energy related entities that have done, or are doing, renewable energy projects in Hawaiʻi?</u>

Longroad Energy affiliate, Mahi Solar, LLC, is seeking to develop a solar energy facility on the island of Oahu. Another Longroad affiliate Pulehu Solar, LLC is developing a solar project on Maui. Also, many personnel from Longroad Energy previously worked at First Wind and were involved with the successful development of the Kawailoa and Waipio solar energy facilities, which sought the first SUPs for a utility scale solar project on Oʻahu.

8. <u>Can you describe the purpose of the Mahi Solar Project ("*Project*") that is the subject of the SUP Application?</u>

The purpose of the Project is to provide low-cost renewable energy in the form of solar electric power to Hawaiian Electric Company's ("***HECO***") existing power grid. The 620-acre Project is projected to generate a total of 120 megawatts ("***MW***") of energy, which is enough to power approximately 37,000 O'ahu homes or 3% percent of the state's electricity annually and the project is estimated to avert the consumption of 11,111,800 barrels of oil. As such, development of the Project will move the state forward in achieving its Hawaii Clean Energy Initiative ("***HCEI***") goal.

Since the Project is located on agricultural land the Project will also support local agriculture by allowing landowners to lease out less productive agricultural lands for solar use and continue farming on the most productive lands. In order to achieve this, Mahi Solar has consulted with the Hawai'i Agricultural Research Center ("***HARC***") and with several local farmers to develop an agricultural plan and an Agrivoltaic Program that will research and implement multiple different agricultural activities that will be co-located at a utility-scale solar project. The goals of this program are (i) to study what types of solar-compatible farming could work in Hawai'i; (ii) to support local farmers with land, water, and start-up funds to grow out these products at a commercial scale; and (iii) to share results with others in the local solar and agricultural industries to find new solutions for solar and agriculture to be productive on the same land.

9. <u>Can you describe the Project's location?</u>

The Project will be located on portions of TMKs (1) 9-2-001:020 and (1) 9-2-004: 003, 006, 010, and 012 in Kunia, O'ahu, Hawai'i and totals approximately 620 acres. The site will be developed in five areas identified as Areas 1, 2, 3, 4A, 4B, 4C, and 5, across the five TMK parcels. The site lies within the traditional moku of 'Ewa and the ahupua'a of Honouliuli.

The site is bounded by agricultural land to the north, south, east, and west. A portion of the project site is also bounded by the Honouliuli Forest Reserve and State of Hawai'i - owned vacant preservation land to the west. The National Park Service ("***NPS***") Honouliuli National Historic Site is located adjacent to the southwest of the proposed site with the Royal Kunia residential development located further southeast.

10. <u>Who owns the land for the project area?</u>

The five TMK's identified are collectively owned by three separate landowners: Monsanto Technology LLC, Hartung Brothers Hawaii LLC, and Fat Law's Farm Inc. Mahi Solar will lease the land from these landowners for the duration of the solar project.

11. <u>Why does Mahi Solar have to obtain a SUP?</u>

Since the Project will be developed on lands situated in the State Land Use Agricultural District, and because the land has a Land Study Bureau classification of B and C, HRS Chapter 205 and Act 55 require Mahi Solar to obtain a SUP.

12. What are the basic requirements of HRS Chapter 205 to obtain an SUP?

Under HRS § 205-4.5(a)(21)(A), the land occupied by the solar farm must also be made available for compatible agricultural activities at a lease rate that is at least fifty percent (50%) below the fair market rent for compatible properties. The term "agricultural activities" is defined as (1) cultivation of crops, including crops for bioenergy, flowers, vegetables, foliage, fruits, forage, and timber; (2) game and fish propagation; and (3) raising of livestock, including poultry, bees, fish, or other animal or aquatic life that are propagated for economic or personal use.

With respect to decommissioning, HRS § 205-4.5(a)(21)(C) requires the owner of the solar farm to remove all of the solar energy equipment within 12-months of the conclusion of operation or the useful life of the improvements, and to restore the ground to substantially the same physical condition as existed prior to the development of the solar energy facility.

Furthermore, under § 205-4.5(a)(21)(B), Mahi Solar must provide proof of financial security to cover the cost of those decommissioning activities before it starts commercial generation of energy.

13. Is Hawaiian Electric Company ("*HECO*") involved in the Mahi Solar Project?

Yes, the Project has been selected by HECO to participate in the Hawaiian Electric Companies' Final Stage 2 Renewable and Grid Services Request for Proposals.

14. Has Mahi Solar executed a Power Purchase Agreement ("*PPA*") with HECO?

Yes, we executed the PPA dated September 11, 2020, and the contract was approved by the Public Utilities Commission on December 31, 2020.

15. Has HECO completed the Interconnection Requirements Study for the Project to determine the requirements to interconnect the Project to HECO's system?

The interconnection requirements study is currently underway and should be completed in the next few months.

16. Will this Project lower energy costs for Hawai'i consumers?

Absolutely. Analysis by HECO estimated that the Project will save Oahu consumers $175 million over a 25-year lifespan, also avoiding half a billion gallons of oil use over 25 years. This project will provide enough power for 37,000 Oahu households and will move the state 3% closer to its 100% clean energy goal.

17. What is the term of the PPA and can the term be extended?

The PPA has a term of 25-years with the potential to extend for additional years with the mutual agreement of both the producer and the utility.

18. How long is construction of the Project expected to take?

Construction of the Project is proposed to start in early 2022 through late 2023 and is estimated to take approximately 18 months.

19. When does Mahi Solar intend to have the Project operational?

The Project should be operation in late 2023.

20. What would be the impact on the Project if it is not into commercial operations by 2023?

If the Project exceeds its guaranteed commercial operation date of December 31, 2023, then the Project would be obligated to pay liquidated damages under the PPA.

21. What happens if the Planning Commission does not approve the SUP Application?

If the SUP is not approved, then the Project would not be able to proceed and the PPA would be terminated. Since energy from Mahi Solar is needed to replace energy that will no longer be produced by the AES coal-fired plant which closes in 2022, the Oahu grid may face an energy shortage if the Mahi project is not completed on schedule.

22. Does Mahi Solar have to construct an access road for the Project?

No. Access to the project site is via three established entrances from Kunia Road and an existing network of dirt access roads which are actively maintained in support of the surrounding agricultural operations.

23. Will Mahi Solar comply with the requirement to remove all of the solar energy equipment within 12 months of the conclusion of operation or the useful life of the improvements, and to restore the ground to substantially the same physical condition as existed prior to the development of the solar energy facility?

Yes, we prepared a Decommissioning Plan, which was filed as Appendix I to the SUP Application, which addresses the scope and timeframe for the decommissioning. It is Mahi Solar's obligation and commitment to conduct this decommissioning and remove all of the PV panels, racks, foundational piles and underground collector lines following the useful life of those components.

24. What does the decommission plan entail?

The decommissioning activities include the complete removal of the foundational piles and modules and all associated components to a depth of 24 inches below grade, which include any concrete foundations, thereby, restoring the site to the original topography. The terrain will then be revegetated.

