Draft Environmental Impact Statement

Infrastructure Improvements at the Yap International Airport and the Yap Seaport

Yap State, Federated States of Micronesia

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Appendix K
Noise Analyses

K-1
Yap Noise Impact Analysis

ANL-26/13

Yap Airport and Seaport Noise Analysis

Environmental Science Division

ANL-26/13

Yap Airport and Seaport Noise Analysis

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ACRONYMS AND ABBREVIATIONS

AAD	Annual average day
AADNL	Annual average day-night sound level
AED	Average exercise day
ANSI	American National Standards Institute
ASA	Acoustical Society of America
BMP	Best management practice
CMU	Concrete masonry unit
CNRC	Community Noise Review Committee
dB	Decibel(s)
DCNL	Designated Community Noise Liaison
DNL	Day-night average sound level
DNWG	Department of Defense Noise Working Group
DoD	Department of Defense
DoW	Department of War
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FICAN	Federal Interagency Committee on Aviation Noise
FICON	Federal Interagency Committee on Noise
FSM	Federated States of Micronesia
Hz	Hertz
ISO	International Organization for Standardization
ICE	Internal combustion engine
kHz	Kilohertz
LDS	Latter-day Saints
L_{eq}	Equivalent continuous sound level
L_{max}	Maximum sound level
LUC	Land use compatibility
NA	Number of Events Above a Threshold Level
NATO	North Atlantic Treaty Organization
NIOSH	National Institute for Occupational Safety and Health
OINRL	Outdoor-to-indoor noise reduction level
OSHA	Occupational Safety and Health Administration

PEL	Permissible exposure limit
RCNM	Roadway construction noise model
REL	Recommended exposure limit
SEL	Sound exposure level
TNM	Traffic noise model
U.S.	United States
WHO	World Health Organization

1 RESOURCE DEFINITION AND METHODOLOGY

1.1 NOISE

1.1.1 Definition of Resource

Sound is a physical phenomenon consisting of minute pressure fluctuations that travel through a medium such as air or water. Noise is defined subjectively as any sound that is undesirable because it interferes with normal activities, diminishes environmental quality, or causes annoyance. The environmental resource evaluated in this section is the overall acoustic environment of the project area. This analysis assesses the extent to which the Proposed Action, including temporary construction phases and long-term military aircraft operations, may alter the baseline acoustic environment and introduce noise that impacts noise-sensitive receptors.

1.1.1.1 Noise Effects on General Public

Noise impacts on the public encompass human physiological and psychological responses to changes in the acoustic environment. The primary effects of environmental noise include general annoyance, speech interference, and sleep disturbance. General annoyance is a cumulative response to repeated noise events that disrupt daily life. Speech interference occurs when background noise masks human voices, causing frustration in homes, degrading learning environments in schools, and disrupting communication in places of worship. Sleep disturbance, typically caused by high-intensity nighttime events, can lead to awakenings, altered sleep stages, and subsequent daytime fatigue. Prolonged exposure to severe noise and repeated sleep disruption is also recognized as a pathway to broader physiological stress and downstream health effects (WHO, 2018).

1.1.1.2 Noise Effects on Land Use

Noise impacts on land use are evaluated based on the compatibility of specific activities with the surrounding acoustic environment. Land uses possess varying degrees of noise sensitivity. For example, residential areas, early childhood education centers, schools, hospitals, and places of worship are highly noise-sensitive receptors that require lower ambient noise levels to function normally. Conversely, industrial zones, commercial businesses, and agricultural lands are generally less noise-sensitive and tolerate higher noise thresholds. This assessment compares projected noise levels against established land use compatibility (LUC) guidelines, such as FAA Advisory Circular 150/5020-1 (DOT/FAA, 1983), to determine whether the introduced noise would render existing or planned land uses incompatible.

1.1.2 Basics of Sound and Noise

To accurately assess the population, land use, and ecological effects described above, it is necessary to understand how sound is physically generated, quantified, and perceived. This foundational standing dictates the specific acoustic metrics used to evaluate the Proposed Action.

