Noise and Vibration Technical Report
Honolulu High-Capacity Transit Corridor Project

October 1, 2008

Prepared for:
City and County of Honolulu

Preface

This technical report supports the Draft Environmental Impact Statement (EIS) prepared for the Honolulu High-Capacity Transit Corridor Project. It provides additional detail and information as it relates to:

- Methodology used for the analysis
- Applicable regulations
- Results of the technical analysis
- Proposed mitigation
- Coordination and consultation (as appropriate)
- References
- Model output (as appropriate)
- Other information/data

As described in the Draft EIS, the Locally Preferred Alternative, called the "Full Project," is an approximate 30-mile corridor from Kapolei to the University of Hawaiʻi at Mānoa with a connection to Waikīkī. However, currently available funding sources are not sufficient to fund the Full Project. Therefore, the focus of the Draft EIS is on the "First Project," a fundable approximately 20-mile section between East Kapolei and Ala Moana Center. The First Project is identified as "the Project" for the purpose of the Draft EIS.

This technical report documents the detailed analysis completed for the Full Project, which includes the planned extensions, related transit stations, and construction phasing. The planned extensions and related construction planning have not been fully evaluated in the Draft EIS and are qualitatively discussed in the Cumulative Effects section of the Draft EIS as a foreseeable future project(s). Once funding is identified for these extensions, a full environmental evaluation will be completed in a separate environmental study (or studies), as appropriate.

Figure 1-3 through Figure 1-6 (in Chapter 1, Background) show the proposed Build Alternatives and transit stations, including the areas designated as planned extensions.

Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

ANSI	American National Standards Institute
dB	decibels
dBA	A-weighted sound levels (decibels)
EIS	environmental impact statement
EPA	Environmental Protection Agency
‘Ewa (direction)	toward the west (see also Wai‘anae)
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
H-1	Interstate Route H-1 (the H-1 Freeway)
HDOH	Hawai‘i State Department of Health
ips	Inches per second
Koko Head (direction)	toward the east
L_{dn}	day/night sound level (dBA)
L_{eq}	equivalent sound level (dBA)
L_{max}	maximum sound level (dBA)
LRT	light rail transit
makai (direction)	toward the sea
mauka (direction)	toward the mountains
NEPA	National Environmental Policy Act
O‘ahuMPO	O‘ahu Metropolitan Planning Organization
ORTP	O‘ahu Regional Transportation Plan 2030
RMS	root-mean-square
RTD	City and County of Honolulu Department of Transportation Services Rapid Transit Division
TPSS	traction power substation
UH	University of Hawai‘i
VdB	vibration decibels
Wai‘anae (direction)	toward the west (see also ‘Ewa)

Summary

The City and County of Honolulu Department of Transportation Services Rapid Transit Division (RTD), in coordination with the U.S. Department of Transportation Federal Transit Administration (FTA), is preparing a Draft Environmental Impact Statement (EIS) to evaluate alternatives that would provide high-capacity transit service on O‘ahu. The project study area is the travel corridor between Kapolei and the University of Hawai‘i (UH) at Mānoa. The alternatives being considered are as follows:

1. No Build Alternative
2. Fixed Guideway Transit Alternative via Salt Lake Boulevard (Salt Lake Alternative)
3. Fixed Guideway Transit Alternative via the Airport (Airport Alternative)
4. Fixed Guideway Transit Alternative via the Airport & Salt Lake (Airport & Salt Lake Alternative)

This Noise and Vibration Technical Report presents the noise and vibration impact analysis for high-capacity transit service on O‘ahu. The FTA Noise and Vibration Impact Criteria were used to evaluate the Project’s potential noise and vibration impacts.

Noise and Vibration Criteria

FTA Noise Criteria

The criteria in the FTA guidance manual *Transit Noise and Vibration Impact Assessment* (FTA 2006) are founded on well-documented research on community reaction to environmental noise, and based on change in noise exposure using a sliding scale. The degree to which the Project may increase the existing level of environmental noise is reduced with increasing levels of existing noise. The FTA Noise Impact Criteria group noise-sensitive land uses into the following three categories:

- **Category 1**: Buildings or parks, where quiet is an essential element of their purpose.
- **Category 2**: Residences and buildings where people normally sleep. This includes residences, hospitals, and hotels where nighttime sensitivity is assumed to be of utmost importance.
- **Category 3**: Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, churches, office buildings, and other commercial and industrial land uses.

The day/night sound level (L_{dn}) in units of A-weighted decibels (dBA) is used to describe noise exposure for residential receivers/areas (Category 2). The maximum one-hour equivalent sound level (L_{eq}), also in units of dBA, is used to describe noise exposure for other noise-sensitive land uses such as school buildings (Categories 1 and 3). The FTA criteria include two levels of impact. Interpretations of these levels of impact are as follows:

- **Severe Impact:** Severe noise impacts are considered "significant" as this term is used in the National Environmental Policy Act (NEPA) and implementing regulations. Severe noise impacts represent the most compelling need for mitigation. However before mitigation measures are considered, the project sponsor should first evaluate alternative locations/alignments to determine whether it is feasible to avoid Severe impacts altogether. If it is not practical to avoid Severe impacts by changing the location or design of the project, mitigation measures must be considered. Impacts in this range have the greatest adverse impact on the community; thus there is a presumption by FTA that mitigation will be incorporated in the project unless there are truly extenuating circumstances which prevent it.
- **Moderate Impact**: Project noise levels in the Moderate Impact range will also require consideration and adoption of mitigation measures when it is considered reasonable. While impacts in this range are not of the same magnitude as Severe impacts, there can be circumstances regarding the factors outlined below which make a compelling argument for mitigation. These other factors can include the predicted increase over existing noise levels, the type and number of noise-sensitive land uses affected, existing outdoor/indoor sound insulation, community views, special protection provided by law, and the cost-effectiveness of mitigating noise to more acceptable levels.

FTA Vibration Criteria

The FTA has developed impact criteria for acceptable levels of ground-borne vibration and noise. Ground-borne vibration from transit vehicles is characterized in terms of the root-mean-square (RMS) vibration velocity amplitude. The threshold of vibration perception for most humans is around 65 vibration decibels (VdB). Levels in the 70 to 75-VdB range are often noticeable but acceptable, and levels greater than 80 VdB are often considered unacceptable.

For urban transit systems with 10 to 20 transit movements per hour throughout the day, limits for acceptable levels of residential ground-borne vibration are usually between 70 and 75 VdB. Ground-borne noise is not considered for at-grade or aboveground transit operations, because the level of airborne noise from passing trains that is transmitted through the windows or walls of a building would exceed the ground-borne noise potentially generated inside the building by transit operations.

Existing Conditions

To describe existing baseline noise levels along the study corridor, the Project Team conducted a series of noise measurements at representative locations along the corridor. The following section provides details on the existing noise levels used to establish baseline (existing) environmental noise conditions.

Noise was measured at 53 noise-sensitive locations along the study corridor. These locations were deemed to be a good representation of all noise-sensitive land uses along the study corridor. In total, 29 long-term (24-hour) noise measurements and 24 short-term (15-minute) measurements were conducted in the study corridor.

To determine the maximum-noise-hour L_{eq}, each short-term measurement was compared to the closest 24-hour data obtained during the same hour of the day. The short-term measured levels were then adjusted relative to the 24-hour measurement data to develop a maximum-noise-hour-L_{eq} for each short-term measurement location. Where the short-term measurements were conducted at hotels/motels or residential land uses, the 15-minute noise measurement was adjusted to an L_{dn} level by comparison to the closest 24-hour measurement location during the same hour of the day.

The existing noise levels are primarily the result of motor vehicle traffic on local streets. The 24-hour L_{dn} levels range from 54 to 77 dBA, and maximum-one-hour noise levels range from 56 to 80 dBA L_{eq}.

Ambient vibration levels were not measured as part of this study. The FTA Vibration Impact Criteria were used to identify locations where potential impacts may occur based on existing land use activities. If needed, locations that exceed these criteria will be surveyed for ambient vibration levels at a later time as part of final engineering design. No buildings with special ground-borne vibration concerns were identified.

Noise and Vibration Impacts

No Build

No noise impacts are predicted for the No Build Alternative.

Build Alternatives

This report discusses potential noise impacts by station area for steel wheel technologies, with a solid 3-feet-high parapet wall on both sides of the structure and wheel skirts on the vehicles. Both light rail transit (LRT) and rapid rail technologies would generate potential moderate noise impacts. The Salt Lake Alternative, employing LRT or rapid rail, would result in moderate impacts on the 9^{th} to 15^{th} floors of five high-rise buildings in the Salt Lake area.

Ground vibration levels from operation would not exceed the FTA criterion of 72 VdB for residential buildings and other structures where people normally sleep (Category 2) at any location along the corridor. No land use along the alignment has been identified as having vibration-sensitive equipment that would be subject to lower vibration impact criteria. Therefore, no vibration impacts are projected.

Construction Impacts

Noise Impacts

Noise impacts from construction of the Project would be generated by heavy equipment that would be as close as 50 feet from existing structures along the alignment. These noise levels would be bothersome to nearby residents, but they would be temporary and would not create long-term adverse effects.

Vibration Impacts

Common vibration-producing equipment used during at-grade project construction activities includes jackhammers, pavement breakers, hoe rams, augur drills, bulldozers, and backhoes. Pavement breaking and soil compaction would most likely produce the highest level of vibration. The analysis in Chapter 5, Consequences, presents various types of construction equipment measured under a wide variety of construction activities, with an average of source vibration levels reported in terms of vibration velocity levels. Although one vibration level for each piece of equipment is presented, it should be noted that there is considerable variation in reported ground vibration levels from construction activities. The data provide a reasonable estimate for a wide range of soil conditions.

Noise and Vibration Mitigation

No Build

No noise impacts are predicted under the No Build Alternative. Therefore, no mitigation is proposed.

Build Alternatives

By placing a solid 3-feet-high noise barrier above the top of rail at the edge of the guideway structure and wheel skirts to the LRT vehicles, as part of the design, severe noise impacts have been avoided.

During final design, a detailed analysis of this noise abatement measure will be conducted to determine if additional attenuation from a higher barrier would be necessary and feasible. Additional abatement measures can include higher barriers in places with moderate impacts and the use of sound absorptive materials on the top surface of the track bed.

Mitigation for Construction Noise and Vibration

Noise-control measures during construction would be required to minimize sound levels on existing noise-sensitive land uses. All construction activities will have to comply with Hawai‘i State Department of Health noise regulations.

1 Background

1.1 Introduction

The City and County of Honolulu Department of Transportation Services Rapid Transit Division (RTD), in cooperation with the U.S. Department of Transportation Federal Transit Administration (FTA), is evaluating fixed-guideway alternatives that would provide high-capacity transit service on O‘ahu. The project study area is the travel corridor between Kapolei and the University of Hawai‘i at Mānoa (UH Mānoa) (Figure 1-1). This corridor includes the majority of housing and employment on O‘ahu. The east-west length of the corridor is approximately 23 miles. The north-south width is, at most, 4 miles because the Ko‘olau and Wai‘anae Mountain Ranges bound much of the corridor to the north and the Pacific Ocean to the south.

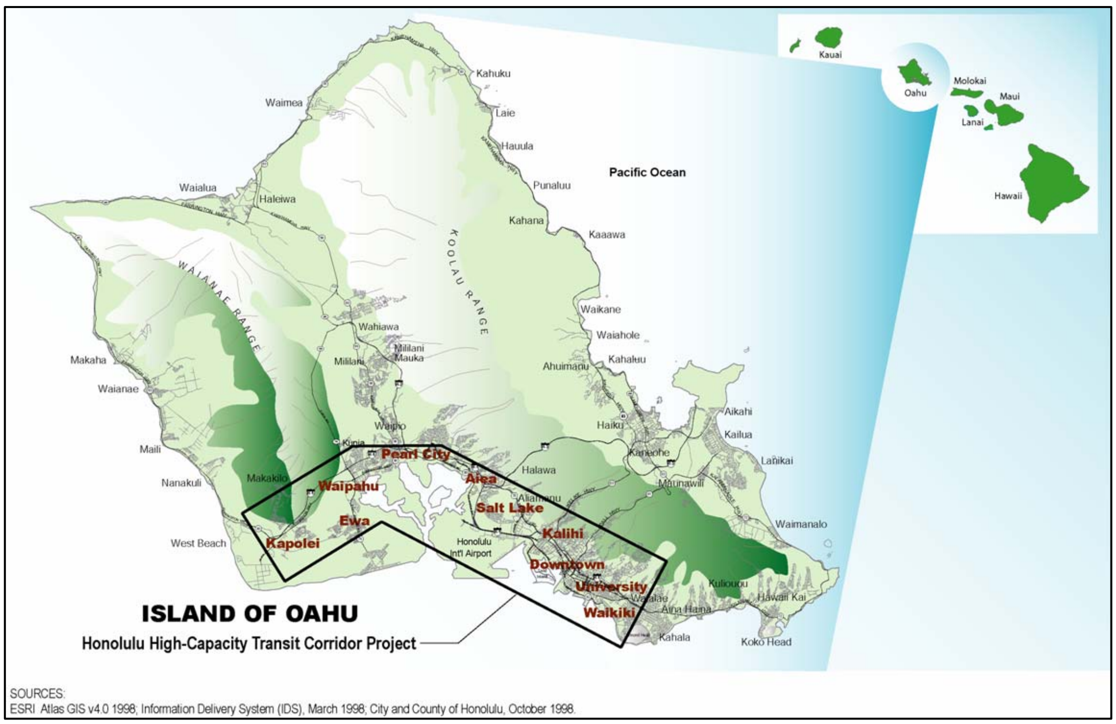


Figure 1-1: Project Vicinity

1.2 Description of the Study Corridor

The Honolulu High-Capacity Transit Corridor extends from Kapolei in the west (Wai‘anae or ‘Ewa direction) to UH Mānoa in the east (Koko Head direction) and is confined by the Wai‘anae and Ko‘olau Mountain Ranges in the mauka direction (towards the mountains, generally to the north within the study corridor) and the Pacific Ocean in the makai direction (towards the sea, generally to the south within the study corridor). Between Pearl City and ‘Aiea, the corridor's width is less than 1 mile between Pearl Harbor and the base of the Ko‘olau Mountains (Figure 1-2).

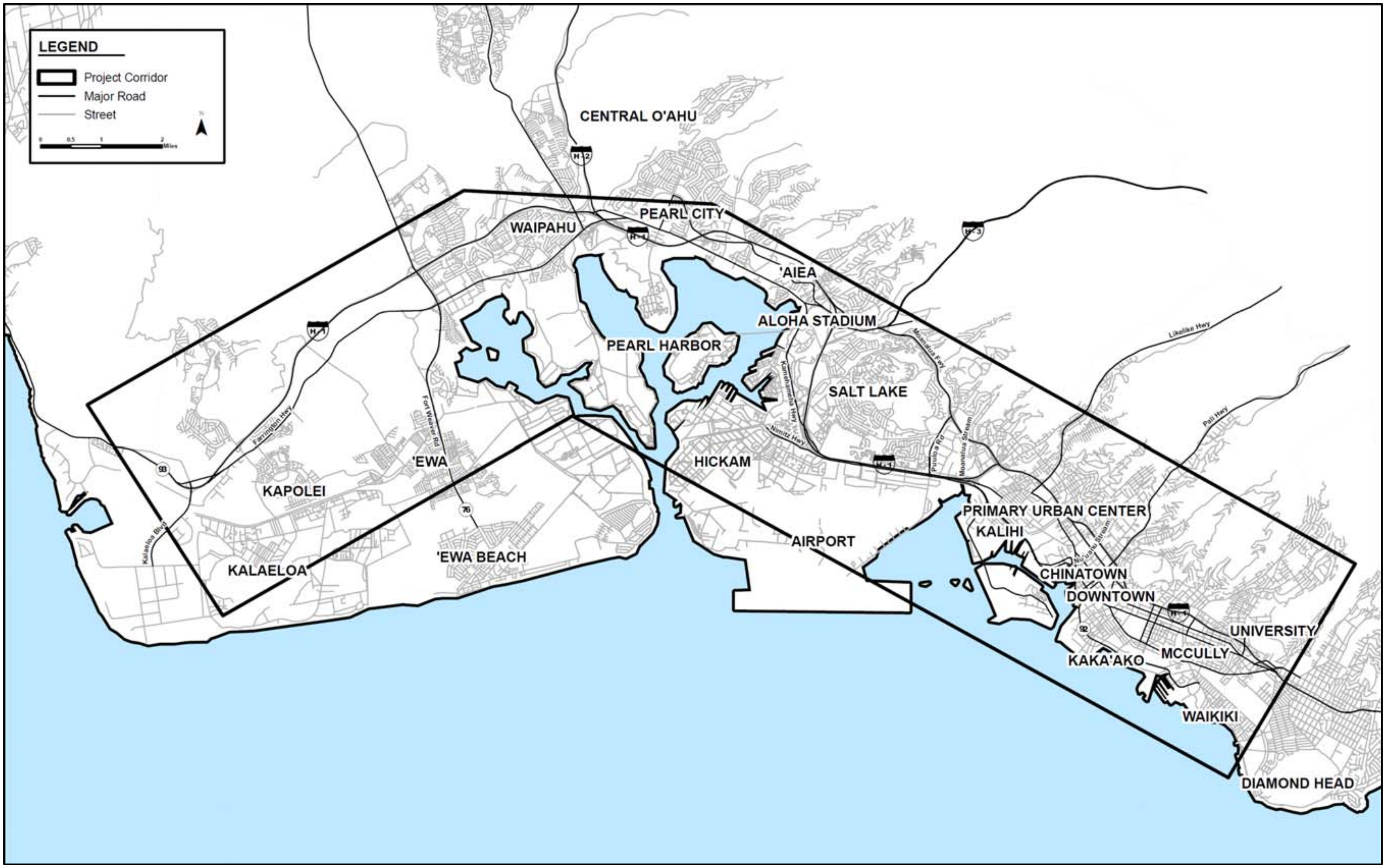


Figure 1-2: Areas and Districts in the Study Corridor

1.3 Alternatives

Four alternatives are being evaluated in the Environmental Impact Statement (EIS). They were developed through a screening process that considered alternatives identified through previous transit studies, a field review of the study corridor, an analysis of current and projected population and employment data for the corridor, a literature review of technology modes, work completed by the O‘ahu Metropolitan Planning Organization (O‘ahuMPO) for its *O‘ahu Regional Transportation Plan 2030* (ORTP) (O‘ahuMPO 2007), a rigorous Alternatives Analysis process, selection of a Locally Preferred Alternative by the City Council, and public and agency comments received during the separate formal project scoping processes held to satisfy National Environmental Policy Act (NEPA) (USC 1969) requirements and the Hawai‘i EIS Law (Chapter 343) (HRS 2008). The alternatives evaluated are as follows:

1. No Build Alternative
2. Salt Lake Alternative
3. Airport Alternative
4. Airport & Salt Lake Alternative

1.3.1 No Build Alternative

The No Build Alternative includes existing transit and highway facilities and committed transportation projects anticipated to be operational by 2030. Committed transportation projects are those identified in the ORTP*,* as amended (O‘ahuMPO 2007). Highway elements of the No Build Alternative also are included in the Build Alternatives. The No Build Alternative would include an increase in bus fleet size to accommodate growth, allowing service frequencies to remain the same as today.

1.3.2 Build Alternatives

The fixed guideway alternatives would include the construction and operation of a grade-separated fixed guideway transit system between East Kapolei and Ala Moana Center (Figure 1-3 to Figure 1-6). Planned extensions are anticipated to West Kapolei, UH Mānoa, and Waikīkī. The system evaluated a range of fixed-guideway transit technologies that met performance requirements, which could be either automated or employ drivers. All parts of the system would either be elevated or in exclusive right-of-way.

Steel-wheel-on-steel-rail transit technology has been proposed through a comparative process based on the ability of various transit technologies to cost-effectively meet project requirements. As such, this technology is assumed in this analysis.

The guideway would follow the same alignment for all Build Alternatives through most of the study corridor. The Project would begin by following North-South Road and other future roadways to Farrington Highway. Proposed station locations and other project features in this area are shown in Figure 1-3. The guideway would follow Farrington Highway Koko Head on an elevated structure and continue along Kamehameha Highway to the vicinity of Aloha Stadium (Figure 1-4).