The PV panels used for the Mahi Solar project includes cells with thin film CdTe semiconductor that are 90 percent recyclable. Therefore, upon decommissioning of the Project, components of the PV panels will be recycled or landfilled. The solar panels and other components, such as inverters and substation components, are expected to retain value and may be resold on the solar resale market. Structural components that cannot be reused will be scrapped and recycled at a recycling facility. Concrete will be broken up into transportable sized pieces and then transported to a location for re-use in road bases.

Erosional protection will be in place in accordance with a decommissioning stormwater protection plan.

25. <u>How long is the decommissioning expected to take?</u>

The decommissioning is expected to take 12 months to complete.

26. <u>How much is the decommissioning expected to cost?</u>

The decommissioning is expected to cost $5,166,260.

27. <u>What is the financial security for decommissioning?</u>

Mahi Solar will post security to decommission the Project after the end of commercial operation. Mahi Solar will post financial security in the form of a bond, a letter of credit, escrow account or similar instrument in favor of the landowner, to ensure that the decommissioning funds will be available at the time that the project is decommissioned should the Project owner be unable to complete the decommissioning. Maintaining this financial security is typically required in any lease agreements, and needs to be kept in place for the duration of the project life. If the project itself is ever sold, the site lease agreements and the obligation to maintain this security passes to the new owner.

28. <u>Will Mahi Solar conduct an EA or EIS prior to decommissioning?</u>

There is no HRS Chapter 343 trigger that would require an EA or EIS to be conducted prior to decommissioning the solar farm. However, Mahi Solar will comply with all applicable laws and regulations.

B. <u>AGRICULTURE AND AGRIVOLTAICS</u>.

1. <u>Describe the Project site and existing uses of the land?</u>

The Project lands are designated as Agricultural by the State Land Use Commission and are zoned AG-1, Restricted Agricultural District by the City and County of Honolulu's Land Use Ordinance. The site is planned for "Agriculture and Preservation" uses within both the City and County of Honolulu Central Oʻahu Sustainable Communities Plan and ʻEwa Development Plan.

The Project site currently consists of actively farmed areas, undeveloped and fallow agricultural land, overgrown natural vegetation, and structures associated with farming and business operations. After construction of the solar farm is completed, Mahi Solar intends to work with local farmers and ranchers to implement multiple different agricultural activities that will be co-located at the Project. The common term for this is "agrivoltaics.".

2. **<u>What is agrivoltaics?</u>**

Agrivoltaics describes the use of the same area for both solar photovoltaic energy and agriculture. Agrivoltaic projects such as Mahi Solar are designed to share land and sunlight between agriculture and solar panels, and to study which crops, or livestock can co-produce with solar most successfully. The co-location of solar energy production and agriculture results in a more efficient use of land, which is important on Oʻahu where both local farming and local clean energy are priorities, but land resources are limited.

3. **<u>What are the climate and wind patterns for the Project area?</u>**

Over the course of the year, the temperature varies between 65°F to 87°F. During the hot season's months of June through October the average daily high temperature is above 85°F. During the cool season months from December to March the average daily high temperature is below 81°F. The Project area experiences an average rainfall of approximately 30 inches. The average hourly wind speed in the area varies significantly over the seasons, with the windier part of the year being between June to September, with average wind speeds of more than 14.4 miles per hour.

4. **<u>What are the soil classifications for the Project area?</u>**

The Project area contains multiple soil classifications and groups to include the following: Helemano silty clay, 30 to 90 percent slopes (HLMG); Kawaihapai clay loam, 0 to 2 percent slopes (KlA); Kawaihapai clay loam, 2 to 6 percent slopes (KlB); Kawaihapai stony clay loam, 2 to 6 percent slopes (KlaB); Kolekole silty clay loam, 1 to 6 percent slopes (KuB); Kolekole silty clay loam, 6 to 12 percent slopes (KuC); Kolekole silty clay loam, 12 to 25 percent slopes (KuD); Kunia silty clay, 0 to 3 percent slopes (KyA); Kunia silty clay, 3 to 8 percent slopes (KyB); Kunia silty clay, 8 to 15 percent slopes (KyC); Lahaina silty clay, 7 to 15 percent slopes, severely erode (LaC3); Mahana silty clay loam, 12 to 20 percent slopes, eroded (McD2); Mahana silty clay loam, 20 to 35 percent slopes, eroded (McE2); Tropohumults-Dystrandepts association (rTP); Wahiawa silty clay, 0 to 3 percent slopes (WaA); and Water > 40 acres (W).

5. **<u>What is the Land Study Bureau's rating for the Project area?</u>**

The Project includes soils rated by the Land Study Bureau of the University of Hawaiʻi ("***LSB***") as Class B, C, D, and E. The Project area does not contain soils designated as Class

A. Hawaii Revised Statutes Section 205-4.5(21) permits solar energy facilities on land classified by LSB as Class B and C, with approval of a SUP. A SUP is not required for development for lands classified as LSB D and E.

6. <u>What types of Agricultural Lands of Importance to the State of Hawai'i ("*ALISH*") are within the Project area?</u>

The Project area is comprised of all three types of ALISH lands, prime, unique, and other important agricultural land, and unclassified lands where the gulches exist.

7. <u>How many acres of the Project area consists of Important Agricultural Lands ("*IAL*")?</u>

Approximately 85 acres of the Project area is located within lands designated as IAL.

8. <u>Can IAL land be used for solar?</u>

Yes, using the land for solar and innovative agricultural uses is consistent with the intent of IAL lands articulated in HRS Chapter 205.

9. <u>Will the Project area continue to be used for agricultural purposes?</u>

Yes, the Agricultural Plan proposes to continue agricultural uses within the Project area.

10. <u>How does the Agricultural Plan propose to continue agricultural uses within the Project area?</u>

Most of the Project area will be leased or licensed to local farmers and ranchers at a nominal cost to grow various crops or livestock beneath and between the solar panels. These farmers will be provided with access to water (also at a nominal cost) and start-up funding. The Project's agricultural plan dedicates the land to long-term agricultural uses, supports the sustained growth of agriculture uses, supports the sustained growth of the agricultural industry, and meets the objectives of IAL land articulated by HRS Chapter 205-42. In addition, the use of currently unused land for agrivoltaics will expand the agricultural footprint of the land by allowing farmers to explore new uses for land under the solar panels. This Agrivoltaic Program will actually put more land into productive agriculture and food production than currently exists at the site.

11. <u>What is the water supply for the Project area?</u>

Kunia Water Association provides water service to most of the Project area and surrounding agricultural lands. The design of the Project includes an onsite water supply to support the farming and ranching activities. The Project will have access to water for agriculture through its lease agreements for the property. Irrigation infrastructure will be installed as needed to support crop production.

12. <u>Explain the drainage system for the Project area?</u>

There is no city storm drainage system in the Project area and the state storm drainage system is limited to concrete culverts crossing Kunia Road. There is no subsurface drainage system on the Project property. Drainage on site currently exists in the form of surface runoff on the natural topography, with rainfall and run-off eventually flowing into the various ephemeral tributaries of Honouliuli Stream. Because grading will be limited the Project will not significantly alter existing drainage patterns.

