Appendix J

Draft Noise Measurement and Evaluation Report
CENSEO AV+ Acoustics
October 19, 2018

DRAFT NOISE MEASUREMENT AND EVALUATION REPORT

KEĀLIA MAUKA HOMESITES

KAPA'A, KAUAI

October 19, 2018

Prepared For:

HHF Planners

Prepared By:

CENSEO AV+ACOUSTICS

www.CENSEO.design

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 Executive Summary

CENSEO AV+Acoustics completed a noise measurement and evaluation study detailing sound levels at Keālia Mauka Homesites a planned housing development in Kapa'a, Kauai.

- Traffic noise:
  - Measured 1-hour L_{eq} ambient sound levels at all measurement locations were between 44 and 61 dBA depending on the time of day. The primary noise source during the ambient noise measurements was vehicular traffic on Kuhio Highway.
  - Traffic noise impacts on future residences are expected for the first row of residences next to Kuhio Highway with direct line-of-sight to the road.
  - 4-foot tall earthen berms or noise barrier walls at the eastern property line are recommended.
- Construction noise:
  - Construction noise is expected to impact nearby residents within 55 feet of residences during periods of construction work.
  - Barrier walls with or without sound-absorbing materials, limiting the number of construction vehicles in use near residences, and limiting the duration of construction operations near residences are feasible noise mitigation options.

2 Introduction

A housing community, Keālia Mauka Homesites has been planned for development. CENSEO AV+Acoustics visited the project area on September 24, 2018 and September 30, 2018 to observe existing conditions and conduct noise level measurements in the project area. This noise measurement and evaluation report summarizes our measurement results, site observations, and analysis. The purpose of this noise study is to measure the existing noise in the project area, identify potential noise impacts to and from the surrounding area as a result of implementing this project, evaluate sound levels with respect to state or local noise regulations, and provide conceptual approaches to noise mitigation.

3 Project Location Description

Keālia Mauka Homesites is a planned housing development located in Kapa'a, Kauai. The proximity of the project site to Kuhio Highway has raised questions about the need for potential noise mitigation. Construction noise may also impact the existing neighboring residences. A map of the project area and the surrounding area is shown in Figure 1.

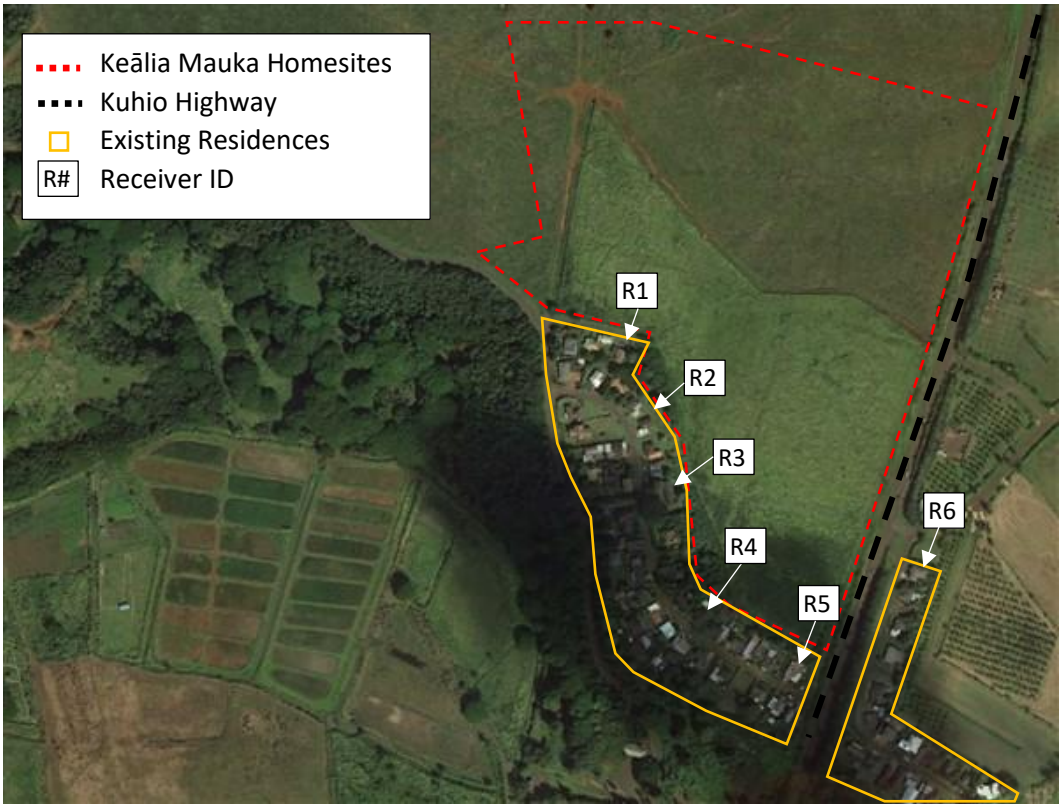

Figure 1: Map of Project Site and Surrounding Area

The properties surrounding the new development are primarily residential with some farmland use. Distances between the existing residences, the project property line, and Kuhio Highway are provided in Table 1 below.

Table 1: List of Noise Sensitive Receivers Locations

Receiver ID	Approximate Address	Receiver Type	Distance from Project Property Line to Existing House	Distance from Kuhio Highway to Residential Property Line
R1	4619 Hopoe Road	Single Family Residence	25 ft.	1100 ft.
R2	4620 Kaao Road	Single Family Residence	50 ft.	830 ft.
R3	4600 Kaao Road	Single Family Residence	25 ft.	670 ft.
R4	4554 Kaao Road	Single Family Residence	35 ft.	460 ft.
R5	4516 Kaao Road	Single Family Residence	30 ft.	100 ft.
R6	2486 Kamalii Street	Single Family Residence	200 ft.	120 ft.

4 Sound Regulations and Guidelines

4.1 State of Hawaii Administrative Rules, Department of Health (DOH)

Hawaii Administrative Rules, Title 11 – Department of Health, Chapter 46 – Community Noise Control regulates environmental noise limits within the state of Hawaii. Table 2 summarizes the maximum permissible noise levels for each zoning district.