Physically, sound is a pressure oscillation (a continuous sequence of compressions and rarefactions) generated by a vibrating object that propagates (travels) through a medium (air, water, solids) as a wave. As illustrated in Figure 1, these longitudinal sound waves are characterized by their amplitude, frequency, and wavelength. The height of the wave crests and depth of the troughs represent the amplitude, or sound pressure, of the wave, which determines the intensity of the wave. The frequency of the wave is the number of complete wave cycles (one crest and one trough) that pass a given point in one second. The spatial distance between consecutive peaks is the wavelength. Wavelength and frequency are inversely proportional: A low frequency wave has a long wavelength, and a high frequency wave has a short wavelength.

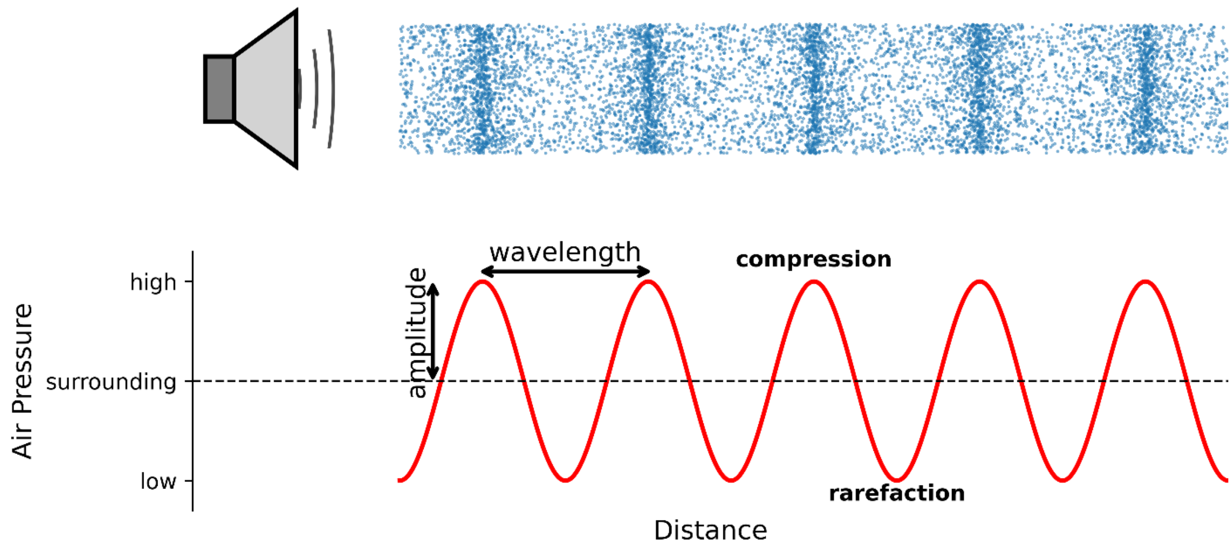

Figure 1: Traveling Sound Waves from a Loudspeaker

Human perception of sound relies on three physical characteristics of the sound: intensity, frequency, and duration.

- **Intensity**: A measure of sound energy directly related to the magnitude of the sound pressure oscillation. The human ear perceives intensity as the loudness of a wave.

- **Frequency**: A measure of the rate of wave oscillations, which is perceived as pitch. Low-frequency sounds are perceived as low pitches (often described as rumbles or roars), while high-frequency sounds are perceived as high pitches (described as screeches or clicks).

- **Duration**: The measurable length of time a sound is detected or perceived by a receiver.

1.1.3 The Decibel Scale and Human Hearing

The loudest sounds that can be comfortably heard possess intensities a trillion times greater than those that are barely perceivable. Because of this extremely wide range of audible sound intensities (spanning twelve orders of magnitude) and the ear's nonlinear response to sound, a logarithmic measure called the decibel (dB) is used to represent sound intensity, formally referred to as the sound level (L).

In the standard representation for airborne sound levels, which utilizes a reference sound pressure of 20 micropascals (ASA, 1985), the threshold of human hearing is approximately 0 dB, while the threshold of discomfort is near 120 dB. Typical conversational speech ranges between 60 and 70 dB.

Hearing sensitivity is also frequency dependent. For young adults with normal hearing, the audible frequency range extends from 20 hertz (Hz) to 20,000 Hz (20 kHz). Aging naturally diminishes the ability to hear higher frequencies (typically above 10 kHz), a condition known as presbycusis, though this hearing loss can be exacerbated by prolonged exposure to high-intensity sound levels. The complete range of audible frequencies and sound levels, alongside the typical acoustic profiles for speech and music, is illustrated in Figure 2 below (adapted from Rossing, 2002).