13. <u>What types of agricultural activities can be co-located at a utility-scale project?</u>

Mahi Solar has consulted with HARC and with several local farmers to develop an agricultural plan and an Agrivoltaic Program that will research and implement multiple different agricultural activities that will be co-located at a utility-scale solar project. The goals of this program are (i) to study what types of solar-compatible farming could work in Hawaiʻi; (ii) to support local farmers with land, water, and start-up funds to grow out these products at a commercial scale; and (iii) to share results with others in the local solar and agricultural industries to find new solutions for solar and agriculture to be productive on the same land.

While HARC's research is just beginning, crops that are anticipated to grow well at a solar project in the Kunia area are those that are shade tolerant and do not grow too tall to interfere with the panels, such as lettuce, basil, mint, sweet potato and flowering plants that support honeybees, as well as alfalfa and legumes that could be used for animal forage. Several local farmers and ranchers have already expressed interest in participating in the Agrivoltaic Program, including HARC, Hartung Brothers (alfalfa forage), and Oʻahu Grazers (livestock grazing), Kunia Country Farms (hydroponic lettuce), Alluvion (nursery products), Fat Law Farms (basil) and Island Bee Removals (honey production)

14. <u>Explain the improved animal forage of the agricultural plan.</u>

The animal forage agricultural option will include both grazing of on-site sheep and forage of production including nitrogen-fixing legumes and nutritious grasses. Free range chickens may also be evaluated as potential co-use.

15. <u>What methods will be used to grow crops?</u>

Both hydroponic and conventional soil planted crops will be grown to determine whether both types can co-exist with a solar project and a comparison will be done to determine whether one or both can successfully be conducted.

16. <u>How will the Agrivoltaic Program support farming?</u>

Once the Project is completed and operating, the Agrivoltaic Program will make available most of its 620-acre Project area to local farmers and ranchers. After submitting an agrivoltaic proposal, farmers and ranchers will be provided with land and water at nominal cost so they may grow agrivoltaic crops or products that will be commercially successful. In order to develop best practices for compatible solar and agricultural activities, this part of the program is meant to be flexible allowing multiple farmers to test different products. A small portion of the Project cannot be used for farming/ranching for safety reasons, including the high-voltage substation, switching station and battery yard.

17. <u>Does the farming community support the Agrivoltaic Program?</u>

Yes, several professional local farmers and ranchers have indicated an interest in subleasing land for various agricultural activities that include growing shade-tolerant vegetable crops, high-quality livestock feed, pollinator-friendly flowering plants; and to raise livestock. Farmers will be consulted to determine the appropriate area and location, or each activity and it is anticipated subleases or licenses of five years or longer will be negotiated.

C. <u>COMMUNITY OUTREACH</u>.

1. <u>What community outreach was done for this Project?</u>

A considerable amount of community outreach has been conducted for the Project, including a series of well-attended virtual public meetings held on July 15, 2020 and October 29, 2020. A designated webpage was created to provide public information about the Project. We also shared information on the Project to be communicated on the websites of Hawaiian Electric and the State Energy Office. Presentations have also been made to the Mililani/Waipiʻo/Melemanu, Kapolei/Makakilo and Waipahu Neighborhood Boards, Royal Kunia Community Association and Kunia Loa Ridge Farmlands.

Mahi Solar has also conducted extensive outreach with residents, government officials and key community stakeholders through presentations to individuals and groups, as well as one-on-one interviews with cultural practitioners from the region.

With respect to state and county agencies, Mahi Solar held online meetings with the Office of Hawaiian Affairs, the State Historic Preservation Division ("***SHPD***"), State Energy Office, the State Department of Agriculture, and the City and County of Honolulu, Department of Planning and Permitting ("***DPP***").

2. <u>Were there any issues or concerns expressed by community stakeholders?</u>

Community stakeholders expressed the following issues and/or concerns: (i) loss of agricultural land; (ii) viability of co-location of agriculture and solar; (iii) biological resources; (iv) cultural resources; (v) construction characteristics; (vi) solar PV panel glare; (vii) decommissioning; (viii) stormwater runoff; (ix) visual impacts; and (x) renewal energy impact.

3. <u>What mitigation measures will Mahi Solar implement to address the issues and or concerns expressed by community stakeholders?</u>

Loss of Agricultural Land:

The Project follows the objectives established by the State of Hawaiʻi Land Use Law and Regulations. HRS Section 205-4.5 requires that agricultural activity be integrated with the solar energy facility. In cooperation with HARC, Mahi Solar developed an Agrivoltaic Program (“***Program***”) to (i) study what types of solar-compatible farming would work in Hawaiʻi; (ii) support local farmers with land, water, and start-up funds to grow out said products at a commercial scale at the Project site; and (iii) share results with others in the local solar and agricultural industries to find new solutions for solar and agriculture to be productive on the same land. During the research phase of the Program, plots of agricultural land located directly under the PV arrays will be cultivated on a trial basis to test compatible market crops. Further, Mahi Solar will coordinate with local agricultural organizations and agencies to share the Program and make available a majority of its 620 acres to local farmers. Local farmers who expressed a willingness to participate will be provided with land plots underneath the solar PV panels and water at a nominal cost to support the cultivation of agricultural activities. Mahi Solar and HARC will gather data, evaluate, and share the results with farmers, ranchers, and the broader community; thereby, providing information to assist farmers and solar developers to co-utilize Hawaii agricultural land for both farming and renewable energy.

Viability of Co-location of Agriculture and Solar

To meet the state’s clean renewable energy and food sustainability policies, in coordination with HARC, Mahi Solar will test and grow shade crops, both hydroponically and conventionally in soil and then engage local farmers to prove out the viability of these crops at commercial scale. Mahi Solar will evaluate and share the data and results of these test crops with other farms and solar farm operators.

Construction Characteristics

For the Project, the anticipated equipment manufactures may include First Solar (a U.S. company who will provide the solar PV modules), Nextracker (racking) and SMA (inverters). Most of these components may be produced in U.S., Malaysia, Germany, Vietnam, Mexico, and China.

Solar PV Panel Glare

A Glare Study, which is attached to the SUP Application as Appendix H, assessed potential glare the solar PV system. The study determined that no potential glare will be visible from the proposed solar operations due to the orientation of the single-axis true tracking PV panels and distance from sensitive views to the Project. Further, there is no evidence that the presence of a solar farm in will raise temperatures in the area.

Stormwater Runoff

The Project design will have no adverse effect to nearby surface water resources, including Honouliuli Stream or its tributaries. To mitigate for the potential stormwater runoff and erosion, the Project will obtain a NPDES permit for construction activities and will adhere to DPP's Water Quality Rules. State and City and County of Honolulu permits require the preparation of an ESCP.

View Impacts

The solar farm will be developed on agricultural lands and will not be visible from distant viewsheds articulated in the Central Oʻahu SCP and ʻEwa DP. The Project design will meet AG-1 Restricted Agricultural District development standards. Where the solar PV panels may be slightly visible, landscaping will be incorporated on top of the existing berm to enhance screening and to break up views of the solar project. With the implementation of these mitigation measures, adverse impacts to visual resources are not anticipated.