Between Aloha Stadium and Kalihi, the alignment differs for each of the Build Alternatives, as detailed later in this section (Figure 1-5). Koko Head of Middle Street, the guideway would follow Dillingham Boulevard to the vicinity of Ka‘aahi Street and then turn Koko Head to connect to Nimitz Highway in the vicinity of Iwilei Road.

The alignment would follow Nimitz Highway Koko Head to Halekauwila Street, then along Halekauwila Street past Ward Avenue, where it would transition to Queen Street and Kona Street. Property on the mauka side of Waimanu Street would be acquired to allow the alignment to cross over to Kona Street. The guideway would run above Kona Street through Ala Moana Center.

Planned extensions would connect at both ends of the corridor. At the Wai‘anae end of the corridor, the alignment would follow Kapolei Parkway to Wākea Street and then turn makai to Saratoga Avenue. The guideway would continue on future extensions of Saratoga Avenue and North-South Road. At the Koko Head end of the corridor, the alignment would veer mauka from Ala Moana Center to follow Kapi‘olani Boulevard to University Avenue, where it would again turn mauka to follow University Avenue over the H-1 Freeway to a proposed terminal facility in UH Mānoa’s Lower Campus. A branch line with a transfer point at Ala Moana Center or the Hawai‘i Convention Center into Waikīkī would follow Kalākaua Avenue to Kūhiō Avenue to end near Kapahulu Avenue (Figure 1-6).

Salt Lake Alternative

The Salt Lake Alternative would leave Kamehameha Highway immediately ‘Ewa of Aloha Stadium, cross the Aloha Stadium parking lot, and continue Koko Head along Salt Lake Boulevard (Figure 1-5). It would follow Pūkōloa Street through Māpunapuna before crossing Moanalua Stream, turning makai, crossing the H-1 Freeway and continuing to the Middle Street Transit Center. Stations would be constructed near Aloha Stadium and Ala Liliko‘i. The total guideway length for this alternative would be approximately 19 miles and it would include 19 stations. The eventual guideway length, including planned extensions, for this alternative would be approximately 28 miles and it would include 31 stations.

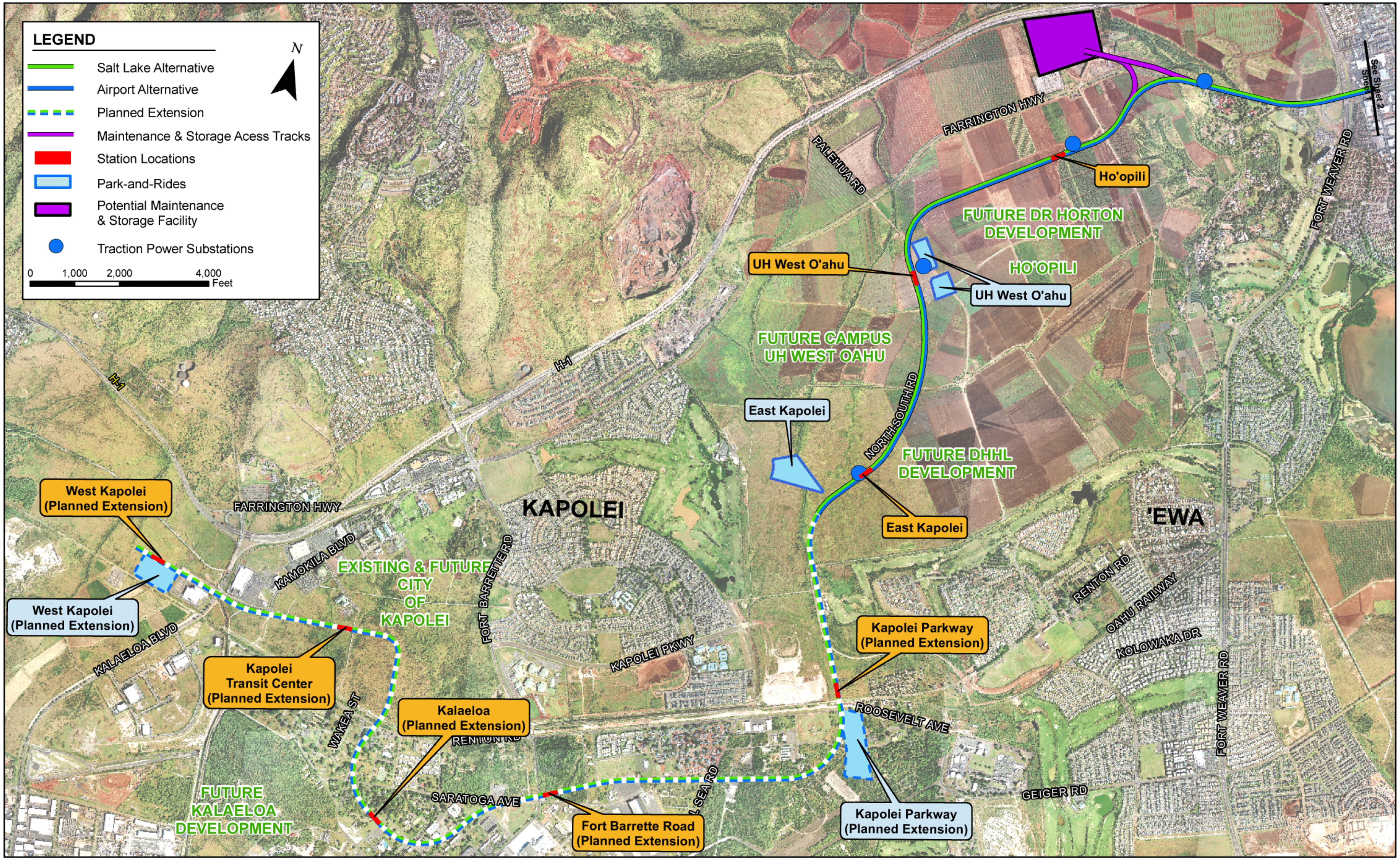


Figure 1-3: Fixed Guideway Transit Alternative Features (Kapolei to Fort Weaver Road)

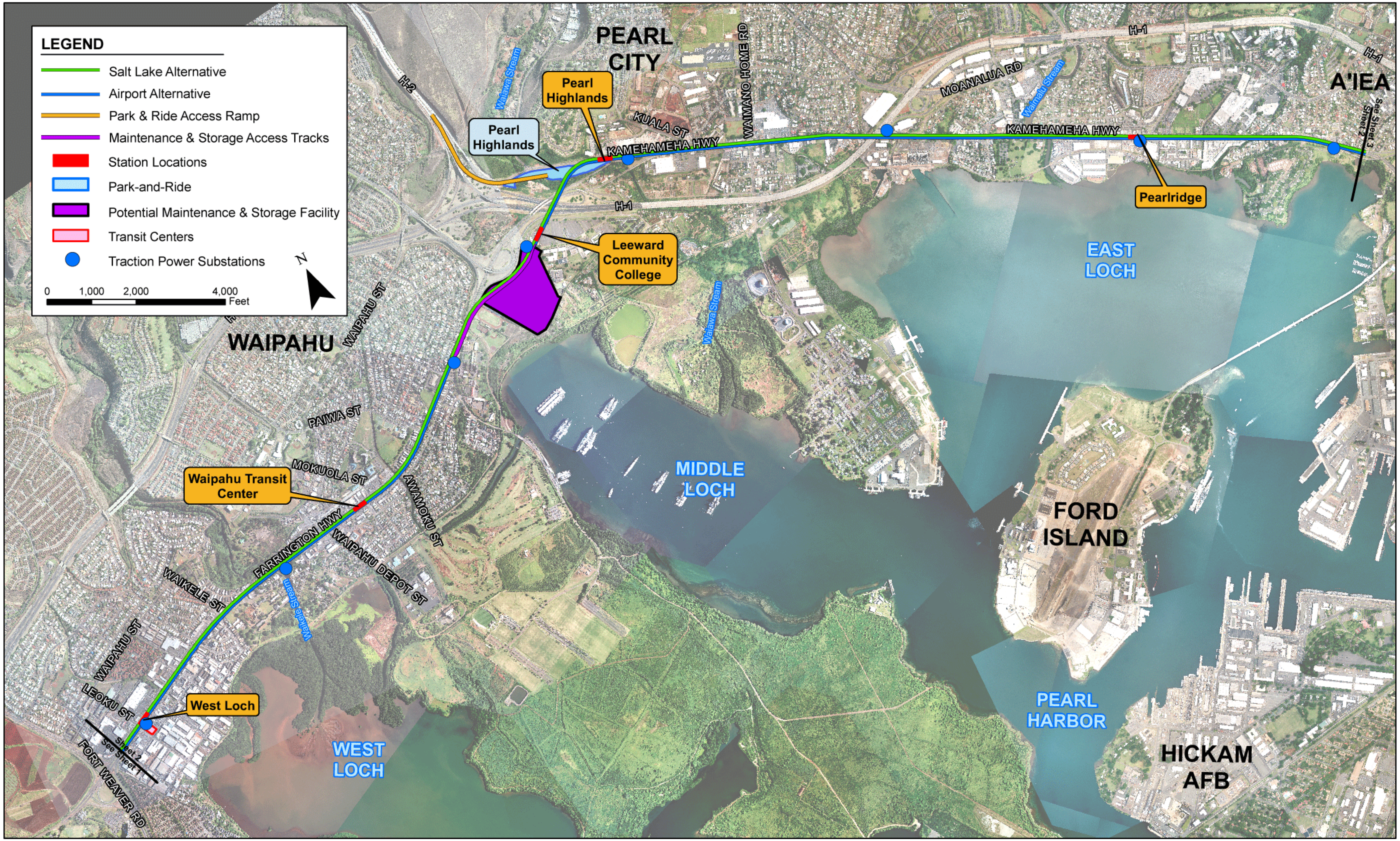


Figure 1-4: Fixed Guideway Transit Alternative Features (Fort Weaver Road to Aloha Stadium)

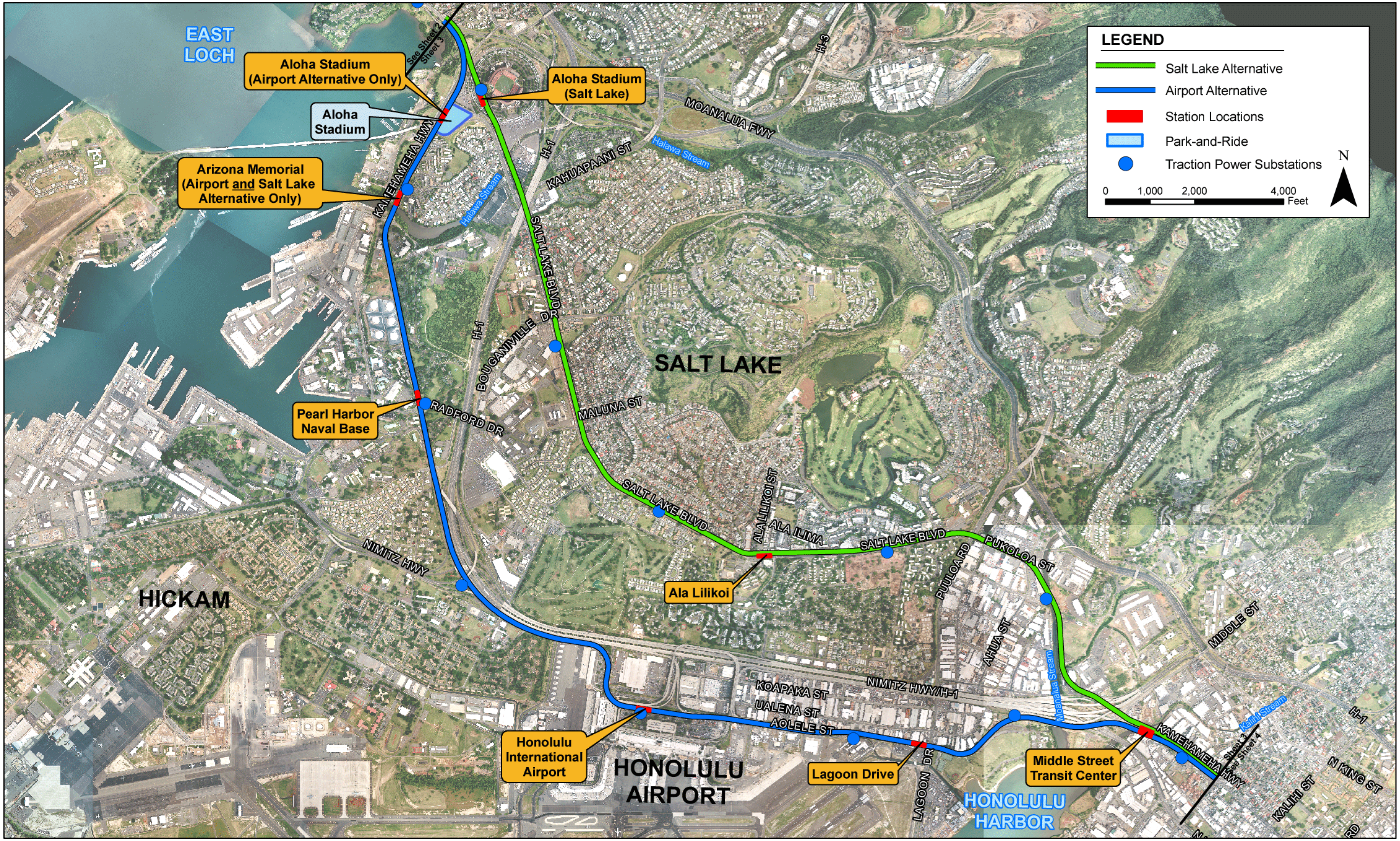


Figure 1-5: Fixed Guideway Transit Alternative Features (Aloha Stadium to Kalihi)

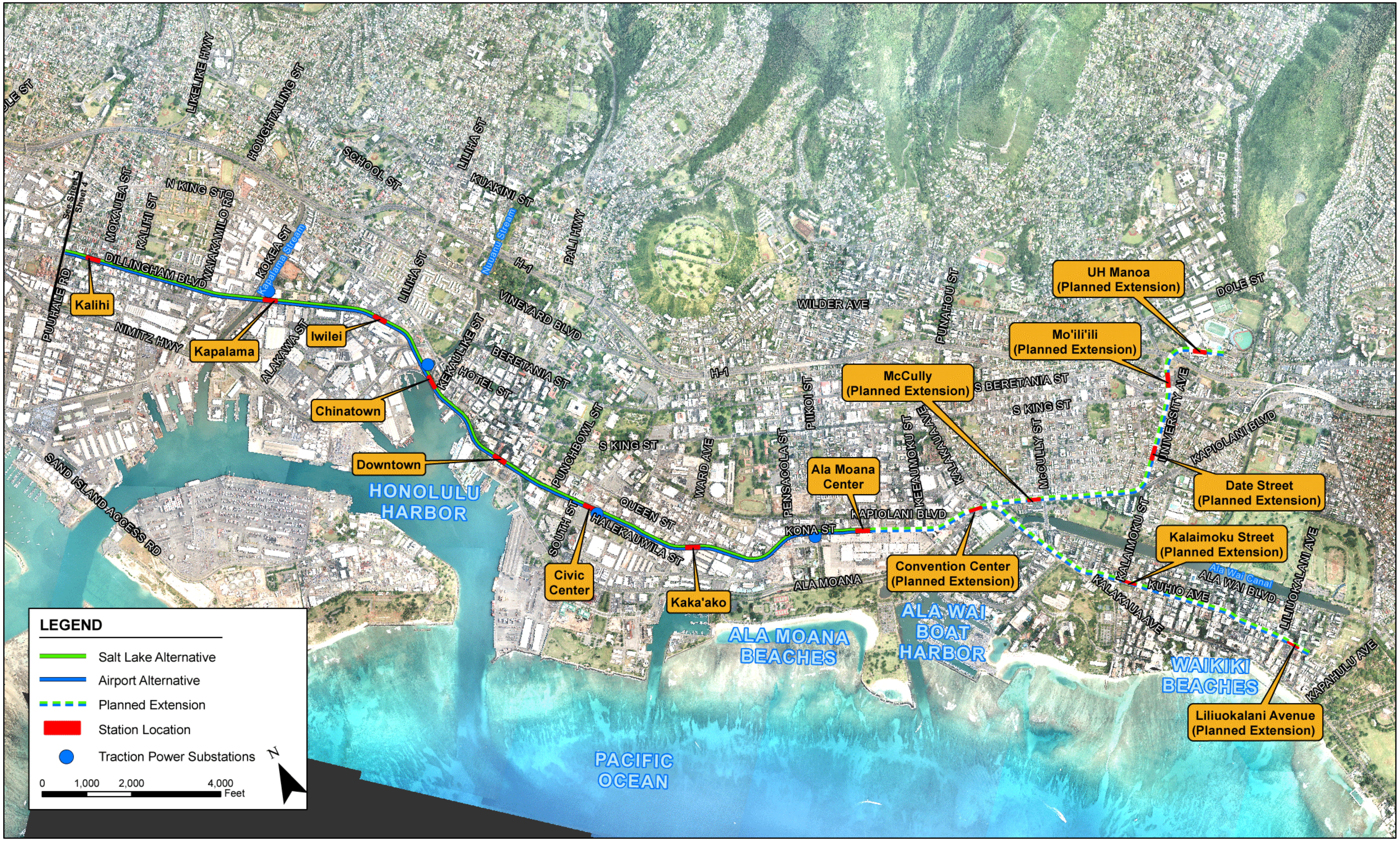


Figure 1-6: Fixed Guideway Transit Alternative Features (Kalihi to UH Mānoa)

Airport Alternative

The Airport Alternative would continue along Kamehameha Highway makai past Aloha Stadium to Nimitz Highway and turn makai onto Aolele Street and then follow Aolele Street Koko Head to reconnect to Nimitz Highway near Moanalua Stream and continuing to the Middle Street Transit Center (Figure 1-5). Stations would be constructed at Aloha Stadium, Pearl Harbor Naval Base, Honolulu International Airport, and Lagoon Drive. The total guideway length for this alternative would be approximately 20 miles and it would include 21 stations. The eventual guideway length, including planned extensions, for this alternative would be approximately 29 miles and it would include 33 stations.

Airport & Salt Lake Alternative

The Airport & Salt Lake Alternative is identical to the Salt Lake Alternative, with the exception of also including a future fork in the alignment following Kamehameha Highway and Aolele Street at Aloha Stadium that rejoins at Middle Street. The station locations discussed for the Salt Lake Alternative would all be provided as part of this alternative. Similarly, all the stations discussed for the Airport Alternative also would be constructed at a later phase of the project; however, the Aloha Stadium Station would be relocated makai to provide an Arizona Memorial Station instead of a second Aloha Stadium Station. At the Middle Street Transit Center Station, each line would have a separate platform with a mezzanine providing a pedestrian connection between them to allow passengers to transfer. The total guideway length for this alternative would be approximately 24 miles and it would include 23 stations. The eventual guideway length, including planned extensions, for this alternative would be approximately 34 miles and it would include 35 stations.