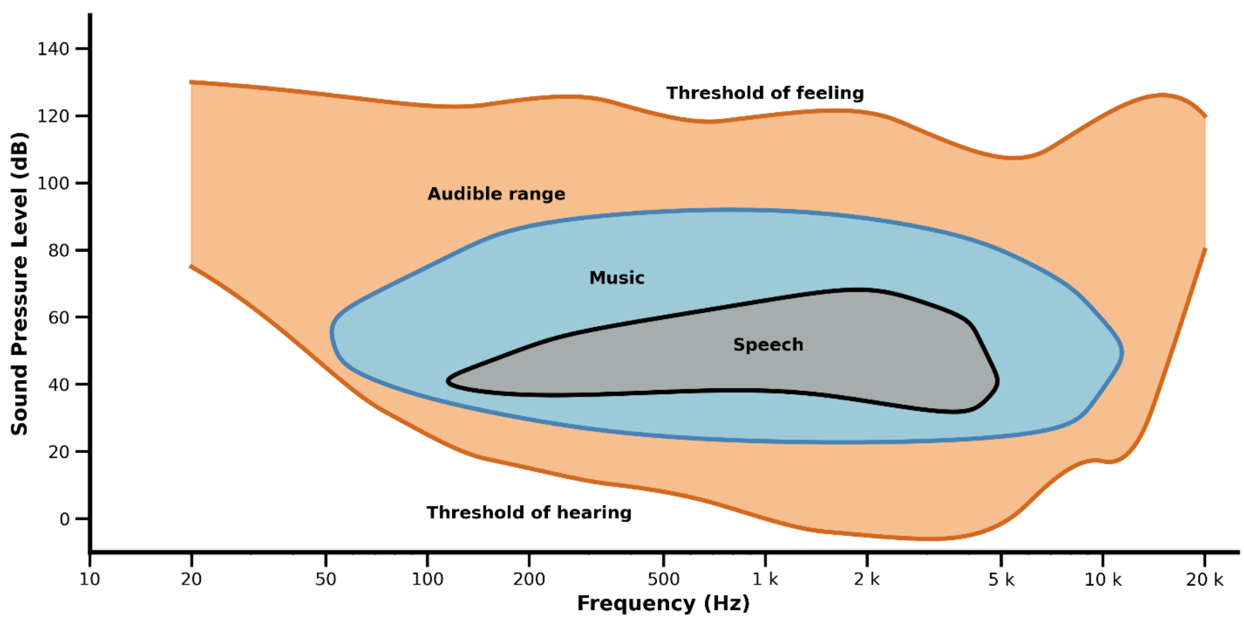

Figure 2: Range of Human Hearing and Typical Ranges for Speech and Music (adapted from Rossing, 2002).

1.1.4 Perception of Loudness and Frequency Weighting

As previously noted, the logarithmic decibel scale accommodates the ear's nonlinear response to a vast range of acoustic pressures. Within this scale, sound levels between 130 and 140 dB typically reach the threshold of physical pain (Berglund and Lindvall, 1995). For individual noise events, the minimum change in sound level detectable by the average human ear is approximately 1 dB. A 10 dB increase or decrease in sound level is generally perceived as a doubling or halving of the sound's loudness, respectively (Stevens, 1955). Figure 3 illustrates the sound levels of common sources, their associated comfort levels, and how quantitative changes in sound level translate into perceived loudness (Harris, 1979).