Table 2: DOH Maximum Permissible Noise Levels

Land Use	Day Noise Limit (L_{eq}) 7am – 10pm	Night Noise Limit (L_{eq}) 10pm – 7am
Class A – Residential, conservation, preservation, public space, open space, or similar	55 dBA	45 dBA
Class B – Multi-family dwellings, apartment, business, commercial, hotel, resort, or similar	60 dBA	50 dBA
Class C – Agriculture, country, industrial, or similar	70 dBA	70 dBA

In mixed zoning areas, the primary land use designation is used for determining the zoning district. The maximum permissible sound levels shall not be exceeded (at or beyond the property line) by more than 10% of the time for any 20-minute period. The maximum permissible sound levels for impulsive sounds can be up to 10 dB above the maximum sound levels in the table above.

These sound level limits apply to *"stationary noise sources, and equipment related to agriculture, construction, and industrial activities".* The noise regulation further defines stationary sources as *"any mechanical source of noise fixed in or on a station, course, or mode within any premises, including but not limited to mechanical air conditioning units, exhaust systems, generators, compressors, pumps, or other similar equipment".* Therefore, sounds generated by vehicles, hand tools, etc. are not required to satisfy the noise limits shown in Table 2 since these sources do not qualify as a stationary noise sources (defined by the noise regulation).

4.2 Hawaii Department of Transportation, Traffic Noise Impacts

For highway projects, the Hawaii Department of Transportation (DOT) states a traffic noise impact occurs when sound levels at a receptor or common use area approach or exceed the Noise Abatement Criteria (NAC) for Considering Barriers, for defined Land Use Categories or when predicted future sound levels exceed existing levels by 15 dB or more. "Approach" is defined as 1 dBA less than the NAC for the applicable Land Use Category. NAC by Land Use Category is summarized in Table 3. A traffic noise impact requires that noise barriers be constructed if a study finds the construction to be "feasible and reasonable". Feasible and reasonable criteria include that the noise receptor be exposed to sound levels which equal or exceed those contained in Table 3, a noise barrier shall provide a minimum of 5 decibels

of noise level reduction, and the total cost of noise barrier may not exceed $60,000 per benefitted residence.

While the subject of this noise evaluation is not a highway project and the Department of Transportation criteria are not applicable, the criteria can be used as a guideline for assessing noise impacts due to vehicle noise.

Table 3: Noise Abatement Criteria (NAC) for Considering Barriers
(Source: Hawai'i State DOT Highway Noise Policy – 2016)

Land Use Category	$L_{eq}(h)$[1] (dBA) (Evaluation Location)	Description of Land Use Category
A	57 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B[2]	67 (Exterior)	Residential
C[2]	67 (Exterior)	Active sports areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playground, public meeting rooms, public or non-profit institutional structures, radio studios, recording studios, recreation areas, schools, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D[3]	52 (Interior)	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or non-profit institutional structures, radio studios, recording studios, schools, and television studios.
E	72 (Exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F.
F	- -	Agricultural, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G	- -	Undeveloped lands that are not permitted.

Notes:

1. "L_{eq}" means the equivalent steady-state sound level, which in a stated period of time contains the same acoustic energy as the time-varying sound level during the same period. For purposes of measuring or predicting noise levels, a receptor is assumed to be at ear height, located five feet above ground surface. "$L_{eq}(h)$" means the hourly value of L_{eq}.
2. Includes undeveloped lands permitted for this activity category or publicly-owned recreation lands formally designated in a public agency's Master Plan.
3. Use of interior noise levels shall be limited to situations where a determination has been made that exterior abatement measures will not be feasible and reasonable and after exhausting all outdoor mitigation options.

4.3 State Department of Health, Noise Reference Manual, Kauai Edition – Construction Noise

The Hawaii State Department of Health allows construction to occur with the appropriate community noise permits during specific hours, as shown on Table 4. Any excessive noise outside of these hours requires an approved Community Noise Variance.

Table 4: Kauai Construction Hours

Equipment Used	Allowed Hours of Operation
Pile Drivers, Jackhammers, Impact Hammers, Demolition Equipment, etc.	9:00 am – 5:30 pm Monday - Friday
Normal Construction Equipment	7:00 am – 6:00 pm Monday – Friday 9:00 am – 6:00 pm Saturday

4.4 State Department of Health, Construction Noise Permits

A Notification of Intent to Construct must be submitted if the total project cost is less than $250,000 and is not expected to exceed 78 dBA. Otherwise, a Community Noise Permit must be submitted and approved by the state before construction can begin. Loud construction activities outside of normal construction hours require an approved Community Noise Variance.

All relevant noise forms can be found at the Hawaii Department of Health website.
http://health.hawaii.gov/irhb/noiseforms/

4.5 Federal Transit Administration, Construction Noise

The State Department of Health does not quantify allowable construction sound levels. For this analysis, Federal Transit Administration (FTA) noise limits proposed as "reasonable criteria for assessment" are utilized to evaluate property line noise levels. The Construction Noise Limit guidelines are summarized in Table 5.

Table 5: FTA General Assessment Construction Noise Limits

Land Use	One-hour L_{eq} (dBA)	
	Day (7am – 10pm)	Night (10pm – 7am)
Residential	90 dBA	80 dBA
Commercial	100 dBA	100 dBA
Industrial	100 dBA	100 dBA

For this project, a 1-hour L_{eq} of 90 dBA is recommended as the maximum daytime construction noise level at the project boundary to the adjacent residential land use properties. Nighttime construction activities are not recommended.

5 Existing Ambient Sound Environment

5.1 Sound Measurement Equipment and Procedure

Ambient noise level measurements were conducted to assess the existing acoustical environment at the proposed development property and to assess potential noise impacts from the nearby Kuhio Highway. Long-term and short-term measurements were conducted. The measurement equipment used for sound level measurements is described in Table 6 below.