Renewable Energy

The Project will help to significantly reduce the number of barrels of imported oil to the state. It is estimated that Mahi Solar will avert the consumption of 11,111,800 barrels of oil over a 25-year lifespan and will move the state forward in achieving its HCEI goal.

Respectfully submitted,

____
WREN WESCOATT

DATED: Honolulu, Hawaiʻi, June 11, 2021.

TRACY CAMUSO

AICP
Associate Principal

Tracy is an environmental and land use planner with more than 15 years of professional experience, including work on numerous renewable energy and biofuels projects in Hawai'i. She prepares environmental impacts documents, applications for various land use permits, master plans and design guidelines. Her project experience includes agricultural developments, residential communities, educational facilities, industrial parks and scientific research institutions. Tracy has specialized knowledge in public policy and coordination with community and governmental organizations. Prior to joining G70, Tracy worked on public relations and policy issues in the Office of U.S. Senator Daniel K. Inouye and the Hawai'i State Legislature.

SELECTED PROJECTS:

Aloha Solar Energy Fund I, Lualualei
Lualualei, O'ahu

Aloha Solar Energy Fund II, Kalaeloa
Kalaeloa, O'ahu

East Kapolei Solar Farm - Environmental Studies, CUP
Kapolei, O'ahu

Hawai'i BioEnergy Kauai Algae Farm - Permitting Strategy, State/County Permits
Līhu'e, Kaua'i

Ho'ohana Solar Farm (52MW) - EA, CUP
Kunia, O'ahu

PAR Petroleum Expansion - CUP, Height Variance
Kapolei, O'ahu

Phycal Algae Pilot Project -State/NEPA EA
Wahiawa, O'ahu

UOP Integrated Biorefinery - Permitting Strategy, State/County Permits
Kalaeloa, O'ahu

Clearway Waiawa Solar (36MW) - SLUBA, CUP, Waiver
Waiawa, O'ahu

Clearway Mililani Solar (65MW) - CUP, Waiver
Mililani, O'ahu

LRE Mahi Solar (120 MW) - SUP, CUP, Waiver
Kunia, O'ahu

U.S. Army Training Areas O'ahu - Environmental Condition of Properties (ECoP)
Central, O'ahu/North Shore, O'ahu

Salvation Army Residence Facilities - Land Use Permitting
Honolulu, O'ahu

Leihano Senior Village CCRC - CUP, UA Status Updates
Kapolei, O'ahu

Marriott Residence Inn - CUP Limited Service Hotel
Kapolei, O'ahu

Farrington Highway Improvements - EA, Pre-Design
East Kapolei, O'ahu

First Assembly of God Windward Church Redevelopment Expansion - EA, SMA, CUP
Kāne'ohe, O'ahu

Halekua - Royal Kunia Phase II, PDH, Zoning Adjustment, UA
Kunia, O'ahu

Hilton Hawaiian Village Master Plan - EIS, SMA, PDR, WSD
Honolulu, O'ahu

Ho'opili Community - Zone Change
Kapolei, O'ahu

Kapolei Haborside Center - EIS, Zone Change
Kalaeloa, O'ahu

PROFESSIONAL REGISTRATIONS & ASSOCIATIONS:

American Planning Association (APA), Member

American Institute of Certified Planners (AICP), Member

American Red Cross, Board Member

Waikīkī Improvement Association, Member

NAIOP Commercial Real Estate Development Association, Member

Urban Land Institute (ULI), Member; Urban Plan Participant

Women in Renewable Energy (WiRE), Member

Chamber of Commerce of Hawaii, Member

Business Industry Association (BIA), Member

Hawaii Society of Business Professionals, Board Member

Patsy T. Mink Leadership Alliance Inaugural Cohort, 2016-2017

Pacific Century Fellows, Fellow 2019-2020

EDUCATION:

Masters in Public Administration
University of Hawai'i at Mānoa, HI

B. A. Political Science
University of Hawai'i at Mānoa, HI

HONORS & AWARDS:

Pacific Business News - Women Who Mean Business Awardee, 2019

Pacific Business News - Forty Under 40 Awardee, 2019

WRITTEN DIRECT TESTIMONY OF TRACY CAMUSO
(Environmental and Land Use Planning)

1. <u>Please state your name and business address for the record.</u>

Tracy Camuso, AICP, Associate Principal, G70

Business address is 111 S. King Street, Suite 170, Honolulu, HI 96813

2. <u>What is your current occupation?</u>

I am an environmental and land use planner.

3. <u>How long have you worked as an environmental and land use planner?</u>

Approximately 16 years.

4. <u>Did you provide a copy of your biography and or resume for these proceedings?</u>

A brief biography and/or resume was filed as Exhibit 13

5. <u>Do you specialize in any particular area?</u>

I specialize in environmental and land use entitlements for renewable energy projects in Hawaiʻi.

6. <u>Can you describe the Mahi Solar Project ("*Project*") that is the subject of the SUP application?</u>

Mahi Solar is proposing to construct a 120-megawatt solar project, a Battery Energy Storage System ("***BESS***"), and other associated appurtenances including fencing, roads, and electrical infrastructure on roughly 620 acres of agriculture-zoned land in Kunia, Oahu.

7. <u>What is your role with this Project?</u>

I am coordinating the land use permits for the Project, including the Special Use Permit ("***SUP***"), Conditional Use Permit ("***CUP***") Minor, and Waiver Permits. These permits will be filed with the City and County of Honolulu Department of Planning and Permitting ("***DPP***").

8. <u>Why does the project require approval of a Special Use Permit?</u>

The project will be placed on lands designated as Agriculture by the State Land Use Commission ("***LUC***"). The use of State Agricultural lands having Land Study Bureau ("***LSB***") rating of B and C for the development of a solar energy facility requires approval of an

SUP by the DPP and Planning Commission. Since the project area is greater than 15 acres, final approval of the SUP must be obtained from State LUC.

9. Does the project comply with the State Land Use Law (HRS Chapter 205)?

The Mahi Solar project meets the requirements of State Land Use Law. Under Section 205-4.5 solar energy facilities are an allowable use on State Agricultural lands with the approval of a SUP by the County Planning Commission and State Land Use Commission. The project will meet requirements stated under Section 205-4.5 (a) through (C).

The Mahi Solar project will incorporate compatible agricultural activities and active farming practices throughout the Project site. The proposed agricultural plan would support local food production of crops such as alfalfa, hydroponic lettuce; basil, sweet potato and other vegetables; livestock grazing; and pollinator plants/honey. Mahi Solar will provide land plots and water to farmers at a nominal cost, which will be at a rate below fifty percent of the fair market rent for compatible properties, to support the cultivation and testing of these agricultural activities at a commercial scale. Financial security will also be posted to ensure proper decommissioning of the project at the end of commercial operations. The decommissioning will include the removal of all equipment within 12 months from the conclusion of operation or useful life, and restoration of the land to substantially the same physical condition as existed prior to the development of the solar energy facility.