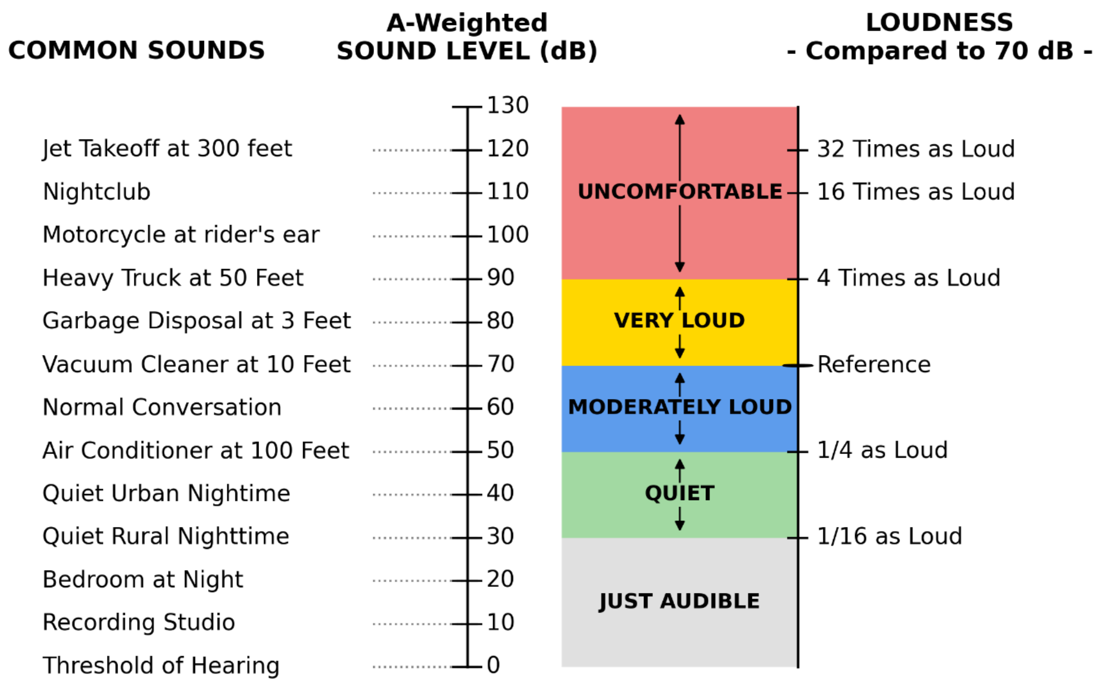

Figure 3: Sound Levels and Loudness of Common Sounds (adapted from Harris, 1979).

Human hearing is nonlinear not only with respect to loudness but with respect to frequency. The ear is most sensitive to sounds in the upper speech frequency range (approximately 1 to 5 kHz) and significantly less sensitive to very low and very high frequencies. To account for this variable sensitivity, acoustic metrics apply frequency weightings that adjust the raw acoustic data to better reflect human perception.

The most widely used standard frequency adjustment for community noise analysis is A-weighting, which approximates the human ear's response to moderate-level sounds. Figure 4 illustrates the standard A-weighting curve. A-weighted sound levels are widely used in community noise assessment because they generally correlate better than unweighted sound levels with human perception of loudness and with community responses such as annoyance, speech interference, and physiological health effects (WHO, 1999; DNWG, 2009a; DNWG, 2009b). A-weighted sound levels are those measured or modeled using this filter and are sometimes indicated by the unit dBA.

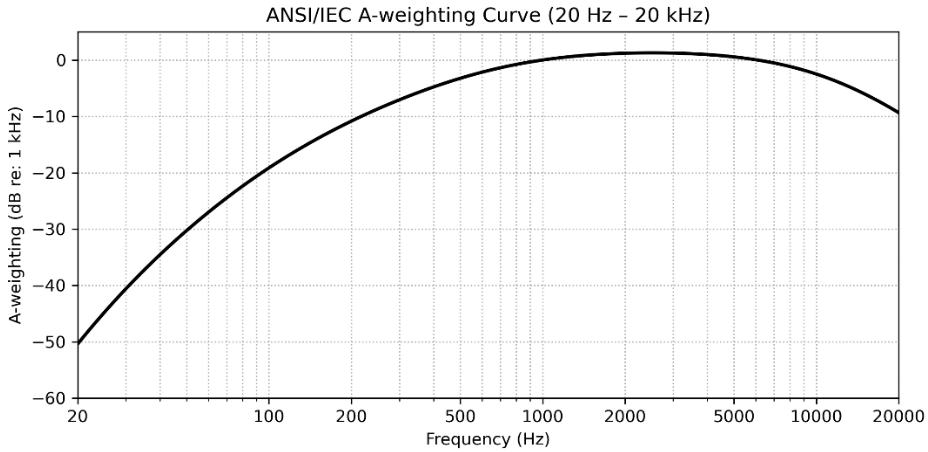

Figure 4: A-Weighting Sound Curve (ASA, 1985)

To ensure consistency and clarity, unless otherwise specified, all sound levels and noise metrics discussed in this report are A-weighted, even when the unit is dB.