Table 6: Summary of Noise Measurement Equipment

Equipment Type	Manufacturer	Model No.	Equipment Quantity
Sound Level Meter	Larson Davis	831	3
Pre-amp	PCB	PRM831	3
Microphone	PCB	377B02	3
Calibrator	Larson Davis	CAL200	2

At the short-term sound measurement location, the sound level meter was mounted on a tripod (approximately 5 feet above grade). The microphone was directly connected to the sound level meter and an open-cell polyurethane foam wind screen covered the microphone. At each long-term sound measurement location, the microphone and preamplifier were mounted on a tripod (approximately 5 feet above grade) and connected to the sound level meter with a microphone extension cable. The sound level meter was contained in a weather-resistant equipment case and an open-cell polyurethane foam wind screen covered the microphone. Efforts were made to select sound level measurement locations that were representative of the existing ambient sound environment.

The metrics used to evaluate the sound level at each site are the equivalent sound level (L_{eq}), 10% exceedance level (L_{10}), 50% exceedance level (L_{50}), and the 90% exceedance level (L_{90}). The L_{eq} is the average sound level over a specified time period, usually 1-hour. A 1-hour L_{eq} can also be labeled as $L_{eq}(h)$. The L_{90} is the sound level that is less than 90% of the measured sound levels over an hour and is widely accepted as the standard for determining the background noise level. Likewise, the L_{10} is the sound level exceeded 10% of the time and the L_{50} is the sound level exceeded 50% of the time. The L_{10} is a good estimate for the sound level of infrequent events and the L_{50} is an estimate for the sound level of common events. Note that the L_{50} is not necessarily equal to the L_{eq}.

5.2 Sound Measurement Locations

A total of two (2) long-term noise measurement locations and one (1) short term noise measurement locations were selected. These noise measurement locations are shown in Figure 2.

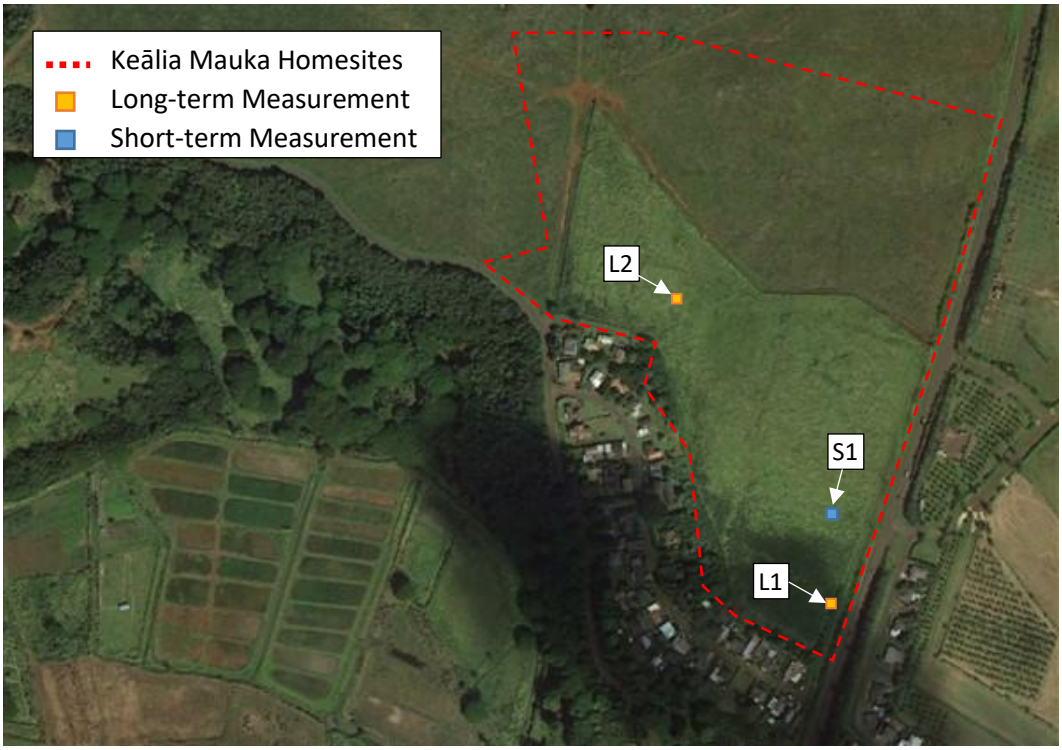

Figure 2: Field Measurement Site Map

The sound level measurement locations, measurement session times, and descriptions of the ambient environments are summarized in Table 7.

Table 7: Measurement Location Summary

Site Name	Location	Sound Sources	Duration	Start Time
L1	Property Line bordering Kuhio Highway On embankment	Primary: Traffic (Kuhio Hwy.) Secondary: Nature	5 days	12:00 PM 9/24/18
L2	Middle of Field Kuhio Highway blocked by hill	Primary: Traffic (Kuhio Hwy.) Secondary: Nature	6 hours	12:00 PM 9/24/18
S1	Near property line bordering Kuhio Highway	Primary: Traffic (Kuhio Hwy.) Secondary: Nature	45 minutes	12:15 PM 9/24/18

5.2.2 Measurement Site L1

Long-term measurement site L1 is on the eastern property line of the project area and is approximately 75 feet from the Kuhio Highway. This meter was placed on an embankment that blocked line-of-sight between the measurement microphone and Kuhio Highway. The measurement session at Location L1 was from Monday, September 24, 2018 through Saturday, September 29, 2018. Site L1 is shown in Figure 3 and Figure 4 shows the measured 1-hour L_{eq}, L_{10}, L_{50}, and L_{90} data.