10. What are the legal requirements for a Special Use Permit (HRS Chapter 205-6)?

HRS Sect. 205-6 specifies the legal requirements and regulations relating to the SUP. Under this section, the county planning commission may permit certain unusual and reasonable uses within the agricultural and rural district other than those for which the district is classified. Under the City and County of Honolulu Administrative Rules Part I - Rules of the Planning Commission, Section 2-45 identifies tests consisting of five guidelines to be applied to determine if a project is considered an unusual and reasonable use. These guidelines and the project's applicability are detailed below.

a. The use will not be contrary to the objectives of the State Land Use Law and regulations;

Under the State land use law, solar energy facilities on State Agricultural land with a soil classification rating of B or C, an SUP must be obtained. To do so, the following three requirements must be met:

1. The project area/site that the solar energy facilities are located must also be made available for compatible agricultural activities at a lease rate that is at least fifty per cent below the fair market rent for comparable properties. Mahi Solar will provide land plots and water to farmers at a nominal cost, which will be at a rate below fifty percent of the fair market rent for compatible properties, to support the cultivation

and testing of agricultural activities at commercial scale. The agricultural plan includes an Agrivoltaic Program that will be implemented in cooperation with Hawaii Agricultural Research Center ("***HARC***"). Plots of agricultural land located directly between and under the PV arrays will be cultivated for compatible market crops, such as lettuce and basil. Livestock grazing and the establishment of nitrogen-fixing legumes such as alfalfa and perennial peanut, and high quality, low growing grasses such as Bahia grass, oats, and barley are also proposed.

2. Proof of financial security to decommission the facility must be provided prior to the commencement of commercial generation. Mahi Solar will post security to ensure proper decommissioning of the Project after the end of commercial operations. A reclamation cost estimate ("***RCE***") will be completed prior to commercial operation date ("***COD***") for the Project, and Mahi Solar will post financial security in the form of a bond, letter of credit or similar instrument in favor of the landowner, to ensure that the decommissioning funds will be available at the time that the Project is decommissioned should the Project owner be unable to complete the decommissioning.
3. The decommissioning must meet certain requirements, including removal of all equipment, within twelve months of the conclusion of operation or useful life; and restoration of the disturbed earth to substantially the same physical condition as existed prior to the development of the solar energy facility. The decommissioning plan for the Mahi Solar project covers all of these requirements. The decommissioning activities will include the complete removal of the foundational piles and modules and all associated components to a depth of 24 inches below grade, which include any concrete foundations. The site will be restored to the original topography and revegetated.

b. *The use would not adversely affect surrounding property;*

The existing development pattern in the vicinity of the Project follows existing zoning and is consistent with the land use character and development pattern that is called for in the City and County of Honolulu's Central Oʻahu Sustainable Communities Plan ("***SCP***") and ʻEwa Development Plan ("***DP***"). The proposed use of this agricultural land for the solar project is compatible with the existing land use of the site and surrounding area.

The nearest residential areas to the Project are Royal Kunia, located approximately 1.2 miles southeast, and Waipahu, located approximately 2 miles southeast. The westernmost portion of Mililani Town is located approximately 1.9 miles to east. A view study was conducted for the Project which found that visibility is minimal and is not expected to result in significant adverse impacts. The solar farm will be developed on agricultural lands and will have a relatively low profile that will run with the existing topography of the land. Landscaping will also be integrated to provide privacy and screen distant views of the project. Plants along Kunia Road will be planted on top of the existing five-foot-tall berm to ensure screening.

Noise or odors are not anticipated to adversely affect surrounding properties. During construction, short-term noise levels and air impacts are likely to occur as a result of earth moving equipment and construction vehicles. Construction activities will comply with applicable state regulations.

Impact relating to glare resulting from the solar PV Project are also not anticipated. A Glare Study was completed which determined no potential glare will be visible from the proposed solar operations due to the orientation of the PV panels and distance from sensitive views to the Project. As such, it was determined that no glare related impacts to airport operations, nearby structures, and motorists on Kunia Road would occur as a result of the Project's development.

Significant traffic related impacts are not anticipated to occur with the Project's development. The Project is not expected to result in the need for typical roadway capacity enhancements. However, during construction, the addition of vehicles, particularly large trucks, turning into and out of the site access road intersections along Kunia Road, may necessitate some modification of traffic control devices in the area to raise driver awareness and enhance safety. To minimize the potential for short-term traffic impacts, a construction traffic management plan would be prepared and implemented for the Project.

c. *The use would not unreasonably burden public agencies to provide infrastructure (i.e., roads, wastewater, water, drainage and school improvements, police, and fire protection);*

The Mahi Solar project will not require public agencies to provide infrastructure, including new roads, wastewater, water, and drainage to support the Project. The Project will not require improvements to schools, as there will be no population increase with the Project's development. Impacts to the police and fire departments' operations or ability to provide adequate protection services to the surrounding community are also not anticipated. No residential use is being proposed as part of the Project, therefore, there will be no increase to the existing population in the area that will require additional public service needs.

d. *Trends and needs have arisen since the district boundaries and regulations were established; and*

Hawaiʻi is the most petroleum-dependent state in the United States. In response to this dependency, the State of Hawaii created the Hawaii Clean Energy Initiative ("***HCEI***") in 2008 and in 2015, set a goal of having 100 percent of electricity sales come from renewable sources by the year 2045 (Act 97). With this, the need for utility scale solar energy facilities on Oʻahu has continued to increase as the State of Hawaii works towards achieving energy efficiency and renewable energy.

The purpose of the Mahi Solar project is to provide low-cost renewable energy in the form of solar electric power to HECO's existing power grid. Selected as part of HECO's competitive Request for Proposal (RFP) process, Mahi Solar is one of 15 HECO Stage 2 renewable energy projects. The 620-acre Mahi Solar project is projected to generate a total of 120 megawatts ("***MW***") of energy, which is enough to power approximately 37,000 Oʻahu homes or 4 percent of the island's electricity annually.

e. The land upon for the proposed use is unsuited for the uses permitted within the district.

The land upon which the solar project is sought is suited for uses permitted within the Agricultural District, including agricultural cultivation and solar facilities. However, with the co-location of agricultural uses with solar, the Project site will continue to be available for uses permitted in HRS Section 205-4.5 and is thus considered suitable for the establishment of the Mahi Solar project.

11. Will the project involve the use of Important Agricultural Lands?

Of the total 620-acre project area, approximately 69.5 acres is located within lands designated as Important Agricultural Lands ("***IAL***"). Approximately 29.3 acres of IAL is located within Area 1 of the project (TMK (1) 9-2-004: 12) and 40.2 acres of IAL are located within Area 5 (TMK (1) 9-2-001:020).

Currently, this IAL land that will be used for the Project is not being used for agricultural activity. However, Mahi Solar will incorporate active agricultural farming practices throughout the site. The Project will include growing of nitrogen-fixing legumes such as alfalfa and perennial peanut and high quality, low growing grasses such as Bahia grass, oats and barley for high-quality forage for livestock grazing. Mahi Solar will coordinate with local agricultural organizations and agencies to implement the Agrivoltaic Program and provide approximately 610 acres to local farmers.