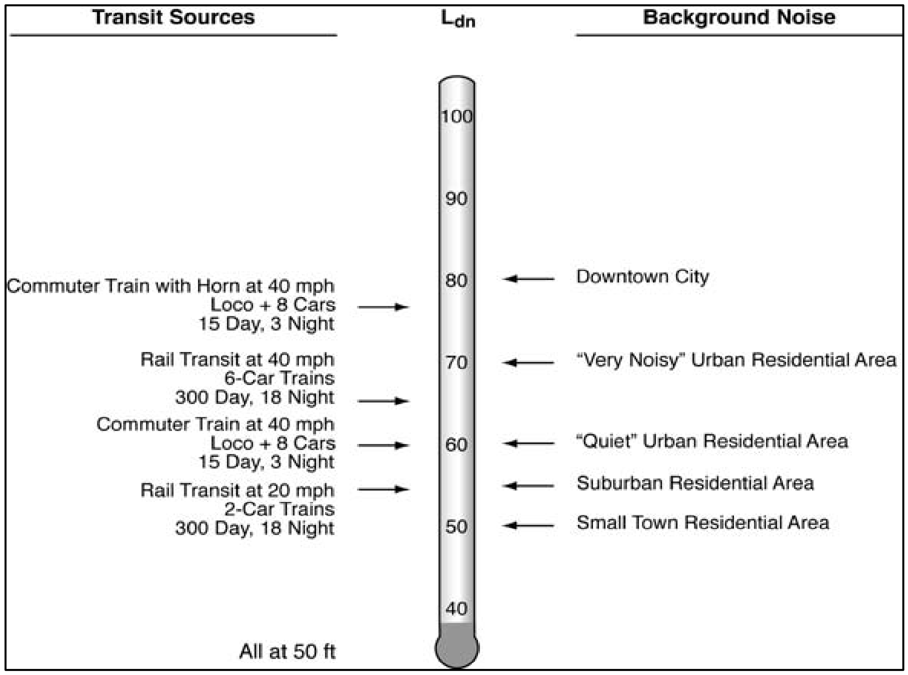
1.3.3 Features Common to All Build Alternatives

In addition to the guideway, the project will require the construction of stations and supporting facilities. Supporting facilities include a maintenance and storage facility, transit centers, park-and-ride lots, and traction power substations (TPSS). The maintenance and storage facility would either be located between North-South Road and Fort Weaver Road or near Leeward Community College (Figure 1-3 and Figure 1-4). Some bus service would be reconfigured to transport riders on local buses to nearby fixed guideway transit stations. To support this system, the bus fleet would be expanded.

2 Studies and Coordination

2.1 Noise Metrics

The basic unit of measurement for noise is the decibel (dB). To better account for human hearing sensitivity to different frequencies contained in sound (or “unwanted sound” called noise), noise is quantified in units of decibels on an "A-weighted scale," abbreviated as dBA. The A scale approximates the average human ear’s sensitivity to sounds comprised of many different frequencies. The terms sound and noise are used interchangeably in the report. The most commonly used noise metric (also called a *noise descriptor*) is the equivalent sound level (L_{eq}), which is the energy sum of all the sound that occurs during a measurement period. This section focuses on a metric known as day-night sound level (L_{dn}), which is used commonly to evaluate environmental noise in areas that contain noise-sensitive uses, such as residential areas. The L_{dn} is a 24-hour L_{eq} with a 10-dB penalty added to noise occurring from 10 p.m. to 7 a.m. The effect of this penalty is that in the calculation of L_{dn}, any sound (or noise event) during nighttime hours is equivalent to 10 identical events occurring during daytime hours. This strongly weights L_{dn} toward nighttime noise, to reflect that most people are more easily annoyed by noise during nighttime hours when background sounds may be lower and most people are sleeping. A rural area with no major roads nearby would have a typical L_{dn} of around 40 dBA; a noisy urban residential area close to a major arterial highway would average around 70 dBA. Most residential areas in the study corridor fall within the range of L_{dn} 60 to 75 dBA. Figure 2-1 provides other typical L_{dn} values for small town residential and urban areas.



Source: Transit Noise and Vibration Impact Assessment, FTA, May 2006

Figure 2-1: Typical L_{dn} Values

2.2 Understanding Ground-Borne Vibration

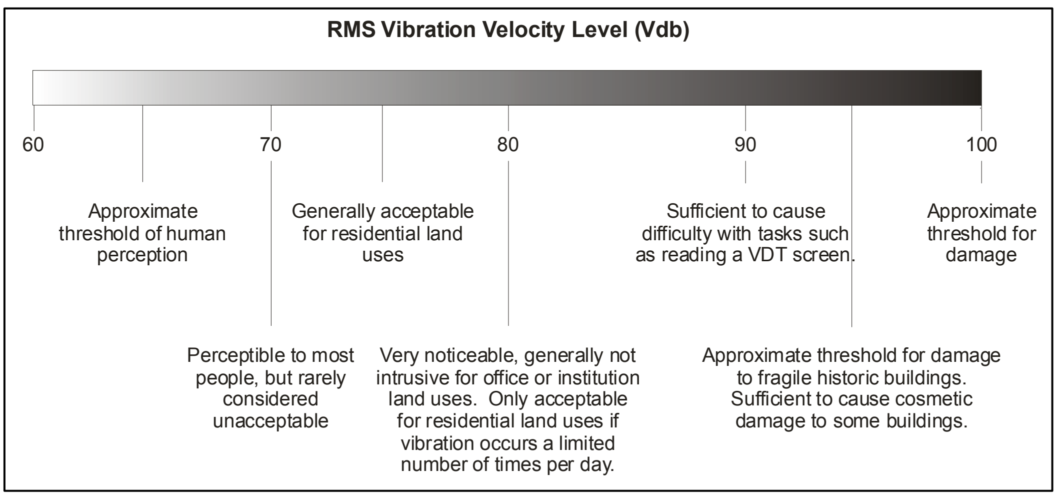
Ground-borne vibration differs from airborne noise in that it consists of energy transmitted through the earth and not the air. It is not a widespread environmental problem, and is generally limited to localized areas near roadways, rail systems, construction sites, and some industrial operations. Automobile and truck traffic rarely create perceptible ground-borne vibration, except where bumps, potholes, or other discontinuities in the roadway surface exist.

When traffic causes phenomena such as rattling windows, the cause is more likely to be acoustic (airborne) excitation rather than ground-borne vibration. The unusual situations where traffic or other existing sources cause intrusive vibration can be an indication of geologic conditions that could also result in higher-than-normal levels of train vibration.

Vibration is an oscillatory (back-and-forth) motion that can be described in terms of the displacement, velocity, or acceleration of the oscillations. Vibration velocity has been standardized as the metric for evaluating environmental vibration effects on humans. Therefore, vibration in this context usually is expressed in units of inches per second (ips). However, because of the very large velocity range over which vibration energy can occur (.001 to 1.0 ips), a more convenient decibel scale has been adopted that allows for compression of this large range into a more practical scale. The velocity of vibration is expressed in units of decibels relative to one micro-inch per second, and the abbreviation *VdB* is used for vibration decibels to minimize confusion with sound decibels. The vibration level in most urban areas ranges typically from about 40 to 100 VdB.

Train vibration is almost always characterized in terms of the root-mean-square (RMS) amplitude. RMS is a widely used but sometimes confusing method of characterizing vibration and other oscillating phenomena. It represents the average energy over a short time interval; typically, a one-second interval is used to evaluate human response to vibration. RMS vibration velocity is considered the best available measure of potential human annoyance from ground-borne vibration, because it has been shown to better correlate with the human body's response to vibration.

Existing background building vibration usually ranges from 40 to 50 VdB, which is well below the range of human perception. Although the perceptibility threshold is about 65 to 70 VdB, human response to vibration is usually not significant unless the RMS vibration velocity level exceeds 70 VdB (Figure 2-2). This is a typical level of vibration noticed 50 feet from a rapid transit or LRT system. Buses and trucks rarely create vibration that exceeds 70 VdB, unless there are large bumps or potholes in the road.



Source: Transit Noise and Vibration Impact Assessment, FTA, May 2006

Figure 2-2: Typical Levels of Ground-Borne Vibration

2.3 Noise and Vibration Criteria

2.3.1 FTA Noise Impact Criteria

The FTA has developed standards and criteria for assessing noise impacts related to transit projects. The standards outlined in *Transit Noise and Vibration Impact Assessment* (FTA 2006) are based on community reaction to noise. These standards evaluate changes in existing noise conditions using a sliding scale. The higher the level of existing noise, the less room there is for a project to contribute additional noise.

Some land use activities are more sensitive to noise than others (e.g., parks, churches, and residences are more noise-sensitive than industrial and commercial areas). The FTA Noise Impact Criteria group sensitive land uses into the following three categories:

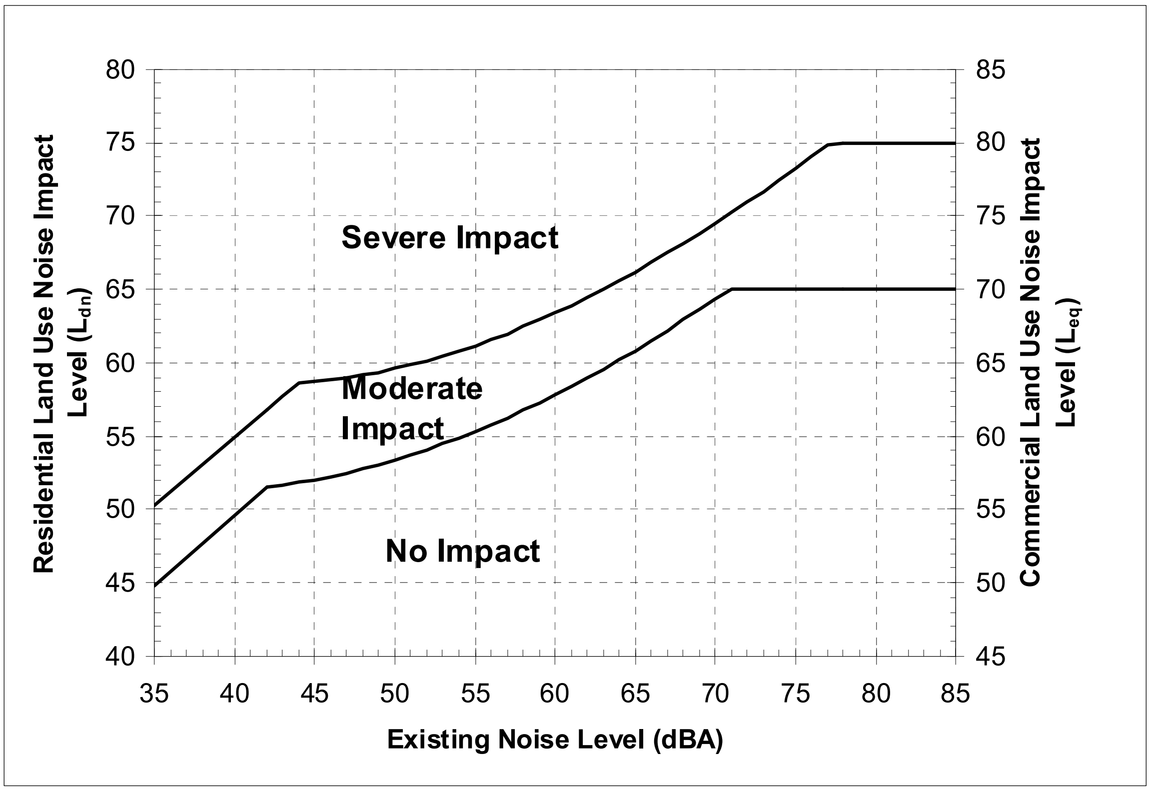
- **Category 1:** Buildings or parks where quiet is an essential element of their purpose.
- **Category 2:** Residences and buildings where people normally sleep. This includes residences, hospitals, and hotels, where nighttime sensitivity is assumed to be of utmost importance.
- **Category 3:** Institutional land uses with primarily daytime use that depends on quiet as an important part of operations (e.g., schools, libraries, and churches).

L_{dn} is used to characterize noise exposure for residential areas (Category 2), and maximum one-hour L_{eq} (during the period that the facility is in use) is used for other noise-sensitive land uses such as school buildings (Categories 1 and 3).

The following two levels of impact are included in the FTA criteria, as shown in Figure 2-3. The level of impact also affects potential mitigation requirements for the Project.

- **Severe Impact:** Severe noise impacts are considered "significant" as this term is used in the National Environmental Policy Act (NEPA) and implementing regulations. Severe noise impacts represent the most compelling need for mitigation. However before mitigation measures are considered, the project sponsor should first evaluate alternative locations/alignments to determine whether it is feasible to avoid Severe impacts altogether. If it is not practical to avoid Severe impacts by changing the location or design of the project, mitigation measures must be considered. Impacts in this range have the greatest adverse impact on the community; thus there is a presumption by FTA that mitigation will be incorporated in the project unless there are truly extenuating circumstances which prevent it.
- **Moderate Impact**: Project noise levels in the Moderate Impact range will also require consideration and adoption of mitigation measures when it is considered reasonable. While impacts in this range are not of the same magnitude as Severe impacts, there can be circumstances regarding the factors outlined below which make a compelling argument for mitigation. These other factors can include the predicted increase over existing noise levels, the type and number of noise-sensitive land uses affected, existing outdoor/indoor sound insulation, community views, special protection provided by law and the cost-effectiveness of mitigating noise to more acceptable levels.

The noise impact criteria for commuter operations are summarized in Table 2-1. The first column shows the existing noise exposure, and the remaining columns show the additional noise exposure caused by a rail project, which is necessary for determining the levels of impact. The future noise exposure would be the combination of the existing noise exposure and the additional noise exposure caused by a rail project. As the existing noise exposure increases, the amount of the allowable increase in the overall noise exposure caused by the Project decreases.



Source: Transit Noise and Vibration Impact Assessment, FTA, May 2006

Figure 2-3: Noise Impact Criteria for Transit Projects

Table 2-1: FTA Noise Impact Criteria

Existing Noise Exposure L_{eq} or L_{dn}[1]	Project Noise Exposure Impact Thresholds: L_{dn} or L_{eq}[1] (all noise levels in dBA)			
	Category 1 or 2 Sites		Category 3 Sites	
	Moderate Impact	Severe Impact	Moderate Impact	Severe Impact
<43	Amb.+10	Amb.+15	Amb.+15	Amb.+20
43-44	52	58	57	63
45	52	58	57	63
46-47	53	59	58	64
48	53	59	58	64
49-50	54	59	59	64
51	54	60	59	65
52-53	55	60	60	65
54	55	61	60	66
55	56	61	61	66
56	56	62	61	67
57-58	57	62	62	67
59-60	58	63	63	68
61-62	59	64	64	69
63	60	65	65	70
64	61	65	66	70
65	61	66	66	71
66	62	67	67	72
67	63	67	68	72
68	63	68	68	73
69	64	69	69	74
70	65	69	70	74
71	66	70	71	75
72-73	66	71	71	76
74	66	72	71	77
75	66	73	71	78
76-77	66	74	71	79
>77	66	75	71	80

Source: Transit Noise and Vibration Impact Assessment, FTA, May 2006

[1]L_{dn} is used for land uses where nighttime sensitivity is a factor; Daytime L_{eq} is used for land uses involving only daytime activities.

Category Definitions:

Category 1: Buildings or parks where quiet is an essential element of their purpose.

Category 2: Residences and buildings where people normally sleep. This includes residences, hospitals, and hotels where nighttime sensitivity is assumed to be of utmost importance.

Category 3: Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, and churches.

2.3.2 FTA Vibration Impact Criteria

The FTA has developed impact criteria for acceptable levels of ground-borne noise and vibration (FTA 2006). Experience with ground-borne vibration from rail systems and other common vibration sources suggest the following:

- Ground-borne vibration from transit vehicles should be characterized in terms of the RMS vibration velocity amplitude. A one-second RMS time constant is assumed. This is in contrast to vibration from blasting and other construction procedures that could cause building damage. When assessing the potential for building damage, ground-borne vibration is usually expressed in terms of the peak particle velocity.
- The threshold of vibration perception for most humans is around 65 VdB; levels in the 70 to 75-VdB range are often noticeable but acceptable; and levels greater than 80 VdB are often considered unacceptable.
- For human annoyance, there is some relationship between the number of events and the degree of annoyance caused by the vibration. It is intuitive to expect that more frequent vibration events, or events that last longer, will be more annoying to building occupants. Because of the limited amount of information available, there is no clear basis for defining this tradeoff. To account for the fact that most commuter rail systems having fewer daily operations than the typical urban transit line, the criteria in the FTA Guidance Manual include an 8-VdB-higher impact threshold if there are fewer than 70 trains trips per day, regardless of the number of cars per train. Thus, for commuter rail systems with less than 70 trains per day, the limit for an acceptable level of residential ground-borne vibration is 80 VdB.
- Ground-borne vibration from any type of train operation will rarely be high enough to cause any sort of building damage, even minor cosmetic damage. The only real concern is that the vibration will be intrusive to building occupants or interfere with vibration-sensitive equipment.
- The vibration of floors and walls may cause a rumble noise within a building. This rumble is the noise radiated from the motion of the room surfaces. In essence, the room surfaces act like a giant loudspeaker. This is called *ground-borne noise*. Ground-borne noise could result in an impact for underground transit operations. It is not considered for at-grade or aboveground transit operations, because the level of airborne noise from the passing train that is transmitted through the windows or walls of a building would exceed the ground-borne noise level occurring inside the building.

Table 2-2 summarizes the FTA impact criteria for ground-borne vibration. These criteria are based on previous standards, criteria, and design goals, including the American National Standards Institute (ANSI) S3.29 (ASA 1983) and the noise and vibration guidelines of the American Public Transit Association (APTA 1981). Some buildings such as concert halls, television and recording studios, and theaters can be very sensitive to vibration but do not fit into any of the three categories. Because of the sensitivity of these buildings, they usually warrant special attention during the environmental review of a transit project. Table 2-3 provides criteria for acceptable levels of ground-borne vibration for various types of special buildings.

Table 2-2: FTA Ground-Borne Vibration Impact Criteria

Land Use Category	Ground-Borne Vibration Impact Levels (VdB re: 1 micro inch/sec)	
	Frequent Events[1]	Infrequent Events[2]
Category 1: Buildings where low ambient vibration is essential for interior operations	65 VdB[3]	65 VdB[3]
Category 2: Residences and buildings where people normally sleep	72 VdB	80 VdB
Category 3: Institutional land uses with primarily daytime use	75 VdB	83 VdB

Source: Transit Noise and Vibration Impact Assessment, FTA, May 2006

[1] "Frequent Events" is defined as more than 70 vibration events per day

[2] "Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

[3] This criterion is based on levels that are acceptable for most moderately sensitive equipment, such as optical microscopes. Vibration-sensitive manufacturing or research uses will require detailed evaluation to define acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC system and stiffened floors.

Table 2-3: FTA Ground-Borne Vibration Impact Criteria for Special Buildings

Type of Building or Room	Ground-Borne Vibration Impact Levels (VdB re: 1 micro inch/sec)	
	Frequent Events[1]	Infrequent Events[2]
Concert Halls	65 VdB	65 VdB
Television Studios	65 VdB	65 VdB
Recording Studios	65 VdB	65 VdB
Auditoriums	72 VdB	80 VdB
Theaters	72 VdB	80 VdB

Source: Transit Noise and Vibration Impact Assessment, FTA, May 2006

[1] "Frequent Events" is defined as more than 70 vibration events per day

[2] "Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

3 Methodology

3.1 Transit Noise Assessment Methodology

The project-related noise levels for the three Build Alternatives and five technological alternatives were based on FTA reference sound levels. The operations assumptions (speed, headways, and schedule) used in the noise analysis were the same as those used in estimating ridership, fare revenue, and other impacts of the Project.

The five technologies studied for the Build Alternatives are LRT, rapid rail (electrically powered), rubber-tired guided transit, monorail, and maglev. The noise impact analysis was performed by combining project-related noise levels from each transit and technological alternative with existing noise levels. The resulting change in anticipated noise levels was compared to the FTA criteria. Based on the identification of potential project-related impacts, appropriate and reasonable mitigation measures were evaluated.

Noise impacts from rail transit operations are generated from the interaction of wheels on track, motive power, and the operation of TPSSs. The interaction of steel wheels on rails generates three different types of noise, depending on track work. These include: (1) noise generated by pass-by trains operating on tangent track sections, (2) noise generated from wheel squeal on tightly curved track, and (3) noise generated on special trackway sections, such as at crossovers or turnouts. The noise impact analysis considered these different sources.

Potentially noise-sensitive land uses and vibration-sensitive buildings were identified, as well as appropriate locations for noise and vibration monitoring. Noise levels were measured at locations along the proposed alternative alignments and near proposed transit station locations, to establish the most sensitive existing environment. All noise measurements were made in accordance with ANSI procedures for community noise measurements.

To assess the potential noise impacts of the transit operations, long-term (24-hour) measurements were conducted at up to 29 sites that include residences and other buildings where people normally sleep. These measurement locations were supplemented with 24 short-term (15-minute) noise measurements, as needed to determine existing noise levels at typical recreational, institutional, and commercial land uses with primarily daytime and evening activity.