Figure 3: Long-Term Measurement Site L1

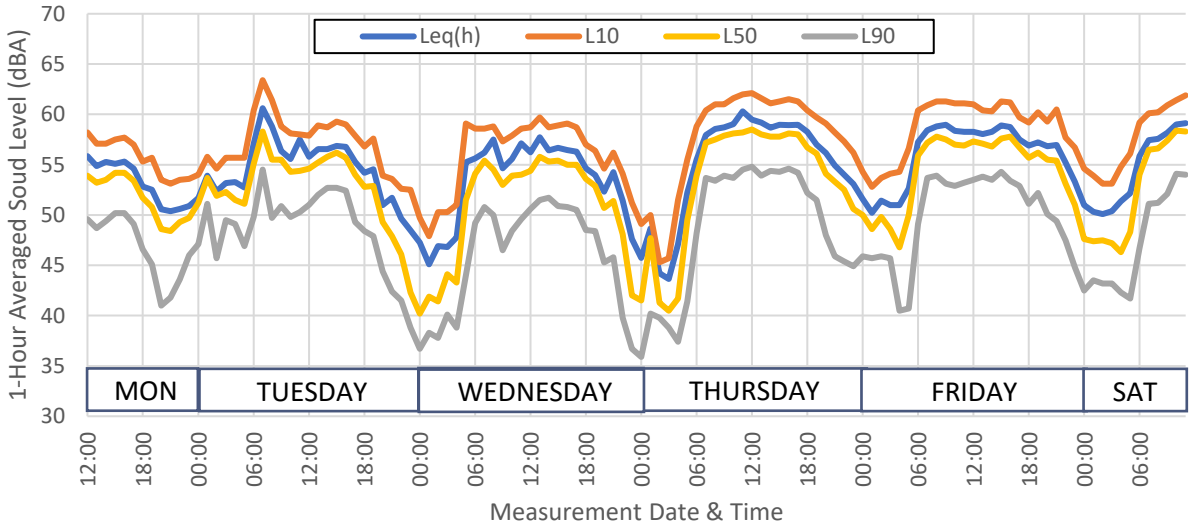

Figure 4: Long-Term Site L1 Measured Sound Levels

5.2.3 Measurement Site L2

Long-term measurement site L2 is in the middle of the project area and is approximately 940 feet from Kuhio Highway. The measurement session at Location L2 was from Monday, September 24, 2018 through Sunday, September 30, 2018. However, an equipment malfunction resulted in only 6 hours of usable data. Sound levels can be extrapolated by comparing the hours where the two long-term measurements overlapped. Since traffic along Kuhio Highway is the sole dominant noise source, the sound level difference between the two long-term measurement locations should remain consistent. Location L2 is shown in Figure 5**.** Figure 6 summarizes the measured 1-hour L_{eq}, L_{10}, L_{50}, and L_{90} data.

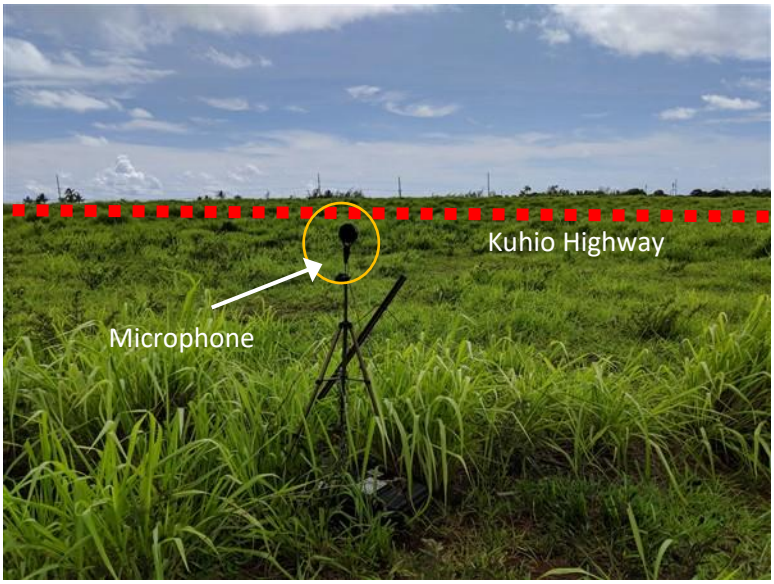

Figure 5: Long-Term Measurement Site L2

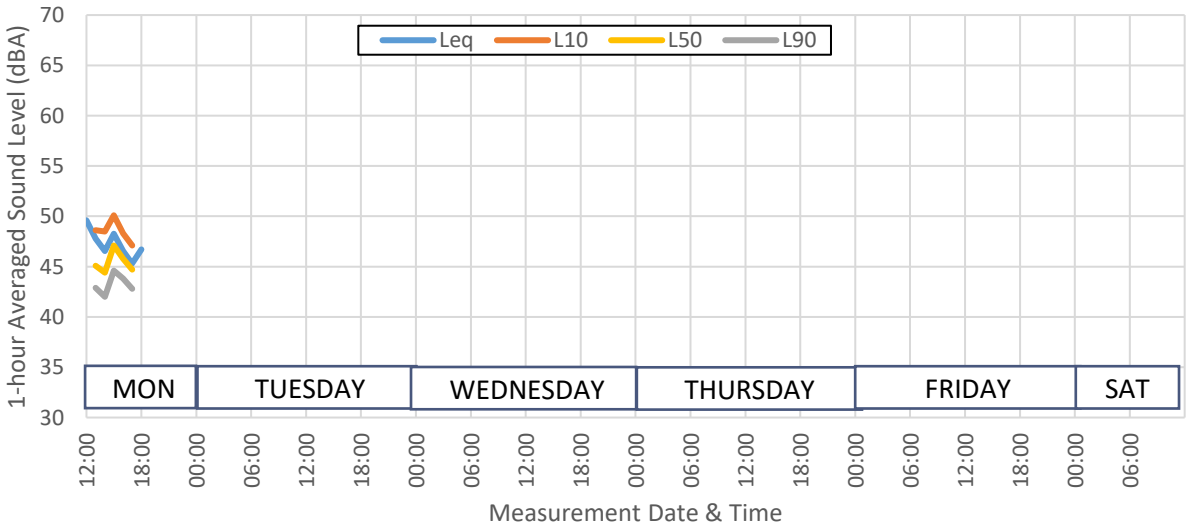

Figure 6: Long-Term Measurement Site L2 Sound Levels

5.2.4 Measurement Site S1

Short-term measurement site S1 is 130 feet from the centerline of the southbound lane of Kuhio Highway. This 45-minute measurement session started at 12:30 PM on Monday, September 24, 2018. Site S1 is shown in Figure 7 and Figure 8 summarizes the measured 1-minute L_{eq}, L_{10}, L_{50}, and L_{90} data. A 30-minute traffic count was also performed during this measurement.