In addition to land plots beneath the solar PV panels, Mahi Solar will provide water to farmers at a nominal cost to support the cultivation and testing of agricultural activities at commercial scale. The agricultural plan for the Project further supports the preservation of the Project parcels for agricultural uses and meets the overall objectives of IAL articulated in HRS Chapter 205-42. Use of the vacant site for solar will expand the land's agricultural use and is anticipated to produce 4 percent of the island's electricity annually, enabling HECO to burn less fossil fuel and emit less GHGs.

12. Was a traffic assessment conducted for the Project?

Yes, a Construction Traffic Assessment for the Project was completed by Fehr & Peers in September 2020. The report assesses vehicle trip generation associated with Project construction and Project operations to determine traffic-related impacts. The assessment also provides mitigation measures to address potential impacts.

13. Will the Project affect traffic in the surrounding area?

The Mahi Solar project will generate a negligible amount of vehicle traffic when the solar farm is fully constructed and operational. The volume of traffic generated by construction of the Project is not expected to result in the need for roadway enhancements. However, the addition of vehicles, particularly large trucks, turning into and out of the site access road intersections along Kunia Road, may require temporary signage to raise driver awareness and enhance safety.

14. What mitigative measures are proposed to minimize potential traffic impacts?

To minimize the potential impacts to traffic operations, particularly during construction of the Project, the following elements in the construction traffic management plan ("***CMP***"):

- Install temporary signage on mauka-bound and makai-bound Kunia Road prior to approaching the site access intersections to indicate the presence of trucks entering/exiting the roadway near each of the three site access roads.
- Field verify available sight distance and maintain adequate sight distance for drivers exiting site access locations and turning onto Kunia Road. Maintenance may include pruning vegetation and not installing signage or other barriers that could block a driver's field of vision at the intersection.
- Extend the painted median solid double yellow line delineating the "Do Not Pass" zone for mauka-bound vehicles at least an additional 500 feet approaching the site access intersections.

The trips generated by the Project once it is fully operational are negligible and no traffic improvements are required. Upon completion of the Project construction, the extension of the "Do Not Pass" zone could be maintained or eliminated at the discretion of Hawaiʻi Department of Transportation ("***HDOT***").

15. Was a Glint and Glare study conducted for the Project?

Yes, a Glare Study was prepared for the Project by POWER Engineers Inc. (October 2020). The study identifies sensitive viewers near the Project including structures, major roadways and approach slopes associated with the Kalaeloa Airport and Wheeler Army Airfield. The study also characterizes typical glare behavior experienced from the solar project throughout the day and year and evaluates when and where glare may be visible to structures, motorists and pilots on final approach.

16. Will the Project generate adverse impacts related to glare?

Findings of the Glare Study determined that no potential glare will be visible from the solar project operations due to the orientation of the single-axis true tracking PV panels and distance from sensitive views to the Project. As such, it was determined that the Project would have no negative impacts to airport operations at the Kalaeloa Airport and Wheeler Army Airfield, nearby structures within the Kunia Loa Ridge Farmlands, and motorists on Kunia Road.

17. Was a View Study conducted for the Project?

Yes, a view study for the Project was conducted by G70 from several locations along Kunia Road and neighboring communities, including Makakilo, Waipahu, and Mililani.

18. Will the Project be visible from the surrounding communities?

The solar farm will be developed on agricultural lands and will not be visible from distant view sheds articulated in the Central Oʻahu Sustainable Communities Plan and ʻEwa Development Plan. The Project will have a relatively low profile and will run with the existing topography of the land. At peak elevation, the panels will be no more than 12 feet above ground level.

The Project may be visible from some locations along Kunia Road, but, in most cases, are blocked by existing berms and vegetation. Mahi Solar is not located near residential communicates however, the Project may be slightly visible to the public from distant areas along the H-1 freeway or mauka of the Project such as Makakilo Drive and from Pearl City; however, the Project is not anticipated to substantially affect these existing distant views.

19. What measures will be implemented to screen the Project and mitigate for potential visual impacts?

Landscaping will be incorporated on top of the existing 5-foot-tall berm to ensure screening, particularly along Kunia Road. Landscape treatments include visual screening plants ranging in mature height from 2 to 8 feet tall, and proposed trees range in mature height from 12 to 15 feet tall.

Landscape treatments identified for other portions of the Project are comprised of low visual screening plants. These plants will provide appropriate landscaping that would avoid blocking necessary sunlight on the panels which is vital for generating solar power.

The solar PV panels in the Project area will be most visible from Pālāwai Street, which is an agricultural road used to access Kunia Loa Ridge Farmlands. However, landscaping will be integrated along the Project boundary to provide screening . Mahi Solar has conducted outreach with the existing members of the Kunia Loa Ridge Farmlands to discuss the Project.

Respectfully submitted,

____
TRACY CAMUSO

DATED: Honolulu, Hawai'i, June 11, 2021.

JOSH MEYERS | Project Executive

ROLE AND RESPONSIBILITIES

Josh, a Project Executive from our Honolulu office, has over two decades of experience in the construction industry, and ten years working specifically with solar. He is quite knowledgeable about working on the islands and has established relationships with various governing agencies, local subcontractors, and unions. Josh is responsible for the oversight of all items related to day-to-day construction operations, including staffing assignments, project plan development, cost and schedule analysis, and owner and subcontractor communications/interface. He is involved with all phases related to preconstruction, engineering, construction, and project closeout.

EDUCATION AND AFFILIATIONS

- Standford University, Bachelor of Science in Civil Engineering
- Military Service, USAF, Military Engineering Officer 1996-2003
- Licensed B-General Contracting Hawai'i (31969)
- Licensed B-General Contracting California (934906)
- Licensed B-General Contracting Oregon (205720)

PROJECT EXPERIENCE SUMMARY

Arizona Solar I
Arizona | Solar | 135 MW DC

Arizona Solar II
Arizona | Solar | 135 MW DC

Kawailoa
Hawai'i | Solar | 63 MW DC

Mililani II
Hawai'i | Solar | 18 MW DC

Waipio
Hawai'i | Solar | 60 MW DC

Waianae
Hawai'i | Solar | 40 MW DC

KIUC Anahola*
Hawai'i | Solar | 15 MW DC

Aloha Solar*
Hawai'i | Solar | 6 MW DC

Kalealoa Solar II*
Hawai'i | Solar | 5 MW DC

EPC Management*
350 MW DC | 200+ Projects

Note: Some project names omitted due to Confidentiality Agreement with clients.
* Projects completed prior to joining Moss

Josh's Expertise

- 25 Years Experience
- 10 Years Solar
- Hawaiian Solar PV EPC Veteran
- Budget Planning/Forecasting
- Complex Projects
- Strategic Procurement
- Project Controls/Scheduling

Contact Information

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KAWAILOA , HI


WAIPIO , HI

WRITTEN DIRECT TESTIMONY OF JOSH MEYERS
(Construction Management)

1. **Please state your name and business address for the record.**

   Josh Meyers

2. **What is your current occupation?**

   Project Executive at Moss & Associates (Moss) – Solar.