Potential noise impacts that may be associated with project-related park-and-ride lots and vehicle maintenance and storage facility operations were also analyzed.

3.2 Transit Rail Vibration Assessment Methodology

Vibration impacts from transit operations are generated by motions/actions at the wheel/rail interface. The smoothness of these motions/actions are influenced by wheel and rail roughness, transit vehicle suspension, train speed, track construction (including types of fixation and ballast), the location of switches and crossovers, and the geologic strata (layers of rock and soil) underlying the track. Vibration from a passing train has the potential to move through the geologic strata, resulting in building vibration transferred through the building foundation. The principal concern is annoyance to building occupants.

Based on the five technologies under consideration, vibration impacts expected from the Build Alternatives were determined using the vibration assessment information and procedures contained in the FTA's *Guidance Manual for Transit Noise and Vibration Impact Assessment*. FTA reference levels for transit vehicles, or if available, vibration measurements from vehicles similar to those proposed for this Project, were used to represent the train's force density level function. Transfer mobility functions used to determine the ground attenuation were based on FTA reference data. The combination of force density and transfer mobility functions provide an estimate of ground vibration as it relates to distance from the fixed guideway.

All estimates of ground-borne vibration were projected to the foundation of each building, and do not include estimates of building coupling loss. Predicted ground-borne vibration levels were compared to the FTA criteria to determine potential impacts.

The maintenance and storage facility operations for the Project were also analyzed. Potential noise impacts that may be associated with transit park-and-ride lots will also be identified.

3.3 Construction Noise and Vibration Assessment Methodology

Because the means and methods of construction will not be known until a contractor is selected for the Project, this analysis was based on typical activities and equipment used for demolition, excavation, and erection work phases. Both daytime and nighttime construction activities were analyzed, because it is likely that construction work would occur 24 hours a day. Impact equipment, such as a pile driver, is expected to result in levels of ground-borne vibration and noise that could affect nearby buildings.

4 Affected Environment

Prior to performing an analysis of future noise and vibration levels, it was necessary to establish existing baseline noise levels along the study corridor. This was accomplished by performing a series of measurements at representative locations along the corridor. Ambient vibration levels were not measured as part of this study. FTA Vibration Impact Criteria were used to identify locations where potential impacts may occur based on existing land use. If necessary, locations that exceed the FTA Vibration Impact Criteria will be surveyed for ambient vibration levels as part of the Project's final engineering and design phase. This chapter provides details on the noise survey used to establish baseline conditions.

Noise measurements were performed at 53 noise-sensitive locations along the study corridor. These locations were evaluated and deemed to be representative of all noise-sensitive land uses along the corridor. Most of the measurements were taken at ground floor elevations, except in locations that included buildings of four or more stories with sensitive land uses. At the locations shown on Figure 4-1 through Figure 4-4 and in Table 4-1 and Table 4-2, at the end of this chapter, 29 long-term (24-hour) noise measurements and 24 short-term (15-minute) measurements were conducted. This chapter discusses the existing land use and noise environment between the proposed station locations along the proposed alignments.

4.1 West Kapolei to Kapolei Transit Center

Land uses between the West Kapolei Station and the Kapolei Transit Center Station are industrial and commercial (Category 3). There are no sensitive land uses along the alignment between these two stations.

4.2 Kapolei Transit Center to Kalaeloa

Land uses between the Kapolei Transit Center and Kalaeloa Station are undeveloped land mauka of Franklin D. Roosevelt Avenue, and military single-family and multifamily housing complexes (Category 2) between Franklin D. Roosevelt Avenue and Kalaeloa Station. This area is slated for redevelopment. Monitoring Location A describes the existing noise environment for the 15 residential buildings in the area. Currently, there is no dominant source of noise in this area. A maximum-hour L_{eq} of 60 dBA and an L_{dn} of 59 dBA were measured.

4.3 Kalaeloa to Fort Barrette Road

Land uses between the Kalaeloa Station and the Fort Barrette Road Station are military single-family and multifamily residences (Category 2) and office buildings (Category 3). This area is slated for redevelopment. Residential land uses are located around Kalaeloa Station; Monitoring Location A was used to describe the existing noise environment for the seven residential buildings in that area. Currently, there is no dominant source of noise in this area. A maximum-hour L_{eq} of 60 dBA and an L_{dn} of 59 dBA were measured.

4.4 Fort Barrette Road to Kapolei Parkway

Land uses between the Fort Barrette Road Station and the Kapolei Parkway Station are mostly open space, with a group of residential buildings (Category 2) around the Independence Road/Coral Sea Road intersection. Monitoring Location B represents the existing noise environment at the 20 residences along these two roads. Independence Road is the main noise source in the area. A maximum-hour L_{eq} of 75 dBA and an L_{dn} of 74 dBA were measured.

4.5 Kapolei Parkway to East Kapolei

Land uses between the Kapolei Parkway Station and the East Kapolei Station are residential buildings (Category 2) located between Franklin D. Roosevelt Avenue and Kapolei Parkway. The area mauka of Kapolei Parkway is undeveloped. The alignment is proposed along the centerline of the future North-South Road. Monitoring Location C reflects the existing noise environment. Currently, Franklin D. Roosevelt Avenue is the main noise source in the area. A maximum-hour L_{eq} of 57 dBA and an L_{dn} of 54 dBA were measured.

4.6 East Kapolei to UH West O‘ahu

Land use between the East Kapolei Station and the UH West O‘ahu Station is open space. The ‘Ewa Development Plan calls for this area to be developed as residences, and UH is planning construction of a campus in the area. The alignment runs along the Koko Head side of the new North-South Road. Because there are no existing sensitive land uses in the area and development in the area has yet to be approved, no noise measurements were conducted between these stations.

4.7 UH West O‘ahu to Ho‘opili

Land uses between the UH West O‘ahu Station and the Ho‘opili Station are open space and farmlands. The ‘Ewa Development Plan calls for mixed-use development in this area, including residences and commercial land uses. Because there are no existing sensitive land uses in the area and development in the area has yet to be approved, no noise measurements were performed between these stations.

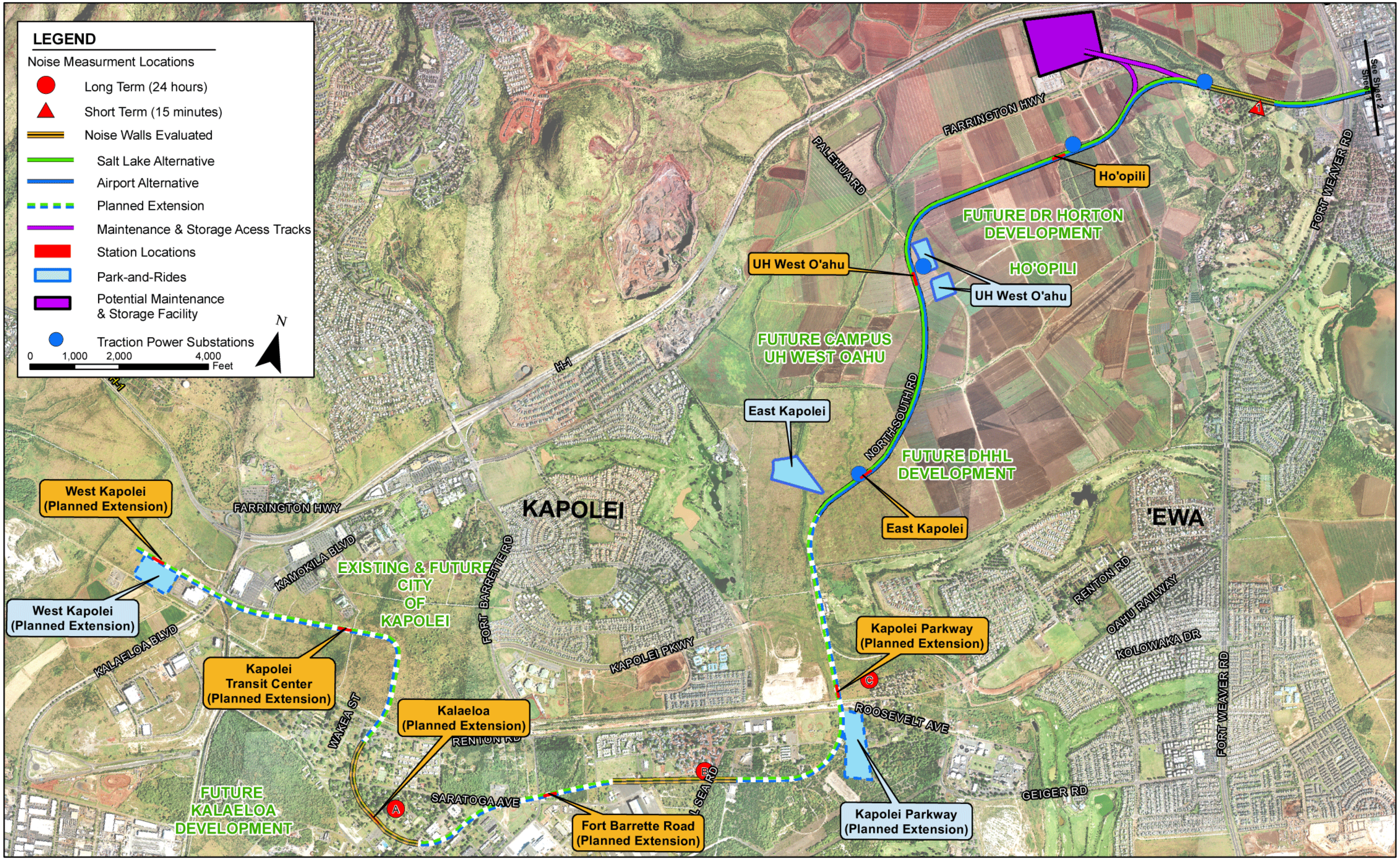


Figure 4-1: Noise Measurement Locations (Kapolei to Fort Weaver Road)

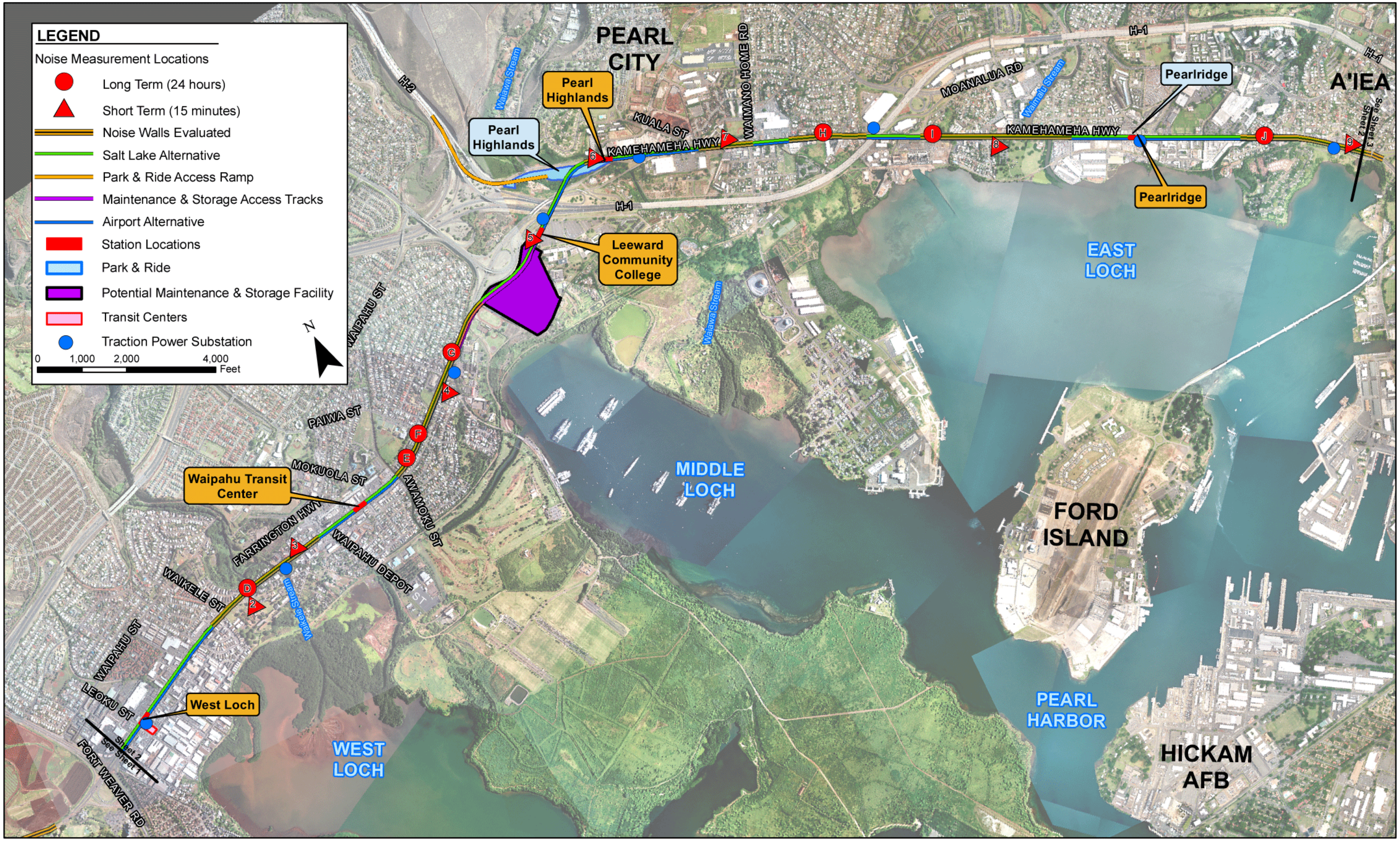


Figure 4-2: Noise Measurement Locations (Fort Weaver Road to Aloha Stadium)

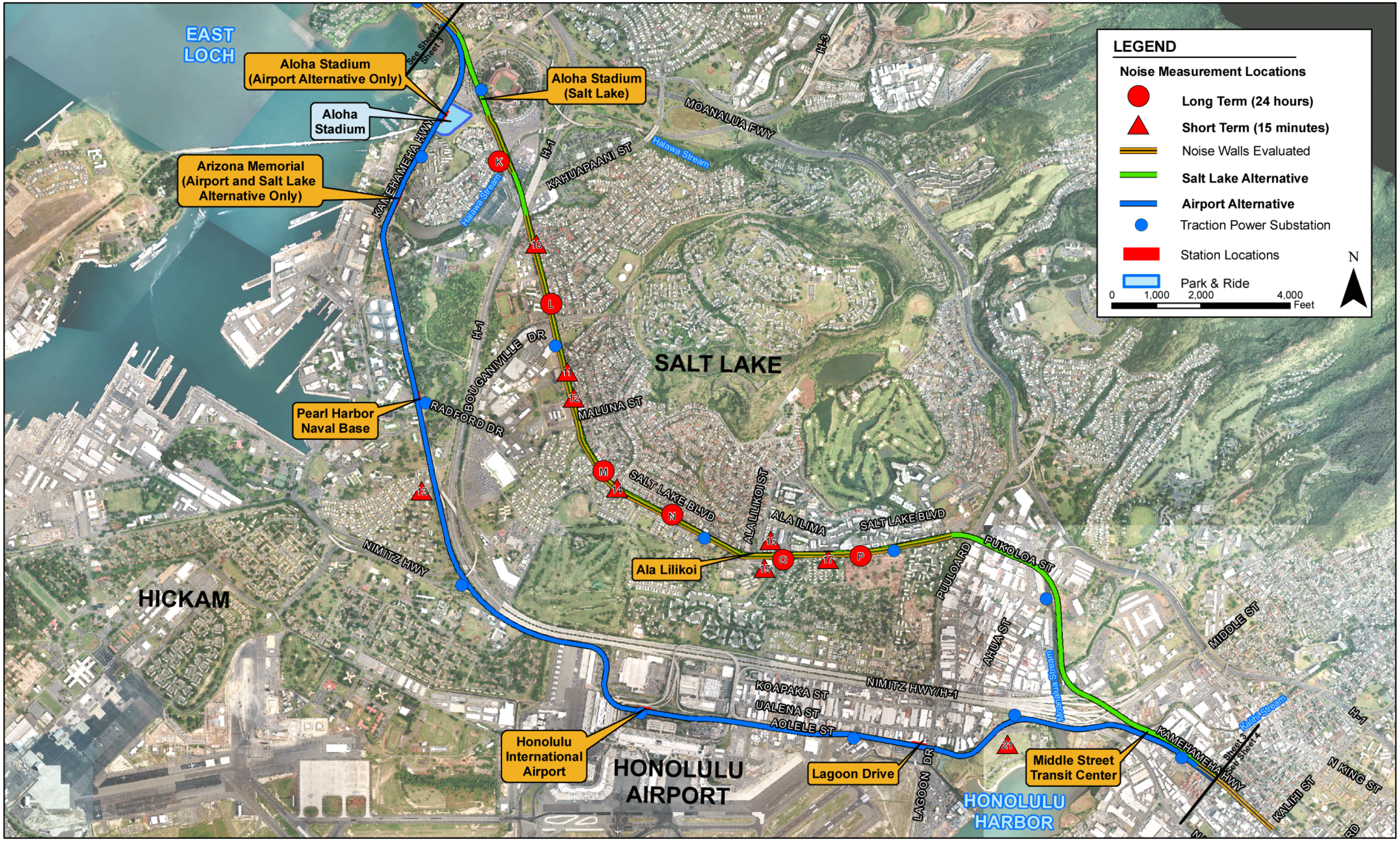


Figure 4-3: Noise Measurement Locations (Aloha Stadium to Kalihi)

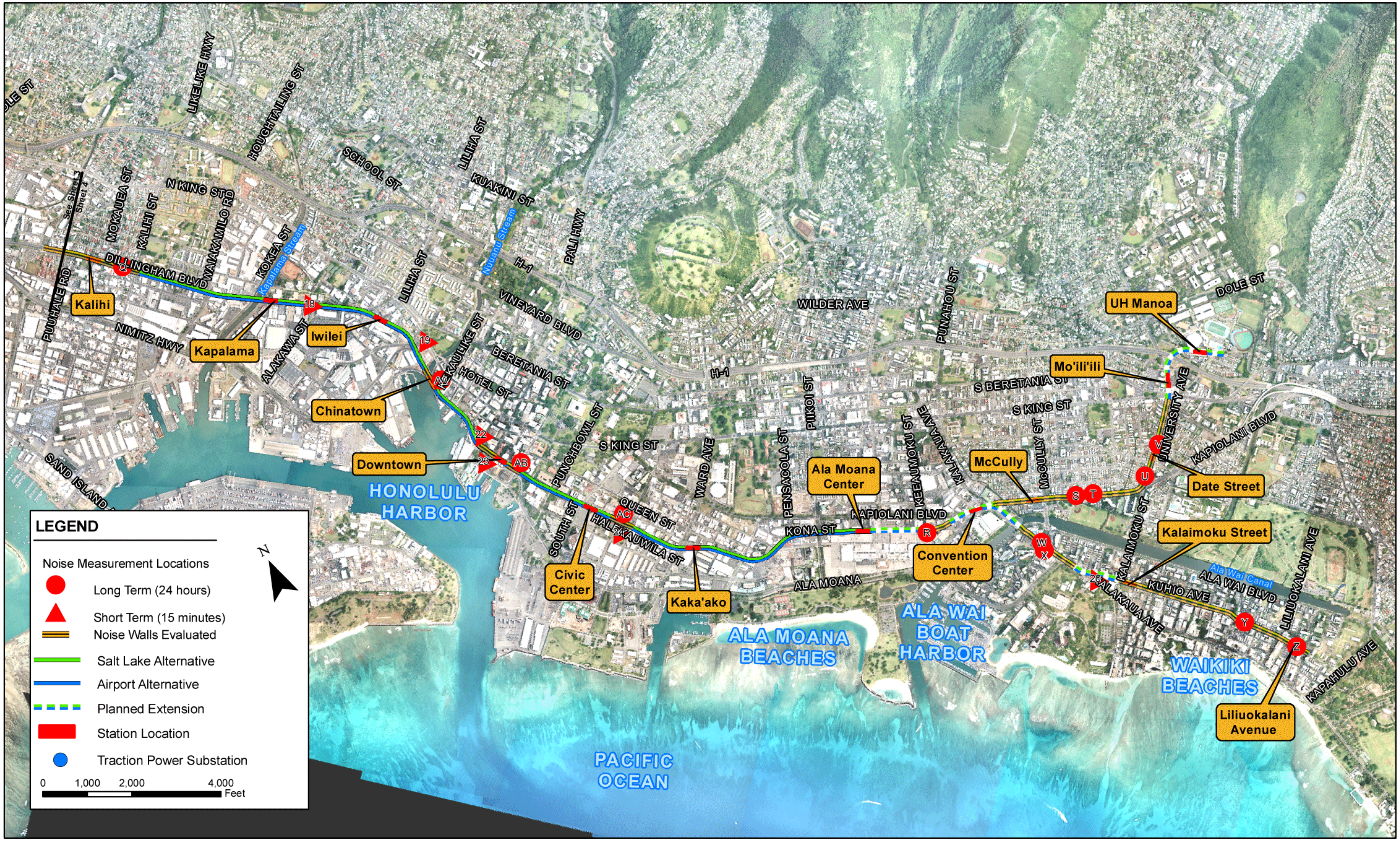


Figure 4-4: Noise Measurement Locations (Kalihi to UH Mānoa and Waikīkī)

4.8 Ho‘opili to West Loch

Land uses between the Ho‘opili Station and Fort Weaver Road are open space, farmlands, and a mental health facility (Category 2). From Fort Weaver Road to the West Loch Station, land uses are industrial (Category 3) and commercial (Category 3). Monitoring Location 1 represents the existing noise environment, with a maximum-hour L_{eq} of 58 dBA and an L_{dn} of 57 dBA. Farrington Highway is the dominant noise source in the area.