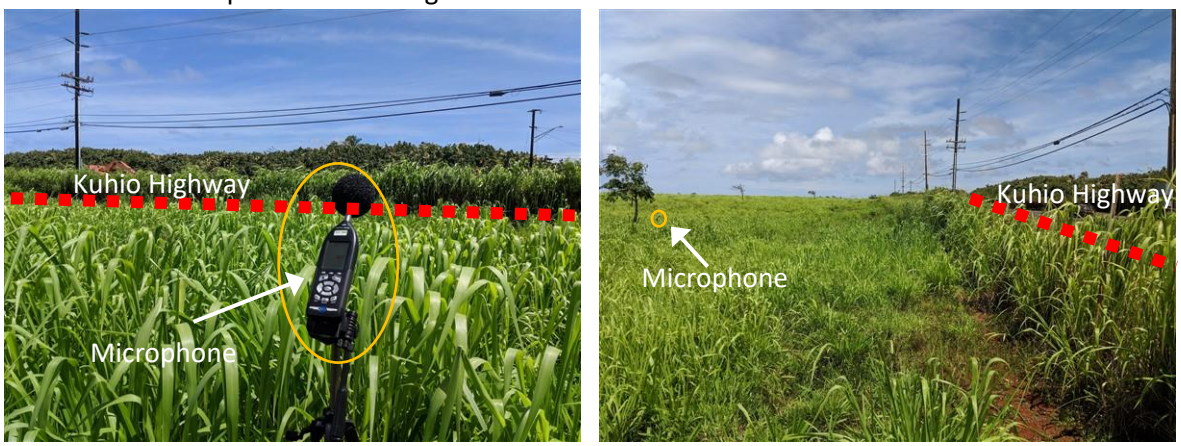

Figure 7: Short-Term Measurement Site S1

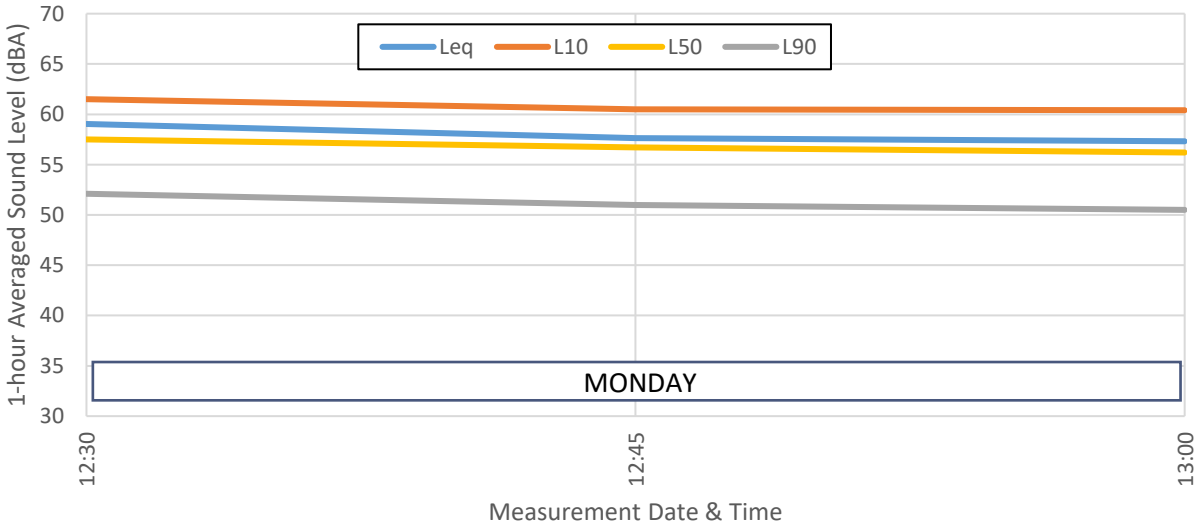

Figure 8: Short-Term Measurement Site S1 Sound Levels

5.3 Sound Measurement Results

5.3.1 Long-Term Measurement Results

Table 8 summarizes the average 24-hour L_{eq}, L_{10}, L_{50}, L_{90}, and peak 1-hour L_{eq} during the long-term measurements.

Table 8: Long-Term Measurement Results Summary

Measurement ID	Distance from Hwy.	Average 24-Hour L_{eq}	Average 24-Hour L_{10}	Average 24-Hour L_{50}	Average 24-Hour L_{90}	Peak 1-Hour L_{eq}
L1	75 ft.	56 dBA	58 dBA	54 dBA	50 dBA	61 dBA
L2[1]	940 ft.	48 dBA	50 dBA	46 dBA	44 dBA	53 dBA

Notes:

1. Sound levels extrapolated by comparing concurrent measurements at L1 and L2.

5.3.2 Short-Term Measurement Results

Traffic noise from Kuhio Highway was the primary noise source for each short-term measurement. Although the total measurement time was less than an hour long, it is representative of the sound levels for the entire hour. Short-term measurement results are shown in Table 9.

Table 9: Short-Term Measurement Results Summary

Measurement ID	Distance from Hwy.	1-Hour L_{eq}	1-Hour L_{10}	1-Hour L_{50}	1-Hour L_{90}
S1	130 ft.	58 dBA	61 dBA	57 dBA	51 dBA

The results of the 30-min traffic count on Kuhio Highway are shown in Table 10

Table 10: Traffic Count Results Summary

Start Time	Duration	Northbound		Southbound	
		Cars[1]	Large Trucks[2]	Cars[1]	Large Trucks[2]
12:30 PM	30-minutes	234	7	188	8

Notes:

1. Includes cars, light trucks, and "light goods vehicles"
2. Includes freight trucks, buses, motorcycles, and other heavy vehicles.