1.1.5 Noise Metrics

1.1.5.1 Maximum Sound Level

The maximum sound level, or L_{max}, is the highest sound level reached during a noise event in which the sound level changes over time. When based on measurements, the reported value depends in part on meter response settings and instrumentation conventions. For noise impact assessment, the A-weighted maximum sound level is used (FICAN, 1980), and throughout the remainder of this report, the term L_{max} can be assumed to refer to A-weighted maximum sound level. L_{max} is one metric used in the analysis of speech interference and learning disruption.

1.1.5.2 Equivalent Continuous Sound Level

The equivalent continuous sound level, or L_{eq}, represents the average sound energy over a specified time period and is expressed in decibels. For L_{eq} to be meaningful, the averaging period must be identified; this is often indicated in the subscript. For example, the L_{eq} for a 24-hour period is typically written as $L_{eq(24h)}$. The L_{eq} for daytime hours of 7 a.m. to 10 p.m. (0700-2200 hours) is commonly written as $L_{eq(D)}$ and the L_{eq} for nighttime hours of 10 p.m. to 7 a.m. (2200-0700) is commonly written as $L_{eq(N)}$. When A-weighting is applied, the letter A is often added to the notation: An A-weighted L_{eq} may be written as L_{Aeq}. Because all sound levels in this report are assumed to be A-weighted, the notation L_{eq} assumes that the equivalent sound level is A-weighted.

1.1.5.3 Sound Exposure Level

The sound exposure level, or SEL, is a cumulative measure of the total sound energy of a noise event, such as an aircraft takeoff or overflight, during which the sound level changes over time. SEL is formally defined as the equivalent sound level L_{eq} that would need to occur for a period of one second to impart the same total sound energy as the event, as shown in Figure 5. Because overflight events typically last longer than one second, the SEL for an event is usually higher than the L_{max}. SEL is a primary metric used in the assessment of sleep disturbance.