4.9 West Loch to Waipahu Transit Center

Land uses between the West Loch Station and the Waipahu Transit Center Station are industrial (Category 3) and commercial (Category 3) from West Loch Station to Pupukahi Road, and residential (Category 2) from Pupukahi Road to the Waipahu Transit Center. Waipahu Intermediate School (Category 2) is also located in this area. Monitoring Locations 2, D, and 3 represent the existing noise environment for the 61 residential buildings and the school, with maximum-hour L_{eq} noise levels ranging from 59 to 69 dBA, and L_{dn} ranging from 63 to 72 dBA. Farrington Highway is the dominant noise source in the area.

4.10 Waipahu Transit Center to Leeward Community College

Land use between the Waipahu Transit Center Station and the Leeward Community College Station is residential (Category 2), with one church (Category 3) and Waipahu High School (Category 3). Monitoring Locations E, F, 4, and G describe the existing noise environment for the 70 residential buildings, one church, and the school located on Farrington Highway. Maximum-hour L_{eq} noise levels ranged from 55 to 80 dBA, and L_{dn} ranged from 59 to 78 dBA. Farrington Highway is the dominant noise source in the area.

4.11 Leeward Community College to Pearl Highlands

Land use between the Leeward Community College Station and the Pearl Highlands Station includes Leeward Community College (Category 3) at the intersection of Farrington Highway and the H-1 Freeway. Monitoring Location 5 describes the existing noise environment at Leeward Community College, west of the H-1 Freeway on Farrington Highway. A maximum-hour L_{eq} noise level of 65 dBA was recorded. Farrington Highway and the H-1 Freeway are the dominant noise sources in the area. Monitoring Location 6 describes the existing noise environment at the residential tower at the Kamehameha Highway/Kuala Road intersection, with a maximum-hour L_{eq} of 68 dBA and an L_{dn} of 67 dBA. Kamehameha Highway is the dominant noise source in the area.

4.12 Pearl Highlands to Pearlridge

Land use is mixed between the Pearl Highlands Station and the Pearlridge Station, including commercial (Category 3), Pearl Ridge Elementary School (Category 3), Pacheco Neighborhood Park and Neal S. Blaisdell Park (Category 3), and residential areas (Category 2). Monitoring Locations 7, H, I, and 8 reflect the existing noise environment at the school, 2 parks, and 35 residential buildings along the proposed alignment. One-hour maximum L_{eq} ranged from 59 to 72 dBA, and an L_{dn} ranging from 66 to 74 dBA was recorded.

4.13 Pearlridge to Aloha Stadium

Land uses between the Pearlridge Station and the Aloha Stadium Station are a mixture of commercial (Category 3), residential areas (Category 2), and Aloha Stadium (Category 3). Monitoring Locations J and 9 represent the existing noise environment for the 33 residential buildings along Kamehameha Highway, with maximum-hour L_{eq} noise levels ranging from 55 to 72 dBA and L_{dn} levels ranging from 57 to 74 dBA. Kamehameha Highway is the dominant noise source in the area.

4.14 Aloha Stadium to Ala Liliko`i

Land uses between the Aloha Stadium Station and the Ala Liliko‘i Station are predominantly single-family residential (Category 2), with some commercial land use (Category 3) and two schools (Category 3); Makalapa Elementary School and Radford High School are located makai of the roadway. Site K describes the existing noise environment at the 16 residential buildings along Salt Lake Boulevard near Aloha Stadium, with a maximum-hour L_{eq} of 63 dBA and an L_{dn} of 60 dBA. Monitoring Locations 10 and L describe the existing noise environment for the 42 residential buildings and one school along Salt Lake Boulevard, with a maximum-hour L_{eq} ranging from 65 to 68 dBA and an L_{dn} ranging from 63 to 66 dBA. Monitoring Locations 11, 12, M, 14, N, and 15 represent the existing noise environment for the 123 residential buildings and one school along Salt Lake Boulevard. At the residences on Salt Lake Boulevard (Sites 12, M, and N), maximum-hour noise levels ranged from 68 to 69 dBA and L_{eq}, and L_{dn} levels ranged from 68 to 69 dBA. Monitoring Sites 11 and 14 describe the noise environment for residences, with a barrier blocking Salt Lake Boulevard traffic noise. Maximum-hour noise levels ranged from 65 to 69 dBA L_{eq} with an L_{dn} of 67 and 66 dBA, respectively, at these two areas. Site 15 describes the noise environment at Āliamanu Elementary School, where a maximum-hour L_{eq} of 60 dBA was measured.

4.15 Ala Liliko`i to Middle Street Transit Center

Land uses between the Ala Liliko‘i Station and the Middle Street Transit Center are multifamily high-rises mauka of Salt Lake Boulevard, military single-family residences (Category 2) makai of Salt Lake Boulevard, and industrial and commercial (Category 3) Koko Head of Pu‘uloa Road. Monitoring Locations O, 16, 17, and P represent the existing noise environment for the 48 residential buildings along Salt Lake Boulevard. Maximum-hour L_{eq} ranged from 58 to 64 dBA and L_{dn} ranged from 59 to 78 dBA.

4.16 Aloha Stadium to Pearl Harbor Naval Base

Land uses between the Aloha Stadium Station and the Peal Harbor Naval Base Station are predominantly commercial and industrial (Category 3). There are no sensitive land uses along this section.

4.17 Pearl Harbor Naval Base to Honolulu International Airport

Land uses between the Pearl Harbor Naval Base Station and the Honolulu International Airport Station are predominantly commercial and industrial (Category 3), with military housing ‘Ewa of the H-1 Freeway. Site 13 describes existing noise levels at the 11 residential buildings, with a maximum-hour L_{eq} of 67 dBA and an L_{dn} of 69 dBA.

4.18 Honolulu International Airport to Lagoon Drive

Land uses between the Honolulu International Airport Station and the Lagoon Drive Station are predominantly commercial and industrial (Category 3). There are no sensitive land uses along this section.

4.19 Lagoon Drive to Middle Street Transit Center

Land uses between the Lagoon Drive Station and the Middle Street Transit Center are predominantly commercial and industrial (Category 3). Ke‘ehi Lagoon Beach Park is the only noise-sensitive land use in the area. Site 21 describes the existing noise level at the park, where a maximum-hour L_{eq} of 66 dBA was measured.

4.20 Middle Street Transit Center to Kalihi

Land uses between the Middle Street Transit Center and Kalihi Station are industrial and commercial (Category 3), with residential (Category 2) located around Kalihi Station. Site Q represents the existing noise level for the 10 residences around the station. The maximum-hour L_{eq} was 73 dBA and the L_{dn} was 75 dBA.

4.21 Kalihi to Kapālama

Land uses from Kalihi Station to the Kapālama Station are industrial and commercial (Category 3) makai of the alignment and residential (Category 2) and an elementary school (Category 3) mauka. Site Q represents the existing noise level for the 20 residences and the school. The maximum-hour L_{eq} was 73 dBA and the L_{dn} was 75 dBA.

4.22 Kapālama to Iwilei

Land uses from the Kapālama Station to Iwilei Station are industrial and commercial (Category 3) makai and mauka of the alignment, with the exception of Honolulu Community College. Site 18 characterizes the existing noise level for Honolulu Community College, with a maximum-hour L_{eq} of 72 dBA.

4.23 Iwilei to Chinatown

Land uses from Iwilei Station to the Chinatown Station are industrial and commercial (Category 3), with the exception of a multifamily residence at 215 King Street. Site 19 describes the existing noise level for the high-rise building, with a maximum-hour L_{eq} range from 72 on the ground floor to 68 on the 26th floor and L_{dn} levels ranging from 73 dBA from the ground to the sixth floor and 70 dBA on the 26th floor.

4.24 Chinatown to Downtown

Land uses between the Chinatown Station and the Downtown Station are predominantly commercial and industrial (Category 3), with the exception of a multifamily residence at 901 River Street (Category 2) and two parks (Fort Street Park and Aloha Tower Marketplace). Site AA describes the existing noise level for the building, with a maximum-hour L_{eq} of 74 dBA and an L_{dn} of 77 dBA. Site 22 reflects the noise level at Fort Street Park, with a maximum-hour L_{eq} of 67 dBA. Site 23 describes the noise level at the Aloha Tower Marketplace, with a maximum-hour L_{eq} of 63 dBA.

4.25 Downtown to Civic Center

Land uses between the Downtown Station and the Civic Center Station are predominantly commercial and industrial (Category 3), with the exception of multifamily high-rises (Category 2) at the intersection of Richards Street and Nimitz Highway (700 Richards Street). Site AB describes the existing noise level for the multifamily residences. Maximum-hour L_{eq} noise level range from 76 dBA on the 7th floor to 72 dBA on the 26th floor, and L_{dn} noise level range from 76 dBA on the 7th floor to 73 dBA on the 26th floor. Ground level to the sixth floor is used for parking.

4.26 Civic Center to Kakaʻako

Land uses between the Civic Center Station and the Kakaʻako Station are predominantly commercial and industrial (Category 3), with the exception of two residential buildings; one 5-floor building at 610 Cooke Street (Category 2), and one 30 floor building at 860 Halekauwila and Mother Waldron Park (Category 3). Site AC describes the existing noise level for the residential buildings, with maximum-hour noise levels L_{eq} range of 71 dBA at ground floor to 73 dBA on the fifth and higher floors. L_{dn} noise levels range from 67 dBA at ground level to 75 dBA at the 5th floor or higher. Site 24 describes the existing noise level for the park, with a maximum-hour L_{eq} of 58 dBA.

4.27 Kaka‘ako to Ala Moana Center

Land uses between the Kaka‘ako Station and the Ala Moana Center Station are predominantly commercial and industrial (Category 3), with the one residential high-rise, Uraku Tower. There are no sensitive below the 7th floor of the Uraku Tower, maximum hour L_{eq} noise levels range from 74 dBA on the 7th floor to 69 dBA on the 30th Floor. L_{dn} noise levels range from 80 dBA on the 7th floor to 75 dBA on the 26th Floor.

4.28 Ala Moana Center to Convention Center

Land uses between the Ala Moana Center Station and the Convention Center Station are predominantly commercial and industrial (Category 3), with the exception of the Ala Moana Hotel (Category 2). Monitoring Location R describes the existing noise environment on Kona Street and the Ala Moana Hotel. The existing noise environment is dominated by local traffic noise, with a maximum-hour L_{eq} of 70 dBA and an L_{dn} of 72 dBA.

4.29 Convention Center to McCully

Land uses between the Convention Center Station and McCully Station are predominantly commercial and industrial (Category 3), with the exception of the area around McCully Station where there are 16 residential buildings (Category 2). Monitoring Locations S and T describe the existing noise environment on Kapi‘olani Boulevard, which is dominated by traffic noise from the boulevard and has a maximum-hour L_{eq} of 72 dBA and an L_{dn} ranging from 74 to 75 dBA.

4.30 McCully to Date Street

Land uses from McCully Station to the Date Street Station are predominantly residential buildings (Category 2). Monitoring Locations S and T describe the existing noise environment for the 30 residential buildings on Kapi‘olani Boulevard. The existing noise environment is dominated by traffic noise from the boulevard, with a maximum-hour L_{eq} of 72 dBA and an L_{dn} ranging from 74 to 75 dBA. Site U describes the existing noise environment for the 20 residential buildings on University Avenue between Kapi‘olani Boulevard and Date Street. The existing noise environment is dominated by traffic noise from University Avenue, with a maximum-hour L_{eq} of 66 dBA and an L_{dn} of 68 dBA.

4.31 Date Street to Mō‘ili‘ili

Land uses from the Date Street Station to the Mō‘ili‘ili Station are predominantly residential buildings (Category 2). Site V describes the existing noise environment for the 25 residential buildings on University Avenue between Date Street and South King Boulevard. The existing noise environment is dominated by traffic from University Avenue, with a maximum-hour L_{eq} of 66 dBA and an L_{dn} of 68 dBA.

4.32 Mōʻiliʻili to UH Mānoa

Land uses from the Mōʻiliʻili Station to the UH Mānoa Station are predominantly commercial and industrial (Category 3). There are no sensitive land uses along this section.

4.33 Convention Center to Kālaimoku Street

Land uses between the Convention Center Station and the Kālaimoku Street Station are a mix of commercial (Category 3) and high-rise apartments and hotels (Category 2). Monitoring Locations W, X, and 20 represent the existing noise environment for the 13 residential buildings on Kalākaua Avenue. The existing noise environment is dominated by traffic from the avenue, with a maximum-hour L_{eq} ranging from 70 to 77 dBA and an L_{dn} ranging from 73 to 77 dBA.

4.34 Kālaimoku Street to Liliʻuokalani Avenue

Land uses between the Kālaimoku Street Station and the Liliʻuokalani Avenue Station are a mix of commercial (Category 3) and high-rise apartments and hotels (Category 2). Monitoring Locations Y and Z describe the existing noise environment for the 31 residential buildings on Kūhiō Avenue. The existing noise environment is dominated by traffic from Kalākaua Boulevard, with a maximum-hour L_{eq} ranging from 75 to 76 dBA, and an L_{dn} of 75 dBA.

Table 4-1: Existing Long-Term Noise Measurements

Site I.D.	Site Description	FTA Land Use Category[1]	Measured Maximum-Hour L_{eq} (dBA)	Measured L_{dn}[2] (dBA)	Alternative	Stations
A	Saratoga Avenue/Franklin Avenue	2	60	59	All Build Alternatives	Kapolei Transit Center to Fort Barrette Road
B	4235 Independence Road	2	75	74	All Build Alternatives	Fort Barrette Road to Kapolei Parkway
C	91-1005 Koahi Street	2	57	54	All Build Alternatives	Kapolei Parkway to East Kapolei Parkway
D	94-508 Farrington Highway	2	69	72	All Build Alternatives	West Loch to Waipahu Transit
E	94-979 Kahuamoku Place	2	80	78 Ground floor, 70 4th Floor	All Build Alternatives	Waipahu Transit to Leeward Community College
F	94-1041 Kahua Moku	2	72	73	All Build Alternatives	Waipahu Transit to Leeward Community College
G	94-261 Kahualena	2	67	69	All Build Alternatives	Waipahu Transit to Leeward Community College
H	751 Puʻu Kala	2	71	66	All Build Alternatives	Pearl Highlands to Pearlridge
I	98-5 Kuleana Place	2	72	74	All Build Alternatives	Pearl Highlands to Pearlridge
J	98-124B Kihale Street	2	72	74	All Build Alternatives	Pearlridge to Aloha Stadium
K	99 Ohialomi Place	2	63	60	Salt Lake and Salt Lake and Airport	Pearlridge to Aloha Stadium
L	4317 Laʻakea Street	2	65	63	Salt Lake and Salt Lake and Airport	Aloha Stadium to Ala Likoʻi
M	3760 Salt Lake Boulevard	2	69	69	Salt Lake and Salt Lake and Airport	Aloha Stadium to Ala Likoʻi
N	3472 Salt Lake Boulevard	2	68	68	Salt Lake and Salt Lake and Airport	Aloha Stadium to Ala Likoʻi
O	827 Ala Likoʻi Street	2	60	61	Salt Lake and Salt Lake and Airport	Ala Likoʻi to Middle Street Transit Center
P	2996 Anderson Avenue	2	64	64	Salt Lake and Salt Lake and Airport	Ala Likoʻi to Middle Street Transit Center
Q	1746 Dillingham Boulevard	2	73	75	All Build Alternatives	Middle Street Transit Center to Kapālama
AA	Harbor Village, 900 River Street	2	74	77	All Build Alternatives	Chinatown to Downtown
AB	Harbor Square, 700 Richards Street	2	74	No Apartment below 7th floor, 74 7th Floor, 73 26th Floor	All Build Alternatives	Downtown to Civic Center
AC	Na Lei Kupuna, 610 Cooke Street	2	65	67 on Ground Floor, 75 on 5th Floor	All Build Alternatives	Civic Center to Kakaʻako
S	2148 Kapiʻolani Boulevard	2	72	74	All Build Alternatives	Convention Center to McCully
T	2232 Kapiʻolani Boulevard	2	72	75	All Build Alternatives	McCully to Date Street
U	630 University Avenue	2	66	68	All Build Alternatives	McCully to Date Street
V	801 University Avenue	2	66	68	All Build Alternatives	Date Street to Mōʻiliʻili
W	1880 Kalākaua Avenue	2	73	73	All Build Alternatives	Convention Center to Kālaimoku Street
X	1911 Kalākaua Avenue	2	77	77	All Build Alternatives	Convention Center to Kālaimoku Street
Y	2406 Kūhiō Avenue	2	75	75	All Build Alternatives	Kālaimoku Street to Liliʻuokalani Avenue
Z	2520 Kūhiō Avenue	2	76	75	All Build Alternatives	Kālaimoku Street to Liliʻuokalani Avenue

[1] Land use category descriptors:
FTA Category 1 = buildings or parks where quiet is an essential element of their purpose;
FTA Category 2 = residences and other buildings where people sleep, such as hotels, apartments, and hospitals
FTA Category 3 = institutional land uses with primarily daytime and evening use, including schools, libraries, and churches.

[2] L_{dn} is used for land uses with nighttime sensitivity to noise and for residential areas where FTA rather than FHWA noise procedures are applicable. Maximum-hour L_{eq} is used for commercial, industrial, and other land uses that do not have nighttime noise sensitivity.