6 Noise Evaluation

The measured ambient sound levels were analyzed with a computer-generated traffic noise model and evaluated with respect to the Hawaii Department of Transportation NAC. When comparing to noise criteria, measured sound levels were adjusted to reflect projected increases in traffic volumes and changes in project site topography. This traffic analysis is based on a traffic count performed during the short-term measurements and information contained in the February 8, 2018 Traffic Impact Analysis Report by Austin, Tsutsumi & Associates included in the draft EIS.

6.1 Traffic Noise Modeling Results (TNM)

The traffic count from Table 10 was used to calibrate a traffic noise model developed using the TNM software. Future traffic noise levels were calculated at locations on the eastern portion of the project site due to the exposure to Kuhio Highway traffic noise. These locations are shown on Figure 9.

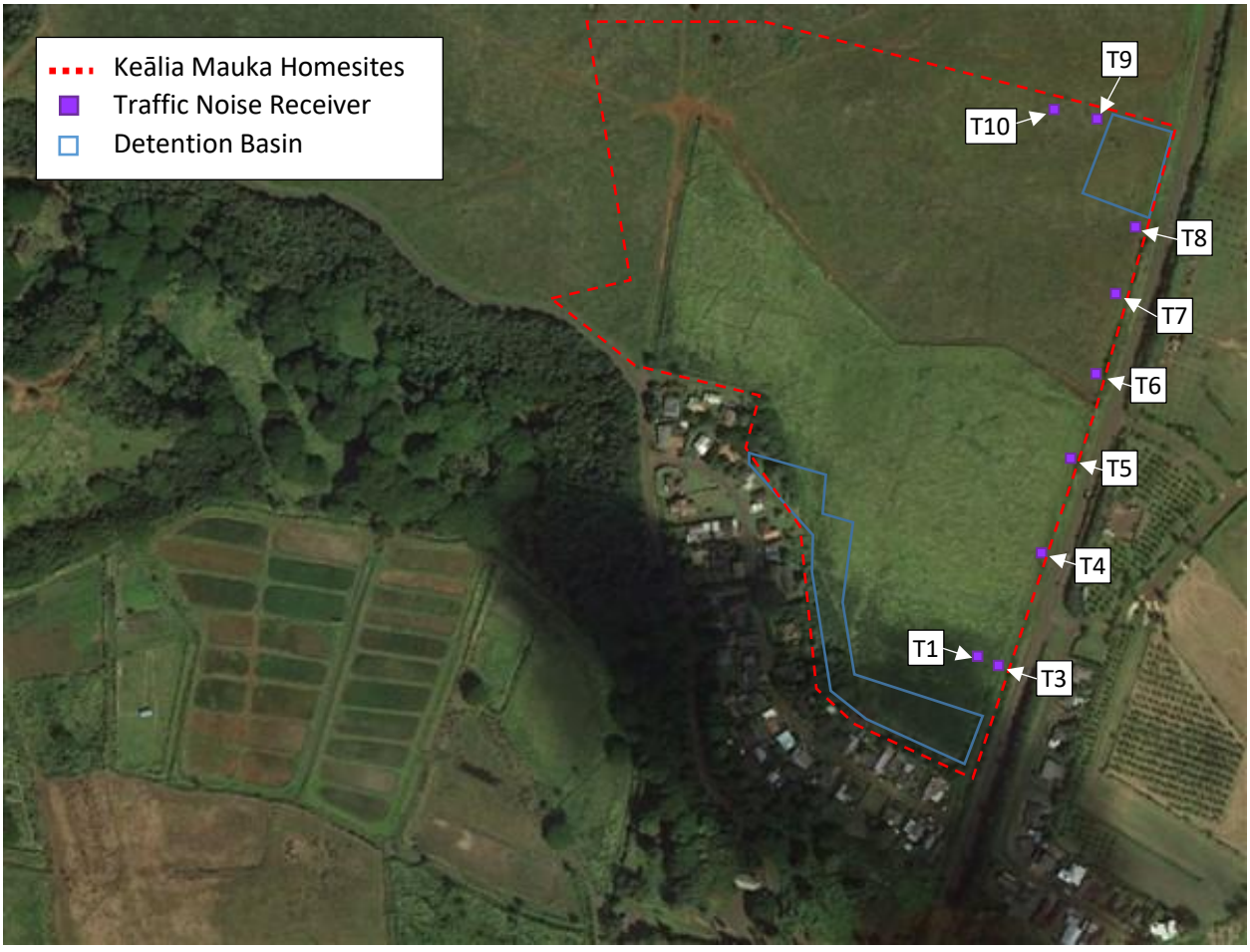

Figure 9: TNM Receiver Locations

Table 11: Predicted Traffic Noise

Receiver ID	Current Conditions		Future 2027 – No Project		Future 2027 – with Project	
	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
T1 (LT1)	64 dBA	63 dBA	65 dBA	65 dBA	63 dBA	64 dBA
T3	70 dBA	70 dBA	71 dBA	71 dBA	67 dBA	68 dBA
T4	71 dBA	71 dBA	72 dBA	72 dBA	66 dBA	68 dBA
T5	71 dBA	71 dBA	72 dBA	72 dBA	67 dBA	69 dBA
T6	71 dBA	70 dBA	71 dBA	71 dBA	68 dBA	70 dBA
T7	65 dBA	65 dBA	66 dBA	66 dBA	69 dBA	70 dBA
T8	67 dBA	67 dBA	68 dBA	68 dBA	70 dBA	71 dBA
T9	52 dBA	52 dBA	53 dBA	53 dBA	62 dBA	62 dBA
T10	50 dBA	51 dBA	51 dBA	52 dBA	59 dBA	59 dBA

As shown in Table 11, calculated noise levels at receiver locations for future Year 2027 without the project are 1 dB louder than current traffic noise levels.