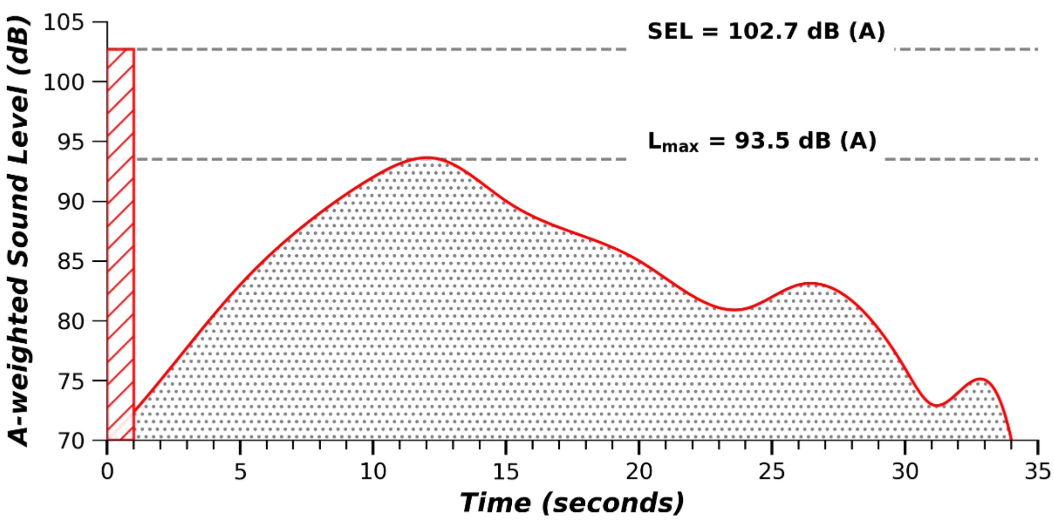

Figure 5: Example of SEL for an Aircraft Flyover Noise Trace

1.1.5.4 Day-Night Average Sound Level (DNL)

The day-night average sound level, or DNL, is a primary noise metric used for assessing aircraft noise impacts. DNL is a modified form of the 24-hour L_{eq} that applies a 10 dB penalty to nighttime sound occurring between 10 p.m. and 7 a.m. to account for increased community sensitivity to noise during those hours. DNL is the preferred metric of the Federal Aviation Administration (FAA), the Department of War (DoW), the U.S. Environmental Protection Agency (EPA), and other government agencies. DNL has been shown to correlate well with community response to noise, and a consistent relationship has been established between DNL and community annoyance (Finegold, 1994). Studies have shown that about 87% of the population is not highly annoyed by sound with DNL under 65 dB (FICUN, 1980). Accordingly, DNL is used to help evaluate the compatibility of military aircraft operations with local land use.

When operations occur regularly throughout the year, such as daily or twice weekly, the common metric is the annual average day-night sound level or AADNL. AADNL represents the annualized average daily day-night sound level and, for operations that occur intermittently during the year, will generally be lower than the DNL calculated for a day on which operations occur.

1.1.5.5 Number of Events Above a Threshold Level (NA)

The number of events above a threshold, or NA, is the total number of noise events that exceed a specified sound level threshold during a given time period. The threshold is typically either SEL or L_{max}. This metric is useful for looking at how often high-noise-level events occur. The metric is commonly denoted as NAXXYYY, where XX is the threshold in dB and YYY is the selected metric. For example, the number of events for which the sound exposure level exceeds 90 dB would be denoted NA90SEL, and the number of events for which the L_{max} exceeds 65 dB would be NA65L_{max}. For either form of the metric, the counting period should also be identified, such as the number of events per hour, per night, or per 24-hour period.

1.1.6 Primary and Supplemental Noise Analyses

Noise impacts are evaluated using both primary and supplemental acoustic metrics because no single metric fully captures all relevant noise effects. For military aircraft operations, the primary analysis is the LUC assessment, based on AADNL, consistent with current DoW compatibility guidance. AADNL is used to evaluate long-term average aircraft noise exposure and the general compatibility of recurring aircraft operations with surrounding land uses.

Because annual-average metrics do not fully capture the timing, loudness, and frequency of individual events, the analysis also uses supplemental event-based metrics, including L_{eq}, $L_{max,}$ SEL, and NA, to evaluate specific effects such as sleep disturbance, learning disruption, worship disruption, and wildlife disturbance.

For construction activities, including airport, roadway, seaport, and dredging-related work, AADNL and LUC are not the primary analytical tools. Construction noise is temporary, location-specific, and variable by phase and equipment usage. It is therefore evaluated separately using receptor-based metrics that more directly characterize noise from specific construction activities.

1.1.7 Land Use Compatibility (LUC)

LUC is evaluated to determine whether projected long-term aircraft noise exposure would be generally compatible with existing or planned land uses in the vicinity of the airport. For this analysis, LUC is based on annual-average aircraft noise exposure, expressed as AADNL, consistent with current DoW compatibility guidance and informed by FAA airport noise compatibility planning guidance. These compatibility guidelines are used here as technical planning benchmarks for evaluating aircraft noise exposure associated with military aviation activities; they are not presented as a statement of FAA regulatory applicability to the Proposed Action.

LUC is primarily a long-term planning tool. It is intended to support decisions such as land use planning, zoning, siting of new noise-sensitive development, and identification of building design measures that may be appropriate in areas exposed to elevated long-term aircraft noise. Because LUC is based on annual-average day-night noise exposure, it is most appropriate for evaluating broad patterns of community exposure and the general compatibility of land uses with recurring aircraft operations over time.

General land use compatibility as a function of annual average DNL at a site is defined in DoD Instruction 4165.57, *Air Installations Compatible Use Zones* (DoD, 2021) which is based, in part, on FAA Advisory Circular 150/5020-1 *Noise Control and Compatibility Planning for Airport*s (DOT/FAA, 1983). In this framework, increasing AADNL corresponds to increasing potential for incompatibility between aircraft noise exposure and noise-sensitive land uses, particularly residential uses, schools, hospitals, and places of worship.