Table 4-2: Existing Short-Term Noise Measurements

Site I.D.	Site Description	FTA Land Use Category[1]	Measured Maximum-Hour L_{eq} (dBA)	Estimated L_{dn}[2] (dBA)	Alternative	Stations
1	Kahi Mohala Mental Health Facility	2	58	57	All Build Alternatives	Ho'opili to West Loch
2	Waipahu Intermediate School	3	58	NA	All Build Alternatives	West Loch to Waipahu Transit
3	94-309 Hanewai Circle	2	59	63	All Build Alternatives	West Loch to Waipahu Transit
4	91-1144 Awaiki Place	2	55	59	All Build Alternatives	Waipahu Transit to Leeward Community College
5	Leeward Community College	3	65	NA	All Build Alternatives	Leeward Community College to Pearl Highlands
6	1060 Kamehameha Highway	2	68	67	All Build Alternatives	Leeward Community College to Pearl Highlands
7	Pacheco Neighborhood Park—Pearlridge Elementary School	3	59	NA	All Build Alternatives	Pearl Highlands to Pearlridge
8	Neal S. Blaisdell Park	3	64	NA	All Build Alternatives	Pearl Highlands to Pearlridge
9	Kauhale Street	2	55	57	All Build Alternatives	Pearlridge to Aloha Stadium
10	444 Loina Place	2	68	66	All Build Alternatives	Aloha Stadium to Ala Liliko'i
11	4148 Salt Lake Boulevard	2	69	67	Salt Lake and Salt Lake and Airport	Aloha Stadium to Ala Liliko'i
12	4034 Salt Lake Boulevard	2	68	69	Salt Lake and Salt Lake and Airport	Aloha Stadium to Ala Liliko'i
13	1086 Fisler Court	2	67	69	Airport and Salt Lake and Airport	Aloha Stadium to Honolulu International Airport
14	1010 Wanaka Street	2	65	66	Salt Lake and Salt Lake and Airport	Aloha Stadium to Ala Liliko'i
15	Āliamanu Elementary School	3	60	NA	Salt Lake and Salt Lake and Airport	Aloha Stadium to Ala Liliko'i
16	2929 Ala 'Ilima Street	2	63	61 at Ground Floor, 63 at 6th Floor, 78 at 12th floor	Salt Lake and Salt Lake and Airport	Ala Liliko'i to Middle Street Transit Center
17	760 Moore Street	2	58	59	All Build Alternatives	Ala Liliko'i to Middle Street Transit Center
18	Honolulu Community College	3	72	NA	All Build Alternatives	Kapālama to Iwilei
19	215 King Street	2	72	73 at Ground Floor and 6th Floor, 70 on 26th Floor	All Build Alternatives	Iwilei to Chinatown
20	King Kalākaua Park	3	70	NA	All Build Alternatives	Convention Center to Kālaimoku Street
21	Ke'ehi Lagoon Beach Park	3	66	NA	Airport and Salt Lake and Airport	Lagoon Drive to Middle Street Transit Center
22	Fort Street Park	3	67	NA	All Build Alternatives	Chinatown to Downtown
23	Aloha Tower Marketplace	3	63	NA	All Build Alternatives	Chinatown to Downtown
24	Mother Waldron Park	3	58	NA	All Build Alternatives	Civic Center to Kaka'ako

NA—These sites do not have sleep activity. L_{dn} existing noise levels are not applicable at these sites.

Each 15-minute noise measurement is compared to the closest 24-hour measurement site at the same hour of the day. The 15-minute noise levels are then adjusted relative to the 24-hour levels, to develop a maximum Leq and Ldn for each of the 15-minute measurement locations.

[1] Land use category descriptors:

FTA Category 1 = buildings or parks where quiet is an essential element of their purpose;

FTA Category 2 = residences and other buildings where people sleep, such as hotels, apartments, and hospitals

FTA Category 3 = institutional land uses with primarily daytime and evening use, including schools, libraries, and churches.

[2] 24-hour noise levels at these locations were estimated based upon short-term noise samples, which were compared to the closest 24-hour noise measurement locations.

5 Consequences

5.1 No Build Alternative

With the No Build Alternative, the only substantial source of future noise levels would be traffic on local arterials. Changes in automobile traffic are not expected to increase the 24-hour (L_{dn}) above existing levels at any of the noise measurement sites. That is because traffic in the area is already at or above road capacity. The maximum-hour noise level could increase by 1 to 2 dBA, but overall noise levels are not expected to increase. Therefore, no traffic noise impacts are projected under the No Build Alternative (Table 5-1).

5.2 Build Alternative

The potential noise and vibration impacts for the Build Alternative are discussed below by station locations. The Build Alternative design includes 3-feet-high barriers on the outside edge of the platform and wheel skirts on the LRT vehicles. These design changes in the design were made to avoid noise impacts. Table 5-1 summarizes the transit services used to analyze potential noise and vibration impacts. If headways are longer than shown in Table 5-1, then project noise exposure (the amount of noise generated by the Project, not including existing noise in the environment) would decrease slightly. The potential noise impacts are determined by comparing existing noise levels and the project-generated noise level to Table 2-1 in Section 2.3. If the project-generated noise is below the level for moderate impact, there is no impact. If the project noise level is between the level for moderate and severe impact, there is a moderate impact. If the project noise level is equal to or above the severe impact level, there is a severe impact. Table 5-2 shows potential noise impacts for any of the alignments with the current design features. The predicted noise and vibration levels at each of the modeling sites are presented in Appendix A. For comparison purposed only, Appendix A also shows noise levels without the barriers and wheel skirts as part of the design.

Table 5-1: Fixed Guideway Operations

Stations	Speed	Hours of Operation	Peak-Hour Headways	Off-Peak Headways	Nighttime-Headways (8:00 p.m. to 12:00 a.m.)
Kapolei Transit Center to Fort Barrette Road	50	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Fort Barrette Road to Kapolei Parkway	55	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Kapolei Parkway to East Kapolei Parkway	50	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Ho‘opili to West Loch	55	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
West Loch to Waipahu Transit Center	55	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Waipahu Transit Center to Leeward Community College	55	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Leeward Community College to Pearl Highlands	45	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Pearl Highlands to Pearlridge	55	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Pearlridge to Aloha Stadium	55	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Aloha Stadium to Ala Liliko‘i	50	4 a.m. to 12 a.m.	3 minute*	6 minute*	10 minute *
Aloha Stadium to Honolulu International Airport	55	4 a.m. to 12 a.m.	3 minute*	6 minute*	10 minute*
Lagoon Drive to Middle Street Transit Center	45	4 a.m. to 12 a.m.	3 minute*	6 minute*	10 minute*
Ala Liliko‘i to Middle Street Transit Center	50	4 a.m. to 12 a.m.	3 minute*	6 minute*	10 minute *
Middle Street Transit Center to Kapālama	50	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Kapālama to Iwilei	50	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Iwilei to Chinatown	45	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Chinatown to Downtown	45	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Downtown to Civic Center	45	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Civic Center to Kaka‘ako	45	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Ala Moana Center to Convention Center	45	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Convention Center to McCully	45	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
McCully to Date Street	45	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Date Street to Mō‘ili‘ili	45	4 a.m. to 12 a.m.	3 minute	6 minute	10 minute
Convention Center to Kālaimoku Street	45	4 a.m. to 12 a.m.	6 minute	12 minute	12 minute
Kālaimoku Street to Lili‘uokalani Avenue	45	4 a.m. to 12 a.m.	6 minute	12 minute	12 minute

*Headways for the Airport & Salt Lake Alternative would be 6 minutes peak-hour, 12 minutes off-peak hour, and 20 minutes nighttime between Aloha Stadium and the Middle Street Transit Center.

Table 5-2: Fixed Guideway Noise Impacts by Station

Stations	Representative Noise Site(s)	Impacts
Common to All Build Alternatives		
West Kapolei to Kapolei Transit Center	No receptors in this area	N/A
Kapolei Transit Center to Kalaeloa	A	No impacts
Kalaeloa to Fort Barrette Road	A	No impacts
Fort Barrette Road to Kapolei Parkway	B	No impacts
Kapolei Parkway to East Kapolei	C	No impacts
East Kapolei to UH West O'ahu	No receptors in this area	N/A
UH West Oʻahu to Hoʻopili	No receptors in this area	N/A
Hoʻopili to West Loch	1	No impacts
West Loch to Waipahu Transit Center	D, 2, 3	Moderate impacts at on the 5th to 9th floors of 1 Apartment Building (Waikele Tower)
Waipahu Transit Center to Leeward Community College	E, F, 4, G	No impacts
Leeward Community College to Pearl Highlands	5, 6	Moderate impacts on the 2nd to 5th floors of 1 Apartment Building
Pearl Highlands to Pearlridge	7, H, I, 8	No Impacts
Pearlridge to Aloha Stadium	J, 9	Moderate impacts at 14 receivers
Middle Street Transit Center to Kalihi	Q	No impacts
Kalihi to Kapālama	Q	No impacts
Kapālama to Iwilei	18	No impacts
Iwilei to Chinatown	19	No impacts
Chinatown to Downtown	AA, 22, 23	No impacts
Downtown to Civic Center	AB	No impacts
Civic Center to Kakaʻako	AC, 24, 800 Halekauwila	Moderate impacts on the 7th to the 11th floor of 800 Halekauwila.
Kakaʻako to Ala Moana Center	Uraku Tower	No impacts
Ala Moana Center to Convention Center	R	No impacts at ground level to height of guideway Moderate impacts to sensitive uses above guideway.
Convention Center to McCully	S	None
McCully to Date Street	S, T, U	None
Date Street to Mōʻiliʻili	V	None
Convention Center to Kālaimoku	W, X, 20	No impacts at ground level to height of guideway Moderate impacts to sensitive uses above guideway.
Kālaimoku to Liliʻuokalani	Y, Z	No impacts at ground level to height of guideway Moderate impacts to sensitive uses above guideway.

Table 5-2: Fixed Guideway Noise Impacts by Station (continued)

Stations	Representative Noise Site(s)	Impacts
Salt Lake Alternative		
Aloha Stadium to Ala Liliko'i	K, 10, L, 11, 12, M, 14, N, 15	No impacts
Ala Liliko'i to Middle Street Transit Center	O, 16, 17, P	Moderate impacts on the 9th to the 15th floors of five 10 to 20 floor buildings
Airport Alternative		
Pearl Harbor Naval Base to Honolulu International Airport	13	No impacts
Honolulu International Airport to Lagoon Drive	No receptors in this area	N/A
Lagoon Drive to Middle Street Transit Center	21	No impacts
Airport & Salt Lake Alternative		
Aloha Stadium to Ala Liliko'i	K, 10, L, 11, 12, M, 14, N, 15	No impacts
Ala Liliko'i to Middle Street Transit Center	O, 16, 17, P	No impacts
Pearl Harbor Naval Base to Honolulu International Airport	13	No impacts
Lagoon Drive to Middle Street Transit Center	21	No impacts

5.3 Common to All Build Alternatives

The following discussion of project consequences describes effects from the Wai'anae to Koko Head end of the Project, for all portions of the study corridor that are common to the Build Alternatives. Discussions of portions of the corridor that differ by alternative follow this section.

5.3.1 West Kapolei to Kapolei Transit Center

There are no sensitive land uses along the alignment between these two stations.

5.3.2 Kapolei Transit Center to Kalaeloa

The existing noise exposure of the 15 residences between the Kapolei Transit Center Station and Kalaeloa Station, represented by Site A, is an L_{dn} of 59 dBA. Project noise exposure between L_{dn} 58 and 63 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 63 dBA would cause a severe noise impact. The project noise exposure would be 52 dBA L_{dn}. No noise impacts to 15 residences are predicted.

5.3.3 Kalaeloa to Fort Barrette Road

The existing noise exposure of the seven residences between Kalaeloa Station and Fort Barrette Road Station, represented by Site A, is an L_{dn} of 59 dBA. Project noise exposure between L_{dn} 58 and 63 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 63 dBA would cause a severe noise impact. The project noise exposure would be 52 dBA L_{dn}. No noise impacts to seven residences are predicted.

5.3.4 Fort Barrette Road to Kapolei Parkway

The existing noise exposure of the ten residences between the Fort Barrette Road Station and the Kapolei Parkway Station, represented by Site B, is an L_{dn} of 74 dBA. Project noise exposure between L_{dn} 66 and 72 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 72 dBA would cause a severe noise impact. The project noise exposure would be 54 dBA L_{dn}. No noise impacts to ten residences are predicted.

5.3.5 Kapolei Parkway to East Kapolei

The existing noise exposure of the six residences between Kapolei Parkway Station and East Kapolei Station, represented by Site C, is an L_{dn} of 54 dBA. Project noise exposure between L_{dn} 55 and 61 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 61 dBA would cause a severe noise impact. The project noise exposure would be 42 dBA L_{dn}. No noise impacts would occur.

5.3.6 East Kapolei to UH West O‘ahu

There are no sensitive land uses along the alignment between these two stations. There are plans for future development in the area, but possible future developments are not considered as noise-sensitive receivers until they are approved.

5.3.7 UH West O‘ahu to Ho‘opili

There are no sensitive land uses along the alignment between these two stations. There are plans for future development in the area, but possible future developments are not considered as noise-sensitive receivers until they are approved.

5.3.8 Ho‘opili to West Loch

The existing noise exposure of the two residential buildings between Ho‘opili Station and West Loch Station, represented by Site 1, is an L_{dn} of 57 dBA. Project noise exposure between L_{dn} 57 and 62 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 62 dBA would cause a severe noise impact. The project noise exposure would be 50 dBA L_{dn}. No noise impacts are predicted for the two residential buildings.

5.3.9 West Loch to Waipahu Transit Center

The existing noise exposure of the 40 residential buildings between West Loch Station and the Waipahu Transit Center Station, represented by Site D, is an L_{dn} of 72 dBA. Project noise exposure between L_{dn} 66 and 71 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 71 dBA would cause a severe noise impact.

The existing noise exposure of the 20 residential buildings, represented by Site 3, is an L_{dn} of 63 dBA. Project noise exposure between 60 and 65 dBA would cause a moderate noise impact; project noise exposure above 65 dBA would cause a severe noise impact.

The existing noise exposure of Waipahu Intermediate School, represented by Site 2, is a maximum-hour L_{eq} of 63 dBA. Project noise exposure between 65 and 70 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 70 dBA would cause a severe noise impact.

The project noise exposure would be 71-dBA L_{dn} at Site 3; and 65-dBA maximum-hour L_{eq} at Site 2. At Site D, project noise exposure at ground level would be 57 dBA $L_{dn.}$ The second floor level would be 57 dBA $L_{dn.}$ Third and fourth floor levels would be 61 dBA $L_{dn.}$ The fifth thru the seven floor levels would be 68 dBA L_{dn} and the eighth and ninth floor levels would be 67 dBA $L_{dn.}$ Moderate noise impacts are predicted for one residential building (Waikele Tower) from the fifth to the ninth floor.

5.3.10 Waipahu Transit Center to Leeward Community College

The existing noise exposure of the 16 residential buildings between the Waipahu Transit Center Station and the Leeward Community College Station, represented by Site E, is an L_{dn} of 78 dBA. Project noise exposure between L_{dn} 66 and 75 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 75 dBA would cause a severe noise impact.

The existing noise exposure of the 15 residential buildings, represented by Site F, is an L_{dn} of 73 dBA. Project noise exposure between L_{dn} 66 and 71 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 71 dBA would cause a severe noise impact.

The existing noise exposure of the 18 residential buildings, represented by Site 4, is an L_{dn} of 59 dBA. Project noise exposure between L_{dn} 58 and 63 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 62 dBA would cause a severe noise impact.

The existing noise exposure of the 21 residential buildings, represented by Site G, is an L_{dn} of 69 dBA. Project noise exposure between L_{dn} 64 and 69 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 69 dBA would cause a severe noise impact.

The existing noise exposure of Waipahu High School, represented by Site G, is a maximum-hour L_{eq} of 67 dBA. Project noise exposure between 68 and 73 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 73 dBA L_{eq} would cause a severe noise impact.

The project noise exposure would be 55 to 60 dBA L_{dn} at Site E and 56 dBA L_{dn} at Sites F, 4, and G. No noise impacts are predicted for the 70 residential buildings (Site 4, E, F, and G).

5.3.11 Leeward Community College to Pearl Highlands

The existing noise exposure of Leeward Community College between the Leeward Community College Station and the Pearl Highlands Station, represented by Site 5, is a maximum-hour L_{eq} of 65 dBA. Project noise exposure between 66 and 71 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 71 dBA L_{eq} would cause a severe noise impact.

The existing noise exposure of the one residential building, represented by Site 6, is an L_{dn} of 68 dBA. Project noise exposure between L_{dn} 63 and 68 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 67 dBA would cause a severe noise impact.

The project noise exposure would be 56 to 63 dBA L_{dn} at Site 6 and 53 dBA maximum-hour L_{eq} at Site 5. Moderate noise impacts are predicted from the second to fifth floor of one residential building (Site 6).

5.3.12 Pearl Highlands to Pearlridge

The existing noise exposure of the Pearl Ridge Elementary School/Pacheco Neighborhood Park between the Pearl Highlands Station and the Pearlridge Station, represented by Site 7, is a maximum-hour L_{eq} of 59 dBA. Project noise exposure between 63 and 68 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 68 dBA L_{eq} would cause a severe noise impact.

The existing noise exposure of the 13 residential buildings, represented by Site H, is an L_{dn} of 66 dBA. Project noise exposure between L_{dn} 66 and 67 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 67 dBA would cause a severe noise impact.

The existing noise exposure of the 22 residential buildings, represented by Site I, is an L_{dn} of 74 dBA. Project noise exposure between L_{dn} 66 and 72 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 72 dBA would cause a severe noise impact.

The existing noise exposure at Neal S. Blaisdell Park, represented by Site 8, is a maximum-hour L_{eq} of 64 dBA. Project noise exposure between 66 and 70 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 70 dBA L_{eq} would cause a severe noise impact.

The project noise exposure would be a maximum-hour L_{eq} noise exposure level of 54 dBA at Site 7, and a maximum-hour L_{eq} noise exposure level of 52 dBA at Site 8. Project L_{dn} noise exposure is predicted to be 55 to 59 dBA at Sites H and I. No noise impacts are predicted for Pearl Ridge Elementary School/Pacheco Neighborhood

Park (Site 7), for Neal S. Blaisdell Park (Site 8), the 13 residential buildings represented by Site I, or the 22 residential buildings represented by Site H.

5.3.13 Pearlridge to Aloha Stadium

The existing noise exposure of the 19 residential buildings between the Pearlridge Station and the Aloha Stadium Station, represented by Site J, is an L_{dn} of 74 dBA. Project noise exposure between L_{dn} 66 and 72 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 72 dBA would cause a severe noise impact.

The existing noise exposure of the 14 residential buildings, represented by Site 9, is an L_{dn} of 57 dBA. Project noise exposure between L_{dn} 57 and 62 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 62 dBA would cause a severe noise impact.

The project noise exposure would be 60 dBA L_{dn} at Site J and 57 dBA L_{dn} Site 9. No noise impact is predicted for the 19 residential buildings represented by Site J, and a moderate noise impact is predicted for the 14 residential buildings represented by Site 9.

5.3.14 Middle Street Transit Center to Kalihi

The existing noise exposure of the ten residential buildings between the Middle Street Transit Center Station and the Kalihi Station, represented by Site Q, is an L_{dn} of 75 dBA. Project noise exposure between L_{dn} 66 and 73 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 73 dBA would cause a severe noise impact.

The project noise exposure would be 56 dBA L_{dn} at Site Q. No noise impacts are predicted for the ten residential buildings.

5.3.15 Kalihi to Kapālama

The existing noise exposure of the 20 residential buildings between the Kalihi Station and the Kapālama Station, represented by Site Q, is an L_{dn} of 75 dBA. The maximum-hour L_{eq} for the elementary school is 73 dBA. Project noise exposure between 66 and 73 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 73 dBA L_{eq} would cause a severe noise impact at the residential buildings. Project noise exposure between 71 and 76 dBA L_{eq} would cause a moderate noise impact, and project noise above 76 dBA L_{eq} would be a severe impact for the school.

The project noise exposure would be 56 dBA L_{dn} at Site Q. No noise impacts are predicted for the 20 residential buildings. A project maximum-hour L_{eq} of 51 is predicted. No impacts would occur at the school.

5.3.16 Kapālama to Iwilei

The existing noise exposure of the Kapālama buildings between the Kapālama Station and the Iwilei Station, represented by Site 18, is a maximum-hour L_{eq} of 72 dBA. Project noise exposure between 71 and 75 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 75 dBA L_{eq} would cause a severe noise impact at the residential buildings.

The project noise exposure would be a maximum-hour L_{eq} of 51 dBA at Site 18. No noise impacts would occur.

5.3.17 Iwilei to Chinatown

The existing noise exposure of the one residential building between the Iwilei Station and the Chinatown Station, represented by Site 19, is an L_{dn} of 73 dBA at ground floor and 70 dBA at the 26th floor. Project noise exposure between L_{dn} 65 and 71 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 71 dBA would cause a severe noise impact.

The project noise exposure would be 61 dBA L_{dn} from ground floor to the 12th floor and 60 dBA L L_{dn} or less from the 13th to the 26th floor at Site 19. No noise impacts would occur.