Also shown in Table 12, calculated noise levels at receiver locations for Future Year 2027 with the project are between 6 dB less and 9 dB greater than noise levels without the project. This wide variance between with and without project calculated noise levels is due to changes to the project site topography, contained in the Preliminary Engineering Report by Kodani & Associates dated July 11, 2017, that will affect relative elevations of vehicular noise sources on Kuhio Highway and future residential locations on the project site.

6.2 Comparison to Hawaii Department of Transportation NAC

The Hawaii DOT Noise Abatement Criteria for residential land uses is 67 dB as shown in Table 3. Table 11 shows future traffic noise approaching or exceeding the NAC residential threshold at many locations along the eastern property line. “Approach” is defined as 1 dB below the threshold. If this was a highway project, the first row of residences along the eastern property line would be considered impacted by traffic noise. We recommend that noise mitigation be considered for any new residences along the eastern property line.

6.3 Traffic Noise Modeling with Mitigation

Table 12: Predicted Traffic Noise with Mitigation

Receiver ID	Future 2027 – with Project No Mitigation		Noise Limit	Exceeds Limit?	Future 2027 – with Project with 4' tall Noise Berm/Barrier	
	AM Peak	AM Peak			AM Peak	PM Peak
T1 (LT1)	63 dBA	63 dBA	66 dBA	No	60 dBA	60 dBA
T3	67 dBA	67 dBA	66 dBA	Yes	61 dBA	62 dBA
T4	66 dBA	66 dBA	66 dBA	Yes	59 dBA	60 dBA
T5	67 dBA	67 dBA	66 dBA	Yes	61 dBA	61 dBA
T6	68 dBA	68 dBA	66 dBA	Yes	61 dBA	61 dBA
T7	69 dBA	69 dBA	66 dBA	Yes	62 dBA	63 dBA
T8	70 dBA	70 dBA	66 dBA	Yes	65 dBA	66 dBA
T9	62 dBA	62 dBA	66 dBA	No	61 dBA	61 dBA
T10	59 dBA	59 dBA	66 dBA	No	58 dBA	58 dBA

From Table 12, receiver locations 3 through 8 will be impacted by traffic noise from Kuhio Highway. By implementing a 4-foot tall berm or barrier wall adjacent to Kuhio Highway, sufficient noise attenuation is provided for calculated sound levels to be within the Hawaii DOT NAC residential threshold. Note that berm or barrier wall would follow the elevation of Kuhio Highway rather than the elevation of the project site and the barrier would only be necessary where properties are adjacent to Kuhio Highway and not at detention basins. Figure 10 shows the proposed berm or barrier wall location.

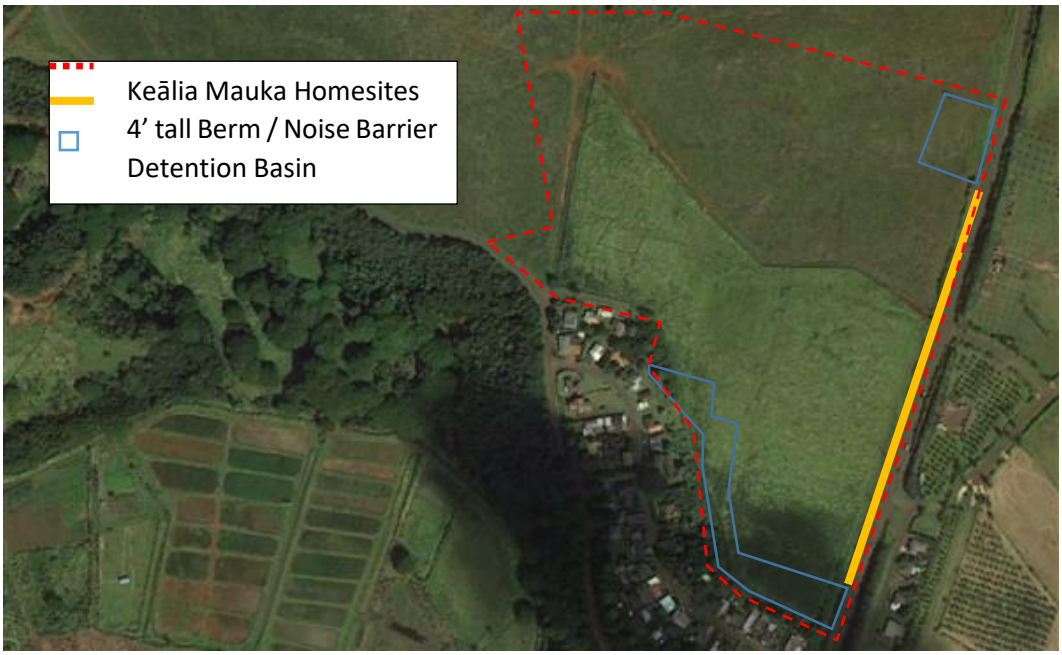

Figure 10: Proposed Noise Mitigation

7 Construction Noise Level Prediction

One of the purposes of this environmental assessment is to predict construction sound levels from the Keālia Mauka Homesites to the noise sensitive areas in the surrounding community. Special attention was focused on the surrounding residential buildings since this type of building tends to be more noise sensitive compared to most industrial and commercial spaces.

7.1 Construction Noise Assessment Procedure, Methodology, and Source Levels

Table 13, taken from the FTA Noise and Vibration Manual, shows reference noise levels for various pieces of construction equipment from 50 ft away. These are the loudest pieces of equipment expected to be used in this project. Construction noise levels at nearby residences can vary significantly. The types and quantity of equipment used, equipment distance from the residence, and ground type are all factors that can affect the noise levels. These levels shown in Table 13 can be adjusted based on these criteria to develop a worst-case construction noise level. We can then determine if construction noise exceeds the recommended 90 dBA threshold at the nearest residences.