Although LUC is the primary framework for evaluating long-term aircraft operations noise, it does not, by itself, capture all noise effects relevant to this analysis. Annual-average metrics such as AADNL may not adequately characterize the importance of individual loud events, nighttime awakenings, classroom disruption, or other short-duration effects that depend on the timing, loudness, and frequency of discrete events. Accordingly, this analysis supplements the LUC assessment with additional noise metrics, including L_{eq}, L_{max}, and SEL, and event-count metrics, where needed to evaluate specific noise effects such as sleep disturbance, speech interference, learning disruption, worship disruption, and wildlife disturbance.

LUC is also of limited utility for evaluating construction noise. Construction activities associated with the runway, airport, and tarmac expansion, roadway improvements, seaport construction, and dredging are temporary, variable by phase, and dependent on the location and duration of specific equipment operations. Because these characteristics are not well represented by an annual-average aircraft noise metric, construction noise is evaluated separately using activity- and receptor-based metrics that are more directly tied to the predicted sound levels from specific construction equipment and work phases.

Assessment of land use compatibility may also consider outdoor-to-indoor noise reduction level (OINRL), which represents the sound attenuation provided by the building envelope. Typical environmental analyses for conventional U.S. residential construction often assume an OINRL of 20 to 25 dB with windows and doors closed. However, because building construction materials on Yap are often of lighter weight and may provide less acoustical isolation than typical mainland U.S. construction, this analysis assumes an OINRL of 15 dB for representative noise-sensitive receptors unless more specific building information is available. This assumption is used in interpreting the extent to which outdoor aircraft noise exposure may affect indoor conditions relevant to certain land uses.

Table 1 presents the LUC categories used in this analysis for long-term aircraft noise exposure.

Table 1: Land Use Compatibility in Aircraft Noise Zones (DoD, 2025)

Land Use	A-Weighted DNL Levels in dB						
	A **<55**	**B** **55-65**	**C-1** **65-70**	**C-2** **70-75**	**D-1** **75-80**	**D-2** **80-85**	**D-3** **>85**
All Residential and Nursing Homes			(1)	(1)			
Transient Lodgings			(1)	(1)	(1)		
Public Assembly and Nature Exhibits							
Schools and Hospitals			(2)	(3)			
Cultural Activities			(2)	(3)			
Entertainment and Recreational Activities				(2)			
Livestock Farming and Animal Breeding							
Business Services, Stores, Restaurants				(2)	(3)		
Religious and Governmental Activities				(2)	(3)		
Outdoor Recreational Activity							
Manufacturing and Industry				(2)	(3)	(4)	
Agriculture, Forestry, and Mining			(5)	(6)	(7)		

KEY: Compatible Incompatible

Notes:

(1) Residential use is discouraged in zone C-1 and strongly discouraged in C-2, and transient lodging use is discouraged in zones C-1, C-2, and D-1. Where the community determines that these uses must be allowed, follow note (2) for zone C-1, note (3) for zone C-2, and note (4) for Zone D-1.
(2) Incorporate measures to achieve an OINRL of at least 25 dB in noise-sensitive areas.
(3) Incorporate measures to achieve an OINRL of at least 30 dB in noise-sensitive areas.
(4) Incorporate measures to achieve an OINRL of at least 35 dB in noise-sensitive areas.
(5) Where residences are permitted, follow (2) for residential designs.
(6) Where residences are permitted, follow (3) for residential designs.
(7) Where residences are permitted, follow (4) for residential designs.
Table notes are reproduced from the cited source and may retain source-originated nomenclature.

1.1.8 Sleep Disturbance

Nighttime aircraft noise events have the potential to disrupt sleep by causing awakenings, increasing sleep stage changes, and degrading sleep quality. Repeated sleep disturbance is a recognized pathway by which environmental noise may contribute to broader health effects by activating stress responses and impairing physiologic recovery during sleep. Reviews and guidelines developed by the World Health Organization (WHO) identify sleep disturbance as a key health endpoint associated with nighttime transportation noise exposure (WHO, 2009; WHO, 2018; Basner and McGuire, 2018). Peer-reviewed reviews and syntheses further describe associations among transportation noise exposure, sleep disturbance, and downstream cardiovascular and metabolic risk pathways (Basner et al., 2014; Munzel et al., 2014).