5.3.18 Chinatown to Downtown

The existing noise exposure of the one residential building between the Chinatown Station and the Downtown Station, represented by Site AA, is an L_{dn} of 77 dBA. Project noise exposure between L_{dn} 66 and 74 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 74 dBA would cause a severe noise impact. Sites 22 and 23 represent Fort Street Park and Aloha Tower Marketplace. Site 22 has an existing maximum-hour L_{eq} of 67 dBA. Project noise exposure between 68 and 72 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 72 L_{eq} dBA would cause a severe noise impact. Site 23 has an existing maximum-hour L_{eq} of 63 dBA. Project noise exposure between 65 and 70 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 70 dBA L_{eq} would cause a severe noise impact.

The project noise exposure would be 52 dBA L_{dn} at Site AA. Maximum-hour project noise exposure L_{eq} levels of 49 and 48 dBA are predicted for Sites 22 and 23, respectively. No noise impacts are predicted for the residential building represented by Site AA or for the two parks.

5.3.19 Downtown to Civic Center

The existing noise exposure of the one residential building between the Downtown Station and the Civic Center Station on Nimitz Highway is represented by Site AB, with existing Ldn levels of 76 dBA at the seventh floor and 73 dBA at the 26th floor. No apartments exist below the seventh floor. Project noise exposure to the 7th floor or above, between L_{dn} 66 and 71 dBA, would cause a moderate noise impact;

project noise exposure above L_{dn} 71 dBA would cause a severe noise impact. The project noise exposure would be 65 dBA L_{dn} on the 7th floor, a 64 dBA L_{dn} or below from the 8th to the 26^{th} floor. No noise impacts are predicted for the residential building represented by Site AB.

5.3.20 Civic Center to Kaka'ako

Site AC and 800 Halekaumila represents the existing noise exposure of the two residential buildings on Halekauwila Street, with an existing L_{dn} level of 67 dBA at ground level and 75 dBA at the fifth floor and above.. Project noise exposure between L_{dn} 63 and 67 dBA would cause moderate noise impacts from ground floor to fourth floor, levels between 66 and 73 dBA would cause moderate noise impacts at the fifth floor and higher. Project noise exposure above L_{dn} 67 dBA would cause severe noise impacts for the ground to the fourth floor, while project noise level above 73 dBA would cause severe noise impacts for the fifth and higher floors. Site 24 represents the existing noise exposure at Mother Waldron Park, with a maximum-hour L_{eq} of 58 dBA. Project noise exposure between 62 and 67 L_{eq} dBA would cause a moderate noise impact; project noise exposure above 67 L_{eq} dBA would cause a severe noise impact.

A project noise level of 58 dBA L_{dn} is predicted at ground floor for Site AC and 800 Halekaumila. Project noise levels of 51 dBA are predicted for the second floor, 58 for the third floor, 61 for the fourth floor, 62 for the fifth floor, 61 for the sixth floor, 69 for the seventh floor and 10 floor, 68 for the eight and ninth floors, 66 for the 11^{th} floor, and 65 dBA for the 12^{th} and 13^{th} floors. Noise levels from the 14^{th} to the 30^{th} floor would be 64 dBA and lower. A project maximum-hour L_{eq} of 47 dBA is predicted for Site 24. A moderate noise impact is predicted for the seventh to the 11^{th} floors of 800 Halekaumila. No noise impact are predicted at site AC or the park.

5.3.21 Kaka'ako to Ala Moana Center

The existing noise exposure of the one residential building between the Kaka'ako Station and the Ala Moana Center Station, the Uraku Tower, has no apartments below the 7^{th} floor and an L_{dn} range of 74 dBA on the 7^{th} floor to 69 dBA on the 30^{th} floor.. Project noise exposure between L_{dn} 64 and 72 and dBA would cause a moderate noise impact; project noise exposure above 72 L_{dn} dBA would cause a severe noise impact.

The project noise exposure would be a project noise level of 61 dBA L_{dn} for on the 7^{th} Floor to 10^{th} Floor and project L_{dn} levels for the 11^{th} to the 30^{th} floors are predicted to be 60 dBA or less. No noise impacts are predicted for the Uraku Tower.

5.3.22 Ala Moana Center to Convention Center

The existing noise exposure of the one residential building between the Ala Moana Center Station and the Convention Center Station, represented by Site R, is an L_{dn} of 72 dBA at ground level. Project noise exposure between L_{dn} 66 and 71 dBA would cause a moderate noise impact; project noise exposure above 71 L_{dn} dBA would cause a severe noise impact.

The project noise exposure would be a project noise level of 58 dBA L_{dn} at floor below the project for Site R. At floors above the project, noise level are predicted to be at most 71 dBA. No noise impacts are predicted for building floors below the height of the project structure. Floors above the project may have moderate noise impact. Current engineering plans do have profile of the project in this area, so the floor level and number of floors can not be determined at this time. A more detailed study of the land uses of the high-rise building in this area will need to be done, when this extension is funded.

5.3.23 Convention Center to McCully

The existing noise exposure of the 16 residential buildings between the Convention Center Station and McCully Station, represented by Site S, is an L_{dn} of 74 dBA. Project noise exposure between L_{dn} 66 and 72 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 72 dBA would cause a severe noise impact.

A project noise exposure of 58 dBA L_{dn} is predicted for Site S. No noise impacts are predicted for 16 residential buildings.

5.3.24 McCully to Date Street

The existing noise exposure of the 12 residential buildings between the McCully Station and the Date Street Station on Kapi‘olani Boulevard, represented by Site S, is an L_{dn} of 74 dBA. Project noise exposure between L_{dn} 66 and 72 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 72 dBA would cause a severe noise impact.

The existing noise exposure of the 18 residential buildings between McCully Station and the Date Street Station on Kapi‘olani Boulevard, represented by Site T, is an L_{dn} of 75 dBA. Project noise exposure between L_{dn} 66 and 73 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 73 dBA would cause a severe noise impact.

The existing noise exposure of the 20 residential buildings between the McCully Station and the Date Street Station on University Avenue, represented by Site U, is an L_{dn} of 68 dBA. Project noise exposure between L_{dn} 63 and 68 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 68 dBA would cause a severe noise impact.

A project noise exposure of 57 dBA L_{dn} is predicted for Site S; an L_{dn} of 69 dBA is predicted for Site T; and a project noise level of 59 dBA L_{dn} is predicted for Site U. No noise impacts are predicted for the 30 residential buildings on Kapi‘olani Boulevard represented by Sites S and T. No noise impacts are predicted for the 20 residential buildings on University Avenue represented by Site U.

5.3.25 Date Street to Mōʻiliʻili

The existing noise exposure of the 25 residential buildings between the Date Street Station and the Mōʻiliʻili Station on University Avenue, represented by Site V, is an L_{dn} of 68 dBA. Project noise exposure between L_{dn} 63 and 68 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 68 dBA would cause a severe noise impact.

A project noise exposure level of 57 dBA L_{dn} is predicted for Site V. No noise impacts are predicted for the 25 residential buildings on University Avenue represented by Site V.

5.3.26 Mōʻiliʻili to UH Mānoa

There are no sensitive land uses along this section.

5.3.27 Convention Center to Kālaimoku Street

The existing noise exposure of the ten residential buildings mauka of Kalākaua and Kūhiō Avenues between the Convention Center Station and the Kālaimoku Street Station, represented by Site W, is an L_{dn} of 73 dBA at ground level. Project noise exposure between L_{dn} 66 and 71 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 71 dBA would cause a severe noise impact.

The existing noise exposure of the three residential buildings makai of Kalākaua Avenue between the Convention Center Station and the Kālaimoku Street Station, represented by Site X, is an L_{dn} of 77 dBA at ground level. Project noise exposure between L_{dn} 66 and 75 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 75 dBA would cause a severe noise impact.

The existing noise exposure of the park at the intersection of Kalākaua and Kūhiō Avenues, represented by Site 20, is a maximum-hour L_{eq} of 70 dBA. Project noise exposure between 70 and 74 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 74 dBA L_{eq} would cause a severe noise impact.

A project noise exposure level of 55 dBA for floors below the guideway and at most 68 dBA L_{dn} for floors above the guide way, are predicted for Site W, and an L_{dn} of 52 dBA is predicted for floors below the guideway and at most 64 dBA is predicted for floors above the guideway at Site X. Site 20 has a predicted maximum-hour L_{eq} of 48 dBA. No noise impacts are predicted for building floors below the guideway or the park, Moderate noise impacts are predicted at floors above the guideway for the ten residential buildings represented by Site W. Current engineering plans do have profile of the project in this area, so the floor level and number of floors can not be determined at this time. A more detailed study of the land uses of the high-rise building in this area will need to be done, when this extension is funded.

5.3.28 Kālaimoku Street to Liliʻuokalani

The existing noise exposure of the 31 residential buildings on Kūhiō Avenue between the Kālaimoku Street Station and the Liliʻuokalani Station, represented by Sites Y and Z, is an L_{dn} of 75 dBA at ground level. Project noise exposure between L_{dn} 66 and 73 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 73 dBA would cause a severe noise impact.

A project noise exposure level of 57 dBA L_{dn} below the guideway for both Site Y and Z. For the building floors above the guideway a 70 dBA L_{dn} is predicted for Site Y, and an L_{dn} of 69 dBA is predicted for Site Z. No noise impacts are predicted for building floors below the guideway Moderate noise impacts are predicted for the 31 residential buildings with floors above the guideway represented by Sites Y and Z. Current engineering plans do have profile of the project in this area, so the floor level and number of floors can not be determined at this time. A more detailed study of the land uses of the high-rise building in this area will need to be done, when this extension is funded.

5.3.29 Park-and-Ride Lots

The park-and-ride lots are currently proposed in areas with commercial/industrial land uses or open space. No noise impacts are predicted for the proposed park-and-ride lots.

5.3.30 Vehicle Maintenance and Storage Facilities

Two maintenance and storage facilities are being studied:

- Option 1 would place the maintenance and storage facility in open space between Farrington Highway and the H-1 Freeway near the electrical substation. The surrounding area is highway or open space; no noise impacts are predicted.
- Option 2 would place the maintenance and storage facility in open space between Waipahu High School and Leeward Community College. The facility would be below the grade of the two schools and near Farrington Highway and the H-1 Freeway interchange. The existing noise environment is dominated by Farrington Highway, with a maximum-hour L_{eq} of 65 dBA at Leeward Community College. The nearest classroom is 700 feet from the center of the site. Given this distance, the grade difference, and current noise levels, no noise impacts are predicted.

5.3.31 Traction Power Substations

The TPSSs would be located away from, or shielded from, noise-sensitive land uses. No noise impacts are predicted.

5.4 Salt Lake Alternative

5.4.1 Aloha Stadium to Ala Liliko‘i

The existing noise exposure of the 16 residential buildings between the Aloha Stadium Station and the H-1 Freeway, represented by Site K, is an L_{dn} of 60 dBA. Project noise exposure between L_{dn} 58 and 62 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 62 dBA would cause a severe noise impact.

The existing noise exposure of the 14 residential buildings between the H-1 Freeway and Bougainville Avenue, represented by Site 10, is an L_{dn} of 66 dBA. Project noise exposure between L_{dn} 62 and 67 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 67 dBA would cause a severe noise impact.

The existing noise exposure of the 28 residential buildings represented by Site L is an L_{dn} of 63 dBA. Project noise exposure between L_{dn} 60 and 65 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 65 dBA would cause a severe noise impact.

The existing noise exposure of Makalapa Elementary and Radford High Schools, represented by Site L, is a maximum-hour L_{eq} of 65 dBA. Project noise exposure between 66 and 70 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 70 dBA L_{eq} would cause a severe noise impact.

The existing noise exposure of the 13 residential buildings represented by Site 11 is an L_{dn} of 67 dBA. Project noise exposure between L_{dn} 63 and 67 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 67 dBA would cause a severe noise impact.

The existing noise exposure of the 23 residential buildings represented by Site 12 is an L_{dn} of 69 dBA. Project noise exposure between L_{dn} 64 and 69 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 69 dBA would cause a severe noise impact.

The existing noise exposure of the 17 residential buildings represented by Site M is an L_{dn} of 69 dBA. Project noise exposure between L_{dn} 64 and 69 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 69 dBA would cause a severe noise impact.

The existing noise exposure of the 40 residential buildings represented by Site 14 is an L_{dn} of 66 dBA. Project noise exposure between L_{dn} 62 and 67 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 67 dBA would cause a severe noise impact.

The existing noise exposure of the 30 residential buildings represented by Site N is an L_{dn} of 68 dBA. Project noise exposure between L_{dn} 63 and 68 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 68 dBA would cause a severe noise impact.

The existing noise exposure of Āliamanu Elementary School, represented by Site 15, is a maximum-hour L_{eq} of 60 dBA. Project noise exposure between 58 and 63 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 63 dBA L_{eq} would cause a severe noise impact.

A project noise exposure level of 56 dBA L_{dn} is predicted for site K, an L_{dn} of 51 dBA is predicted for Site 10, and an L_{dn} of 56 dBA and a maximum-hour (L_{eq}) of 53 dBA is predicted for Site L. A project noise level of 56 dBA L_{dn} is predicted for Sites 11 and 12. At Sites M and 14, L_{dn} levels of 54 and 57 dBA are predicted. An L_{dn} level of 61 dBA is predicted for Site N, and a maximum-hour L_{eq} of 51 dBA is predicted for Site 15. No noise impact are predicted for the 181 residential buildings represented by Sites 10, K, L,11, 12, 14, N, and for the three schools.

5.4.2 Ala Liliko‘i to Middle Street Transit Center

The existing noise exposure of the 12 residential buildings between the Ala Liliko‘i Station and the Middle Street Transit Center Station, represented by Sites O and 16, is an L_{dn} of 61 dBA at ground floor, 63 dBA at the 6^{th} floor and 78 dBA on the 12^{th} to 15^{th} floors . Project noise exposure between L_{dn} 59 and 65 dBA on the ground to 6^{th} floor would cause a moderate noise impact; project noise exposure above L_{dn} 65 dBA would cause a severe noise impact. For the 7^{th} to the 15^{th} floors project noise levels between L_{dn} 65 to 75 would cause a moderate impact and project noise exposure above L_{dn} 75 dBA would cause a severe noise impact.

The existing noise exposure of the 18 residential buildings represented by Site 17 is an L_{dn} of 59 dBA. Project noise exposure between L_{dn} 58 and 63 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 63 dBA would cause a severe noise impact.

The existing noise exposure of the 18 residential buildings represented by Site P is an L_{dn} of 64 dBA. Project noise exposure between L_{dn} 61 and 65 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 65 dBA would cause a severe noise impact.

A project noise exposure levels of 51 dBA L_{dn} is predicted for the ground floor of Sites O and 16. Project noise levels of 52 to 60 dBA L_{dn} are predicted from the 2^{nd} to 8^{th} floors. The 9^{th} and 10^{th} floors are predicted to have a project noise exposure level of 67 dBA $L_{dn,}$ while the project noise levels on the 11^{th} to the 15^{th} floors are predicted to be 66 dBA L_{dn} At Site 17, an L_{dn} of 55 dBA is predicted, and an L_{dn} of 55 dBA is predicted for Site P. Moderate noise impacts are predicted on the 9^{th} to 15^{th} floors of the 5 residential high-rise buildings represented by Sites O, 16.

5.5 Airport Alternative

5.5.1 Aloha Stadium to Pearl Harbor Naval Base

There are no sensitive land uses along this section.

5.5.2 Peal Harbor Naval Base to Honolulu International Airport

The existing noise exposure of the 11 residential buildings between the Pearl Harbor Naval Base Station and the Honolulu International Airport Station, represented by Site 13, is an L_{dn} of 69 dBA. Project noise exposure between L_{dn} 64 and 69 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 69 dBA would cause a severe noise impact.

A project noise exposure level of 52 dBA L_{dn} is predicted for Site 13. No noise impacts are predicted.

5.5.3 Honolulu International Airport to Lagoon Drive

There are no sensitive land uses along this section.

5.5.4 Lagoon Drive to Middle Street Transit Center

The existing noise exposure at Ke‘ehi Lagoon Beach Park, represented by Site 21, is a maximum-hour L_{eq} of 66 dBA. Project noise exposure between 67 and 72 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 72 dBA L_{eq} would cause a severe noise impact.

The project noise exposure would be a maximum-hour noise level of 51 dBA L_{eq} at Site 21. No noise impacts are predicted.

5.6 Airport & Salt Lake Alternative

5.6.1 Aloha Stadium to Ala Liliko‘i

The existing noise exposure of the 16 residential buildings between the Aloha Stadium Station and the H-1 Freeway, represented by Site K, is an L_{dn} of 60 dBA. Project noise exposure between L_{dn} 58 and 62 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 62 dBA would cause a severe noise impact.

The existing noise exposure of the 14 residential buildings represented by Site 10 is an L_{dn} of 66 dBA. Project noise exposure between L_{dn} 62 and 67 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 67 dBA would cause a severe noise impact.

The existing noise exposure of the 28 residential buildings represented by Site L is an L_{dn} of 63 dBA. Project noise exposure between L_{dn} 60 and 65 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 65 dBA would cause a severe noise impact.

The existing noise exposure of Makalapa Elementary and Radford High Schools, represented by Site L, is a maximum-hour L_{eq} of 65 dBA. Project noise exposure between 66 and 70 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 70 dBA L_{eq} would cause a severe noise impact.

The existing noise exposure of the 13 residential buildings represented by Site 11 is an L_{dn} of 67 dBA. Project noise exposure between L_{dn} 63 and 67 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 67 dBA would cause a severe noise impact.

The existing noise exposure of the 23 residential buildings represented by Site 12 is an L_{dn} of 69 dBA. Project noise exposure between L_{dn} 64 and 69 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 69 dBA would cause a severe noise impact.

The existing noise exposure of the 17 residential buildings represented by Site M is an L_{dn} of 69 dBA. Project noise exposure between L_{dn} 64 and 69 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 69 dBA would cause a severe noise impact.

The existing noise exposure of the 40 residential buildings represented by Site 14 is an L_{dn} of 66 dBA. Project noise exposure between L_{dn} 62 and 67 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 67 dBA would cause a severe noise impact.

The existing noise exposure of the 30 residential buildings represented by Site N is an L_{dn} of 68 dBA. Project noise exposure between L_{dn} 63 and 68 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 68 dBA would cause a severe noise impact.

The existing noise exposure of Āliamanu Elementary School, represented by Site 15, is a maximum-hour noise L_{eq} of 60 dBA. Project noise exposure between 58 and 63 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 63 dBA L_{eq} would cause a severe noise impact.

A project noise exposure level of 53 dBA L_{dn} is predicted for site K, an L_{dn} of 48 dBA is predicted at Site 10, and an L_{dn} of 53 dBA and a maximum-hour L_{eq} of 50 dBA are predicted for Site L. A project noise level of 53 dBA L_{dn} is predicted for Site 11; an L_{dn} of 53 dBA is predicted for Site 12. At Sites M and 14, an L_{dns} of 51 and 54 dBA are predicted. An L_{dn} of 53 dBA is predicted for Site N, and a maximum-hour L_{eq} of 45 dBA is predicted for Site 15. No noise impacts are predicted for the 181 residential buildings represented by Sites 10, K, L,11, 12, 14, N, and for the three schools.

5.6.2 Ala Liliko‘i to Middle Street Transit Center

The existing noise exposure of the 12 residential buildings between the Ala Liliko‘i Station and the Middle Street Transit Center Station, represented by Sites O and 16, is an L_{dn} of 61 dBA at ground floor, 63 dBA at the 6th floor and 78 dBA on the 12th to 15th floors . Project noise exposure between L_{dn} 59 and 65 dBA on the ground to 6th floor would cause a moderate noise impact; project noise exposure above L_{dn} 65 dBA would cause a severe noise impact. For the 7th to the 15th floors, project noise levels between L_{dn} 65 to 75 would cause a moderate impact; project noise exposure above L_{dn} 75 dBA would cause a severe noise impact.

The existing noise exposure of the 18 residential buildings represented by Site 17 is an L_{dn} of 59 dBA. Project noise exposure between L_{dn} 58 and 63 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 63 dBA would cause a severe noise impact.

The existing noise exposure of the 18 residential buildings represented by Site P is an L_{dn} of 64 dBA. Project noise exposure between L_{dn} 61 and 65 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 65 dBA would cause a severe noise impact.