3. **How long have you worked in that position?**

   Over four years at Moss, and eight years in the same role with different companies.

4. **Did you provide a copy of your biography and or resume for these proceedings?**

   A copy of my resume was filed as ***Exhibit 15***.

5. **Do you specialize in any particular area?**

   I specialize in overall oversight and execution of Engineering/Procurement/Construction (EPC) of utility scale solar projects.

6. **Can you describe the Mahi Solar Project ("*Project*") that is the subject of the SUP application?**

   Mahi Solar is proposing to construct a 120-megawatt solar project, a Battery Energy Storage System ("***BESS***"), and other associated appurtenances including fencing, roads, and electrical infrastructure on roughly 620 acres of agriculture-zoned land.

7. **What is your role with this Project?**

   I am the EPC Project Executive.

8. **Can you describe the Projects location?**

   The project is located on five portions of TMKs (1) 9-2-001:020 and (1) 9-2-004: 003, 006, 010, and 012 in Kunia, O'ahu, Hawai'i and totals approximately 620 acres. The site will be developed in five areas identified as Areas 1, 2, 3, 4A, 4B, 4C, and 5, across the five TMK parcels. The site lies within the traditional moku of 'Ewa and the ahupua'a of Honouliuli.

   The site is bounded by agricultural land to the north, south, east, and west. A portion of the project site is also bound by the Honouliuli Forest Reserve and State of Hawai'i -owned vacant preservation land to the west. The National Park Service ("***NPS***") Honouliuli National Historic Site is located adjacent to the southwest of the proposed site with the

Royal Kunia residential development located further southeast.

9. **What type of project will this be?**

The project will be developed as a Utility Installation, Type B and will provide 120 MW of solar electricity and 480 Megawatt-hours ("***MWh***") of battery storage.

10. **Please explain the Project Components.**

The project includes ground-mounted, single-axis tracking photovoltaic ("***PV***") arrays, a 480 MWh BESS, and a 34.5 kilovolt ("***kV***")/138 kV substation. The project will interconnect through a new 138 kV switchyard, also called a "switching station" adjacent to the existing Kahe-Waiau 138 kV transmission circuit west of Kunia Road. The 138kV transmission line is not currently serving other renewable projects, and no additional easements or rights of way are required.

11. **Please explain the type of solar panels that will be installed.**

Each panel is approximately 48 inches wide and 79 inches long, dark in color, and stands approximately 6 to 8 feet above ground level when flat (0-degree tilt). At maximum rotation or 50-degree tilt, the height of the panel reaches approximately 9 to 12 feet high and is approximately 1 to 3 feet off the ground. Each PV panel is made up of thin-film Cadmium Telluride ("***CdTe***") semiconductor cells or equivalent. The cells are linked together and function as a single unit.

12. **How will the solar panels be installed?**

The PV panels will be installed on single-axis trackers aligned north-south which will vary in length. The trackers will rotate the panels to follow the sun during the day to maximize solar exposure to the face of the module. Trackers are supported by steel pile foundations at intervals. The PV panels may be mounted in either a portrait or landscape orientation, in single or double combination. Based on the preliminary design criteria for the project, there will be approximately one foundation for every eight-to-ten panels. Foundation spacing will be dependent upon the final chosen panel orientation. The array will have approximately 370,000 ground mounted PV panels, for a combined capacity of 120MW (AC).

13. **Please explain how the panels will be mounted.**

PV panels will be mounted on a rack with steel and aluminum construction and will be designed with a wind resistance to meet wind loading requirements per the adopted building code. There will be an approximately 9-foot-wide aisle between adjacent arrays of panels when they are in the horizontal position or 0-degree tilt.

14. **How will the panels be connected?**

The project's PV panels will be connected in series, referred to as a "string". The maximum string size is limited by a maximum system voltage of 1,500 volts direct current ("***VDC***"). For this project's design, a string is a DC circuit of approximately 6 panels each. Each string is connected to a combiner box with a fused disconnect. Typically, a group of approximately 16-30 strings will be connected at the combiner boxes and are limited by the 400A fuse size. A group of approximately 20-30 combiner boxes are connected via DC feeders into a DC/alternating current ("***AC***") inverter which connects to the AC power system.

15. <u>What does the AC power system consist of?</u>

The AC power system consists of pad-mounted equipment, including the inverters, step up transformer and communication equipment, which increases the power from 400-600 volts to a medium voltage of approximately 34.5 kV. Each pad will tie into the 34.5 kV collector system which terminates at the high-voltage AC substation, whereby the voltage will be increased to 138 kV.

16. <u>Will the substation connect to a switchyard?</u>

Yes, the substation connects to a new adjacent 138 kV switchyard. The new 138 kV switchyard will connect to the existing HECO utility line at the property.

17. <u>Do the inverters contain a safety protocol?</u>

Yes, the inverters contain a safety protocol that automatically shuts off the PV facilities in the event the HECO grid loses power. This prevents adverse effects on grid operation, and electricity from leaving the PV facilities and injuring utility line workers who may be working on a nearby power line.

18. <u>What protective devices and safety protocols will be implemented at the PV facility?</u>

The PV facility will integrate protective devices for safe operation, and a Supervisory Control and Data Acquisition ("***SCADA***") which includes a central system controller, generating station protocols, and sensors to perform plant control and system operation. The SCADA system will allow for remote monitoring and control of select facility functions.

19. <u>Will the PV systems be interconnected with a substation?</u>

Yes, the PV systems will be interconnected with a substation located in Area 5 at the southwest corner of the project area.

20. <u>When will electrical power be produced?</u>

Electrical power from the PV system will be produced during daylight hours.

21. **<u>Where will electrical power be stored?</u>**

Power from the PV system may be stored in the BESS and may be discharged from the BESS at any time of day or night.

22. **<u>Where will the BESS be located?</u>**

The BESS will be located in Area 5 of the Project.

23. **<u>Please explain the BESS system.</u>**

The BESS system provides a four-hour discharge duration and storage capacity of 120 MW/480 MWh. The BESS consists of lithium-ion battery cells that are connected in series into a battery module or array. The battery modules are typically stacked and connected into vertical racks containing several modules. The racks are then collected via cables and fed into DC to AC converters that feeds into the Battery Energy Storage inverter. The battery energy storage transformer steps up the voltage from the BESS inverter from 400–600V to 34.5kV. The battery energy system will typically come equipped with controls and communications systems that integrate into the plant's SCADA, including a battery management system to monitor battery state of health and operations. The battery racks will be stored in cabinets/enclosures and laid on top of a gravel pad. The enclosures will contain an internal thermal management system and/or HVAC units to support battery temperature management. The battery enclosures are also rated for outdoor use. Each BESS container is approximately 15 feet high.

24. **<u>What type of operational support facilities will the project consist of?</u>**

The operational support facilities will consist of an outdoor electrical substation, switchyard, and two control enclosures. The support facilities will be located in Area 5.

25. **<u>What will be the medium voltage AC output from the solar project?</u>**

At the substation, the medium voltage AC output from the solar project will be 138 kV and it will be interconnected to the new HECO-owned switchyard.