Table 13: Construction Equipment Noise Levels

Equipment	Typical Noise Level 50 ft from Source
Backhoe	80 dBA
Grader	85 dBA
Bulldozer	85 dBA
Paver	89 dBA
Compactor	82 dBA
Excavator	81 dBA[A]
Truck	88 dBA

Notes: Abridged version of Table 12-1 from FTA Noise and Vibration Manual, 2006

[A] From FHWA Construction Noise Handbook, Table 9.1

7.2 Construction Noise Assumptions

Construction will be split into three general phases, earthwork, utility installation and paving. Most of the construction work consists of excavation and general earthwork. Backhoes, bulldozers, vibratory compactors, graders, and truck/haulers will be the major noise sources used during the earthwork phase. Backhoes, compactors, trucks, and pavers will be used after the earthwork phase to install roads and utilities.

Detention basins at the north and south ends of the project area will be subject to earthwork only. Pavers will be used on the proposed roadways after the earthwork phase. The remainder of the equipment will be used throughout the project area.

Construction work is limited to 10 acres at a time thus restricting the number of vehicles able to work on the project simultaneously. Though many vehicles are expected to be working in the project area at once, noise at the residences will be dominated by the few vehicles working near the project boundary. It is assumed that construction vehicles will be spaced somewhat evenly throughout the project area and only a maximum of three (3) vehicles will be working near a residence's property line at any one time. The assumed location of equipment use is at the residential property line unless like the paver the equipment is generally restricted to a certain part of the project area.

The project area is mostly grass on soft ground. A ground factor (G) of 0.4 is used to calculate ground attenuation.

7.3 Construction Noise Assessment and Prediction Results

Predicted noise levels at nearby sensitive receivers from the various construction phases are shown in Table 14 below. The overall sound levels are shown in A-weighted decibels.

Table 14: Predicted Construction Noise Levels at Nearby Residences

Noise-Sensitive Receiver	Distance from Residence to Construction	Earthwork Phase Noise Level	Utility Phase Noise Level	Paving Phase Noise Level
R1	25 ft.	97 dBA	94 dBA	91 dBA
R2	40 ft.	93 dBA	90 dBA	77 dBA
R3	35 ft.	94 dBA	91 dBA	82 dBA
R4	40 ft.	93 dBA	90 dBA	71 dBA
R5	30 ft.	96 dBA	92 dBA	68 dBA
R6	200 ft.	77 dBA	74 dBA	70 dBA

The earthwork phase is the main noise concern. Construction noise during the earthwork phase is expected to exceed 90 dBA when vehicles are within 55 ft of a residence. Utility installation noise is expected to exceed 90 dBA when vehicles are within 40 ft of a residence. Paving noise is expected to exceed 90 dBA when vehicles are within 45 ft of a residence.

8 General Sound Mitigation Methods and Techniques

General sound mitigation methods and techniques for attenuating traffic noise to residential receivers include earthen berms and barrier walls. Construction noise and vibration can be mitigated with proper planning and/or various types of barriers. Each of these conceptual approaches are discussed below.

8.1 Earthen Berms

In order to be an effective noise barrier, earthen berms must interrupt the pathway of the noise between the source and receiver. Earthen berms are mounds of earth running between the source and receiver of the noise, typically constructed at a maximum 2:1 slope. Attenuation of up to 15 dBA can be achieved with earthen berms if they are constructed several feet higher than line-of-sight between the source and the receiver. Earthen berms also deflect sound upwards rather than horizontally, so that no additional sound is reflected to the opposite side of the noise source area. However, because of the amount of land required to achieve an effective height, earthen berms are not always practical to implement.

8.2 Barrier Walls

As with earthen berms, for barrier walls to be effective as a noise barrier, the barrier wall must interrupt the pathway of the noise between the source and receiver. Noise attenuation achieved by a noise barrier can be up to 15 dBA if it is several feet higher than the line-of-sight between the noise source and receiver. Barrier walls must be continuous and solid, without any holes, gaps, or openings. Barrier walls must have a minimum density of 4 psf. Typical barrier wall materials include wood, masonry, and precast concrete. To reduce sound energy reflections to the opposite side of the noise source area, acoustically absorptive and weather resistant material should be installed on the surface of the noise barrier wall facing the noise source area. Manufactured barrier wall options include Silent Screen by Empire Acoustical Systems, Noise Shield by IAC Acoustics, and LSE Noise Barriers by Sound Fighter.

8.3 Construction Noise Mitigation

To keep noise levels below the recommended 90 dBA threshold, construction crews should refrain from using loud equipment within 55 feet of a residence. If that is unavoidable, noise impacts may be reduced by utilizing equipment intermittently or by blocking the line-of-sight from noise sources to noise-sensitive receivers with sound-absorbing barriers, material stockpiles, or other designed construction noise mitigation measures. Vehicles should be spread out over the project area and not all working close to the property line simultaneously. Particularly noisy tasks and those in close proximity to the existing residences should be separated throughout the work schedule when possible. All work must be done during approved construction hours unless a noise variance is approved.

Continuous plywood barriers are a commonly used noise barrier option due to the reasonably low cost to fabricate and acoustical effectiveness. However, a potential sound reflection path off the plywood barrier in the opposite direction should be considered. If barrier-reflected noise is an issue, quilted mass-loaded vinyl barriers are an effective noise mitigation option.

8.4 Construction Vibration Mitigation

If vibration from the vibratory compactor is disturbing to nearby residents and generating neighborhood complaints, these vibration inducing activities be scheduled for the middle of the day when the least number of residents are likely to be home.

9 Conclusions

Traffic noise from Kuhio Highway is the primary noise source in the project area. Traffic noise is expected to impact the future project residences closest to the highway. Barrier walls should be constructed along Kuhio Highway at the eastern property line except for along detention basin areas.

Construction noise may impact the existing residences directly adjacent to the project area. Construction crews should refrain from using loud equipment within 55 feet of existing residences. If that is unavoidable, steps should be taken to mitigate the noise impacts with noise barriers, sound-absorbing barriers, or other design construction noise mitigation measures. Limiting the number of construction vehicles operating near existing residences and the duration of those construction operations are also effective mitigation strategies.