A project noise exposure level of 48 dBA L_{dn} is predicted for the ground floor of Sites O and 16. Project noise levels of 49 to 57 dBA L_{dn} are predicted from the 2nd to 8th floors. The 9th and 10th floors are predicted to have a project noise exposure level of 63 dBA $L_{dn,}$ while the project noise levels on 11th to the 15th floors are predicted to be 63 dBA L_{dn} at Site 17, an L_{dn} of 52 dBA is predicted, and an L_{dn} of 51 dBA is predicted for Site P. No noise impacts are predicted for Sites O, 16, 17 and P.

5.6.3 Aloha Stadium to Pearl Harbor Naval Base

There are no sensitive land uses along this section.

5.6.4 Peal Harbor Naval Base to Honolulu International Airport

The existing noise exposure of the 11 residential buildings between the Pearl Harbor Naval Base Station and the Honolulu International Airport Station, represented by Site 13, is an L_{dn} of 69 dBA. Project noise exposure between L_{dn} 64 and 69 dBA would cause a moderate noise impact; project noise exposure above L_{dn} 69 dBA would cause a severe noise impact.

A project noise exposure level of 49 dBA L_{dn} is predicted at Site 13. No noise impacts are predicted.

5.6.5 Honolulu International Airport to Lagoon Drive

There are no sensitive land uses along this section.

5.6.6 Lagoon Drive to Middle Street Transit Center

The existing noise exposure at Ke‘ehi Lagoon Beach Park, represented by Site 21, is a maximum-hour L_{eq} of 66 dBA. Project noise exposure between 67 and 72 dBA L_{eq} would cause a moderate noise impact; project noise exposure above 72 dBA L_{eq} would cause a severe noise impact.

A project a maximum-hour L_{eq} of 48 dBA (L_{eq}) is predicted for Site 21. No noise impacts are predicted.

5.7 Vibration Impacts

The highest vibration levels for the LRT and rapid rail technologies, 65 VdB, would occur at Site Y. This vibration level would not exceed the FTA criterion of 72 VdB for residential buildings and other structures where people normally sleep (Category 2). No land use along the alignment has been identified as having vibration-sensitive equipment that would be subject to lower vibration impact criteria. Therefore, no vibration impacts are projected.

5.8 Construction

5.8.1 Noise

Noise from construction of the Project would be generated by heavy equipment and would occur as close as 50 feet from existing structures along the alignment. Table 5-3 shows the estimated maximum noise levels for the different stages of at-grade construction 100 feet from a receiver. Construction-generated noise levels can result in significant short-term noise impacts.

Table 5-3: Estimated Maximum Construction Noise Levels

Construction Phase	Loudest Equipment	Noise Level at 100 feet L_{max}* (dBA)
Clearing and grubbing	Bulldozers, backhoes, haul trucks	86
Earthwork	Scrapers, bulldozers	88
Foundation	Backhoes, loaders	85
Structures	Cranes, loaders, haul trucks	86
Base preparation	Trucks, bulldozers	88
Paving	Pavers, pumps, haul trucks	89

*L_{max} = Maximum Sound Level: The highest exponential-time-average sound level in decibels that occurs during a stated time period.

Source: Transit Noise and Vibration Impact Assessment, FTA, May 2006

5.8.2 Vibration

Common vibration-producing equipment used during at-grade construction activities includes jackhammers, pavement breakers, hoe rams, augur drills, bulldozers, and backhoes. Pavement breaking and soil compaction would probably produce the highest levels of vibration. Table 5-4 shows types of construction equipment measured under a variety of construction activities, and includes an average of source levels reported in terms of velocity levels. Although the table lists one velocity level for each piece of equipment, considerable variation exists in reported ground-vibration levels from construction activities. The data provide a reasonable estimate for a wide range of soil conditions. Depending on soil conditions, activities such as pile driving can generate enough vibration to result in significant short-term noise impacts.

Table 5-4: Vibration Source Levels for Construction Equipment

Equipment		Peak Particle Velocity at 25 feet (in/sec)	Approximate L_v at 25 feet (VdB)
Pile driver (impact)	Upper range	1.518	112
	Typical	0.644	104
Pile driver (sonic)	Upper range	0.734	105
	Typical	0.170	93
Clam shovel drop (slurry wall)		0.202	94
Hydromill (slurry wall)	In soil	0.008	66
	In rock	0.017	75
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	86
Jackhammer		0.035	79
Small bulldozer		0.003	58

Source: Transit Noise and Vibration Impact Assessment, FTA, May 2006
L_v = RMS velocity in decibels (VdB) re 1 micro-inch/sec.
RMS = The square root of the mean-square value of an oscillation waveform.

6 Mitigation

6.1 No Build Alternative

No traffic noise impacts are predicted for the No Build Alternative. Therefore, no mitigation is proposed.

6.2 All Build Alternatives

By placing a solid 3 foot high noise barrier above the top of rail at the edge of the guideway structure as part of the design, severe noise impacts have been avoided.

During final design a detailed analysis of the noise abatement measures will be conducted to determine if additional attenuation from a higher barrier would be feasible. Additional abatement measures can include a higher barrier in places with moderate impacts, and the use of sound absorptive materials on the top surface of the track bed.

6.3 Construction

Noise control measures during construction would be required to minimize noise levels on existing noise-sensitive land uses. All construction activities will have to comply with State of Hawaiʻi Department of Health (HDOH) noise regulations.

The mitigation measures listed in this section are examples of those that could be incorporated. They should be re-evaluated in greater detail during preliminary design, because impacts to residences cannot be accurately determined without detailed construction plans and schedules. The following measures are general guidelines for developing mitigation to reduce construction noise. These measures can be incorporated into site-specific construction plans to minimize noise impacts to sensitive receivers along the study corridor. Equipment noise emission limits could also be developed and/or adopted from existing sources. Construction hours could be set, and construction activity noise level emission criteria could be determined and compliance required during construction.

6.3.1 Design Considerations

During the early stages of construction plan development, natural and artificial barriers (e.g., ground elevation changes and existing buildings) can be considered for use as shielding against construction noise. Strategic placement of stationary equipment, such as compressors and generators, could reduce impacts at sensitive receivers.

6.3.2 Construction of Noise Barriers during Initial Stages

Noise barriers planned to be constructed along the right-of-way for traffic noise abatement could be constructed during the initial stages of the Project to reduce construction impacts. Initial construction of noise barriers would significantly reduce construction noise impacts at sensitive receivers.

6.3.3 Alternate Construction Methods

Certain phases of transit construction work, such as pile driving, may produce noise levels in excess of acceptable limits, even when feasible noise reduction methods are used. Using alternate methods of construction may reduce these impacts. For pile driving, vibratory or hydraulic insertion could be used, depending on a variety of factors (i.e., vibratory pile driving is not always quieter). Drilling holes for cast-in-place piles is an alternative construction method that would produce significantly lower levels of noise.

6.3.4 Source Control

The contractor shall comply with standard specifications and all local sound control and noise level rules, regulations, and ordinances that apply to any work performed pursuant to the contract. Each internal combustion engine used for any purpose on the Project or related to the Project shall be equipped with a muffler of a type recommended by the manufacturer. No internal combustion engine shall be operated without a muffler.

6.3.5 Time and Activity Constraints

Noisier activities involving large machinery should be limited to daytime hours, when most people normally affected are either not present or engaged in less noise-sensitive activities. Nighttime construction would require a variance. Compliance with local noise ordinances will mitigate impacts associated with construction noise. To comply with these ordinances, all construction activities adjacent to residential uses will be limited to daytime hours (7:00 a.m. to 6:00 p.m.) Monday through Saturday.

6.3.6 Community Relations

Community meetings could be held to explain the construction work, time involved, and control measures to be taken to reduce the impact of construction noise.

References

APTA 1981 — American Public Transit Association. 1981. *Guidelines for design of rail transit facilities.*

ASA 1983 — Acoustical Society of America. 1983. ANSI S3.29-1983. *American national standard: Guide to the evaluation of human exposure to vibration in buildings.*

Census 2002 — U.S. Bureau of the Census. 2002. Population *of counties by decennial census: 1900 to 1990.*

Chiddix 2004 — Chiddix, J., and M. Simpson. 2004. *Next stop Honolulu! The story of the O‘ahu Railway and Land Company.* Sugar Cane Press, Ltd., Honolulu, Hawai‘i.

DBEDT 2003 — State of Hawai‘i Department of Business, Economic Development, and Tourism. May 2003. *The economic contribution of Waikīkī.*

DBEDT 2005 — State of Hawai‘i Department of Business, Economic Development, and Tourism. 2005. *2004 state of Hawai‘i data book.*

DBEDT 2006 — Department of Business, Economic Development and Tourism. 2006. *State of Hawai‘i energy resources coordinator annual report 2005.*

DPP 1997a — City and County of Honolulu Department of Planning and Permitting. 1997. *City and County of Honolulu general plan (as amended)*.

DPP 1997b — City and County of Honolulu Department of Planning and Permitting. August 1997 (revised May 2000). *‘Ewa development plan*.

DPP 2002 — City and County of Honolulu Department of Planning and Permitting. December 2002. *Central O‘ahu sustainable communities plan.*

DPP 2004a — City and County of Honolulu Department of Planning and Permitting. June 2004. *Primary urban center development plan.*

DTS 1992 — City and County of Honolulu Department of Transportation Services and U.S. Department of Transportation Federal Transit Administration. 1992. *Final environmental impact statement—Honolulu rapid transit program.*

DTS 2006a — City and County of Honolulu Department of Transportation Services. 2006. *Honolulu high-capacity transit corridor project alternatives analysis—definition of alternatives report.*

DTS 2006b — City and County of Honolulu Department of Transportation Services. 2006b. *Honolulu high-capacity transit corridor project screening report.*

EPA 1974 — U.S. Environmental Protection Agency, Office of Noise Abatement and Control. March 1974. Report Number 550/9-74-004. *Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety.*

FHWA 1995 Federal Highway Administration, Office of Environment and Planning Noise and Air Quality Branch. June 1995. *Highway traffic noise analysis and abatement—policy and guidance.* Washington, D.C.

FTA 2006 U.S. Department of Transportation, Federal Transit Administration. May 2006. FTA-VA-90-1003-06. *Transit noise and vibration impact assessment, final report.*

HRS 2008 Hawaiʻi Revised Statutes. 2008. HRS 343. *Environmental impact statements.*

OʻahuMPO 1995 Oʻahu Metropolitan Planning Organization. 1995. *Oʻahu regional transportation plan.*

OʻahuMPO 2001 Oʻahu Metropolitan Planning Organization. 2001. *Transportation for Oʻahu plan TOP 2025.*

OʻahuMPO 2004 Oʻahu Metropolitan Planning Organization. 2004. *Exploring public attitudes on Oʻahu about transportation issues—a telephone survey among Oʻahu residents.*

OʻahuMPO 2007 Oʻahu Metropolitan Planning Organization. April 2006 (Amendment #1 2007). *Oʻahu regional transportation plan 2030*.

UH 2002 University of Hawaiʻi Office of the Vice President for Student Affairs. 2002. *Trends in the college experiences of undergraduates at the University of Hawaiʻi at Mānoa from 1990 to 2002*.

UH 2005 University of Hawaiʻi at Mānoa Institutional Research Office. 2005. *Common data set 2004-2005*.

USC 1969 United States Code. 1969. 42 USC 4321-4345. *National environmental policy act of 1969* (NEPA). Washington, D.C.

USDOT 1977 U.S. Department of Transportation. 1977. *Highway construction noise: Measurement, prediction, and mitigation.*

Appendix A
Predicted Project Noise Exposure Levels

Rec.	Receptor Description	# Bldgs	Existing Noise Level (dBA)	Project Noise Exposure without walls and wheel skirt in the design (dBA)	Project Noise Exposure with current design (dBA)
All Build Alternatives					
A	Saratoga Ave/ Franklin Ave	22	59	66	52
B	4235 Independence Rd	20	74	67	54
C	91-1005 Koahi St	6	54	53	42
1	Kahi Mohala Mental Health Facility	2	57	63	50
D	94-508 Farrington Hwy	40	72 Ground Floor	70 Ground floor; 71 2nd, to 4th Floors ; 70 5th, 6th and 7th Floors; 69 8th and 9th Floors	57 Ground floor; 59 2nd Floor, 61 3rd and 4th Floors; 68 5th, 6th and 7th Floors; 67 8th and 9th Floors
2	Waipahu Intermediate	2	63	65	51
3	94-309 Hanewai Circle	20	63	71	57
E	94-979 Kahuamoku Pl	16	78 Ground Floor, 70 4th Floor	69 Ground Floor; 70 2nd to 4th Floor	55 Ground Floor; 57 2nd Floor; 58 3rd Floor; 60 4th Floor
F	94-1041 Kahua Moku	15	73	70	56
4	91-1144 Awaiki Pl	18	59	70	56
G	94-261 Kahualena	21	69	70	56
5	Leeward Community College	1	65	62	53
6	1060 Kamehameha Hwy	1	67	65 Ground Floor; to 5th floor; 64 6th to 9th floor; 63 10th to 13th floor, 62 14th to 66th floors, 61 17th to 20th floor, 60 dBA or less 21 to 46th Floor	56 Ground Floor; 63 2nd to 5th floor; 62 6th to 9th floor; 61 10th to 13th floor, 60 dba or less 14th to 46th floors
7	Pacheco Neighborhood Park—Pearl Ridge Elementary School	3	59	67	54
H	751 Pu‘u Kala	22	66	69	55
I	98-5 Kuleana Pl	13	74	70 Ground Floor to 4th floor	56 Ground Floor; 57 2nd floor; 58 3rd floor; 59 4th floor
8	Neal S Blaisdell Park	1	64	66	52
J	98-124B Kihale St	19	74	70	60

Rec.	Receptor Description	# Bldgs	Existing Noise Level (dBA)	Project Noise Exposure without walls and wheel skirt in the design (dBA)	Project Noise Exposure with current design (dBA)
9	Kauhale St	14	57	70	57
Q	1746 Dillingham Blvd	30	75	71	56
18	Honolulu Community College	4	72	67	51
19	215 King St	1	73 Ground Floor, 73 6th floor, 70 26th Floor	63 Ground to 12th floor; 62 13th to 19th floor, 61 20th to 26th floor	61 Ground to 12th floor; 60 or less 13th to 26th floor
AA	901 River St	1	77	66	52
22	Fort Street Park	1	67	63	49
23	Aloha Marketplace	1	63	62	48
AB	700 Richards St	1	76 Ground Floor, 74 7th floor, 73 26th Floor	No Apartments 1st to 6th Floor; 67 7th Floor; 66 8th to 11th Floor; 65 12th to 14th Floor; 64 15th to 17th Floor, 63 18th and 20th Floor, 62 or less 21st to 26th Floor	No Apartments 1st to 6th Floor; 65 7th Floor; 64 8th to 11th Floor; 63 12th to 14th Floor; 62 or less 15th to 26th Floor
AC	600 Cooke St	1	67 Ground Floor, 75 5th floor and above	71 Ground Floor, to 3rd floor, 72 4th to 5th Floor,	56 Ground Floor, 57 2nd Floor, 58 3rd floor, 61 4th Floor, 62 5th Floor
24	Mother Waldron Park	1	58	62	47
	860 Halekauwila	1	67 Ground Floor, 75 5th floor and above	71 Ground Floor, to 3rd floor, 72 4th to 6th Floor, 71 7th Floor, 70 8th and 9th Floor, 69 10th Floor, 68 11th floor, 67 12th and 13th floor, 66 14th Floor 65 15, and 16th Floor, 64 17th and 18th Floor, 63 20th and 21st Floor, 62 or less 22nd to 30th	56 Ground Floor, 57 2nd Floor, 58 3rd floor, 61 4th Floor, 62 5th Floor, 61 6th Floor, 69 7th Floor, 68 8th and 9th Floor, 67 10th Floor, 66 11th floor, 65 12th and 13th floor, 64 14th Floor, 63 15th, and 16th Floor, 62 17th and 18th Floor, 61 or less 19th to 30th
	Uraku Tower	1	80 7th Floor, 75 26th Floor	No Apartments 1st to 6th Floor, 63 7th to 10th Floor, 62 or under 11th to 16th Floor, 61 or less 17th to 30th Floor	No Apartments 1st to 6th Floor, 61 7th to 10th Floor, 60 or under 11th to 30th
R	Ala Moana Hotel at	1	72	71	58 for floor below the guideway, at most

Rec.	Receptor Description	# Bldgs	Existing Noise Level (dBA)	Project Noise Exposure without walls and wheel skirt in the design (dBA)	Project Noise Exposure with current design (dBA)
	Kona and Mahukona				71 for floor above the guideway
S	2148 Kapiʻolani Blvd	28	74	71	58
T	2232 Kapiʻolani Blvd	18	75	69	57
U	630 University Ave	20	68	72	59
V	801 University Ave	25	68	70	57
W	1880 Kalākaua Ave	10	73	68	55 for floor below the guideway, at most 68 for floor above the guideway
X	1911 Kalākaua Ave	3	77	64	52 for floor below the guideway, at most 64 for floor above the guideway
20	King Kalakaua Park	0	70	63	48
Y	2406 Kūhiō Hwy	17	75	70	57 for floor below the guideway, at most 70 for floor above the guideway
Z	2520 Kūhiō Hwy	14	75	69	57 for floor below the guideway, at most 70 for floor above the guideway
Salt Lake Alternative					
K	99-Ohialomi Pl	16	60	70	56
10	444 Loina Pl	14	66	67	51
L	4317 Laʻakea St	28/ 2 schools	63	69	56
11	4148 Salt Lake Blvd	13	67	70	56
12	4034 Salt Lake Blvd	23	69	70	56
M	3760 Salt Lake Blvd	17	69	69	54
14	1010 Wanaka St	40	66	69	57
N	3472 Salt Lake Blvd	30	68	74	61
O	827 Ala Lilikoʻi St	6	61	64	52
15	Āliamanu Elementary School	2	60	67	51
16	2929 Ala ʻilima St	6	61 Ground Floor 67 6th Floor 78 12th floor	66 Ground Floor, 67 2nd and 3rd floor, 68 4th Floor to 7th Floor, 69 8th Floor, to 10th Floor, 68 11th and 12th Floor	51 Ground Floor, 52 2nd Floor, 53 3rd floor, 54 4th Floor, 56 5th Floor, 55 6th Floor, 57 7th Floor, 60 8th Floor, 67 9th and 10th Floor, 66 11th and 12th Floor
17	760 Moore St	18	59	68	55
P	2996 Anderson Ave	18	64	69	55
Airport Alternative					
13	1086 Fisler Ct	20	69	64	52
21	Keʻehi Beach Lagoon Park	1	66	62	51

Rec.	Receptor Description	# Bldgs	Existing Noise Level (dBA)	Project Noise Exposure without walls and wheel skirt in the design (dBA)	Project Noise Exposure with current design (dBA)
Airport & Salt Lake Alternative					
K	99-Ohialomi Pl	16	60	66	53
10	444 Loina Pl	14	66	64	48
L	4317 La‘akea St	28/ 2 schools	63	66	53
11	4148 Salt Lake Blvd	13	67	67	53
12	4034 Salt Lake Blvd	23	69	66	53
M	3760 Salt Lake Blvd	17	69	65	51
14	1010 Wanaka St	40	66	65	54
N	3472 Salt Lake Blvd	30	68	70	53
15	Āliamanu Elementary School	2	60	58	45
O	827 Ala Liliko‘i St	6	61	64	52
16	2929 Ala ‘Ilima St	6	61 Ground Floor 67 6th Floor 78 12th floor	63 Ground Floor, 64 2nd and 3rd floor, 65 4th Floor to 6th Floor, 66 7th Floor, to 9th Floor, 65 10th and 12th Floor	48 Ground Floor, 49 2nd Floor, 50 3rd floor, 51 4th Floor, 52 5th Floor, 53 6th Floor, 54 7th Floor, 57 8th Floor, 64 9th and 10th Floor, 63 11th and 12th Floor
17	760 Moore St	18	59	64	52
P	2996 Anderson Ave	18	64	65	51
13	1086 Fisler Ct	20	69	61	49
21	Ke‘ehi Beach Lagoon Park	1	66	59	48