26. **<u>Please explain the control enclosures.</u>**

There will be two control enclosures, each with an area of approximately 798 square feet, and a height of approximately 13 feet. The control enclosures will house the PV and BESS plant control systems, HECO remote terminal units, communications equipment, and relays and meters. Within the control enclosures, there will be a small battery system to serve as a back-up power system for data collection.

27. **<u>Please explain an inverter station.</u>**

The project will also include 32 PV inverter stations. The inverter stations will be located within the PV solar array field and include inverters and medium voltage transformers. Inverters rated at 3.95-4.2 MW-AC will be used to convert the DC electricity from the PV modules to AC. The AC electricity will be stepped up with a medium voltage transformer at the inverter station and connected to the substation by an underground or overhead medium voltage line.

28. What is the total building area for the facilities and equipment at the project site?

The total building area or lot coverage of the facilities and equipment at the project site will be approximately 6,495,188 square feet (approximately 149.1acres).

29. Are the buildings and equipment governed by AG-1 Restricted Agricultural District development requirements.

Yes, the buildings and equipment will be governed by AG-1 Restricted Agricultural District development requirements such as lot coverage, setbacks, and height restrictions.

30. How will the project be integrated into HECO's grid?

The project will be interconnected to HECO's Kahe-Waiau 138 kV transmission circuit located west of Kunia Road. The medium voltage collection system will transmit generation from the solar array inverters to the BESS and substation along overhead lines to be installed as part of the project.

31. How will the collector lines be installed?

The collector lines will be installed on new wooden structures along existing roadways, where required to comply with existing land use regulations, and then will cross the existing 138 kV lines underground to the BESS yard and project substation.

32. How will the BESS and substation be connected to the HECO switchyard?

The BESS and substation will be connected to the HECO-owned switchyard via an overhead bus structure. A short extension of the adjacent Kahe-Waiau circuit will extend both transmission lines into a proposed ring bus in the switchyard.

33. Will the Kahe-Waiau circuit be the primary Point of Interconnection ("*POI*")?

The Kahe-Waiau circuit is expected to be the primary POI since the 138 kV line located in the vicinity can accommodate the full output of the project without requiring a more elaborate interconnection scheme.

34. Is an alternative generation tie line ("*gen-tie*") route being considered for the Project?

Yes, at the request of HECO, an alternative gen-tie route and substation/switchyard/BESS location is being considered for the project. The alternative would require the substation and BESS yard to be relocated to the southwest corner of Area 3. The same number of panels would be included in the project and shifted from Area 3 to Area 5. The alternative route would interconnect to a HECO switchyard proposed at the Ho'ohana Solar project site, located directly across Kunia Road to the southeast of the project.

35. Are gen-tie poles permitted use within the AG-1 Restricted Agricultural Zoning District?

Yes, gen-tie poles are a permitted use within the AG-1 Restricted Agricultural Zoning District.

36. Is the design of the site, structures and fire access for the project based on applicable requirements of the State of Hawaii Fire Code.

Yes. Appropriate clear areas are incorporated throughout the site. Fencing will be provided around the perimeter of the PV panel areas, at the project substation, HECO switchyard, and BESS area. Batteries will be installed in self-contained enclosures that are constructed across an open-air gravel pad. The self-contained enclosures are remotely monitored and are intended to contain/suppress fires with no active fire response necessary from the Honolulu Fire Department ("***HFD***"). Coordination with the HFD will occur throughout the project design and permit process to ensure adequate access and fire code requirements are met.

37. How will construction activities take place?

Construction activities will take place sequentially, starting with site preparation and grading, followed by the installation of solar PV racking, construction of the BESS, and construction of the substation. Installation of electrical utilities will overlap with each component. Construction of the entire site is planned to be completed in a single phase.

38. When is construction expected to begin?

Construction is expected to begin in early 2022 and continue through late 2023, for a construction duration of approximately 18 months.

39. What will be the access to the site for construction?

Access to the site for construction will be provided from three proposed access points along Kunia Road and an existing network of dirt access roads. A portion of the access road will be improved with grading and compacting during construction. Gravel may also be added strategically to areas along the access road to prevent vehicles from tracking mud outside of the site and onto Kunia Road.

40. What will be the vehicle access within the solar array?

Vehicle access ways will be provided within the solar array and for the inverter stations, and substation area. There will be eight to twelve feet between each tracker row and access paths to inverters will be about 16 to 20 feet wide.

41. <u>What are the hours of construction?</u>

General hours of construction will occur from 7:00 a.m. through 5:30 p.m.

42. <u>How many construction works are anticipated?</u>

Approximately 340 construction workers are anticipated to be on site at peak production, however the number of workers will fluctuate throughout construction.

43. <u>Was a Traffic Assessment completed to evaluate the impact of construction on traffic in the area?</u>

Yes. The Traffic Assessment evaluates the peak of construction and while the site is expected to generate up to 454 daily vehicle trips including trucks and worker vehicles, the traffic assessment indicated that the project would result in temporary impacts during construction. In order to minimize the impact of the additional vehicles, particularly large trucks, turning into and out of the site and to enhance safety for vehicles utilizing the area, it was recommended that the following be implemented: (i) modification of traffic control devices be done; (ii) installation of temporary signage approaching the intersections to inform drivers of construction activities; and (iii) modification of "Do Not Pass" zones.

44. <u>Is the construction of the Project anticipated to generate a significant amount of solid waste?</u>

No. During construction, waste will be temporarily stored onsite and periodically transported and properly disposed of at a permitted facility.

45. <u>What will be the hours of operation and occupancy for the project?</u>

The Project will operate independently seven days per week throughout the year. Typically, the project will have on-site staff during regular working hours during the week and will be remotely monitored 24/7 by staff. The project staff will include one Asset Manager, one Regional Operations Manager and two onsite operations and maintenance technicians for upkeep of the solar farm. Staff performing vegetation maintenance will also periodically access the site. There will be up to five staff supporting the solar PV operation on site at any given time.

46. <u>Will construction generate noise that exceeds acceptable noise levels.</u>

No, while noise levels are likely to increase as result of earth moving equipment, installation of solar panels, construction vehicles and other construction activities, construction activities will be monitored by the State of Hawaii to comply with community noise control articulated in HRS Chapter 11-46.

47. Will air quality be impacted during construction?

In order to ensure that the air quality of the area will not be impacted during construction a dust control management plan will be developed and effects on air quality during construction will be mitigated by compliance with provisions of HAR Section 11-60.1-33 on Fugitive Dust.

48. Will construction require the use of hazardous materials?

Yes, construction will require a limited use of some hazardous materials, such as diesel fuel, gasoline, and lubricants. A project and chemical specific spill prevention, control, and countermeasure plan will be developed and implemented to avoid and minimize the potential impact of hazardous materials.

Respectfully submitted,

Josh Meyers Digitally signed by Josh Meyers DN: C=US, E=jmeyers@mosscm.com, CN=Josh Meyers Date: 2021.06.14 12:57:40-10'00'

JOSH MEYERS

DATED: Honolulu, Hawai'i, June 14, 2021.