Accordingly, sleep disturbance is evaluated in this analysis as a supplemental aircraft noise effect in addition to the long-term aircraft noise compatibility assessment based on AADNL/LUC. This additional analysis is necessary because while annual-average compatibility metrics are useful for evaluating broad long-term exposure patterns, they do not fully capture the timing, loudness, and frequency of discrete nighttime noise events that may disturb sleep. As a result, reliance on LUC alone could underrepresent an important dimension of community response to nighttime military aircraft operations.

The effects of aircraft noise on sleep disturbance are evaluated in this analysis using the methodology in the *Effects of Aviation Noise on Awakenings from Sleep* (FICAN, 1997), consistent with current DoW interim guidance for environmental noise analysis. FICAN 1997 relates the probability of awakening to the indoor sound exposure level (SEL) of a single nighttime aircraft noise event.

The Department of Defense Noise Working Group (DNWG) had previously endorsed replacing FICAN 1997 with the methodology in ANSI/ASA Standard S12.9-2008 Part 6 (ASA, 2008; DNWG, 2009). However, that standard was withdrawn in 2018 (ASA, 2018), and in April 2025, the Deputy Assistant Secretary of Defense issued the memorandum *Interim Guidance on Noise-Induced Sleep Awakening Analysis* directing a return to the use of FICAN 1997 (DoD, 2025).

Because aircraft noise modeling predicts outdoor event sound levels, indoor SEL is estimated by applying an assumed OINRL to the modeled outdoor SEL. For this analysis, an OINRL of 15 dB is assumed for representative residential receptors on Yap unless more specific building information is available. This assumption reflects the generally lighter-weight construction and lower acoustical isolation expected for many Yap structures compared to typical mainland U.S. residential construction.

Using the FICAN 1997 relationship, the screening-level probability that a person would awaken from a single nighttime event is estimated from the indoor SEL as follows:

$$P_{awakening} = 0.0087 \times (SEL_{indoors} - 30)^{1.79}. \qquad \text{Eq. 1}$$

As illustrated in Figure 6, the FICAN 1997 relationship is most appropriately interpreted as a screening-level estimate of the upper-bound percentage of a residential population that may awaken in response to an event with a given indoor SEL. Accordingly, the method is used in this analysis primarily to compare the relative potential for sleep disturbance among alternatives and scenarios, rather than to predict a precise absolute awakening rate for the affected population.

Sleep disturbance analysis is applied principally to residential receptors and, where relevant, to transient lodging uses that may be exposed to nighttime aircraft activity. In interpreting results, the analysis considers not only the modeled SEL of individual nighttime events, but also the expected number and timing of such events, because repeated disturbances during normal sleeping hours may increase the potential for sleep-related effects.

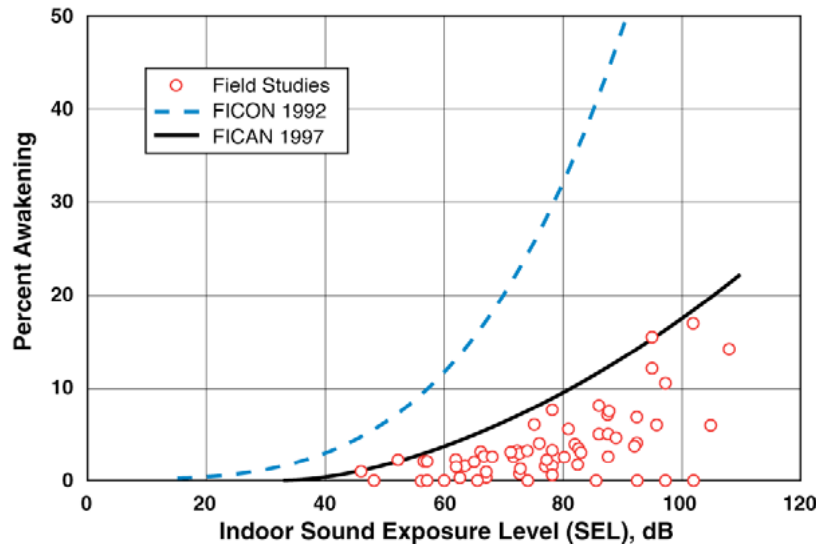

Figure 6: Recommended Sleep Disturbance Dose-Response Relationship (Figure 2 in FICAN 1997)

1.1.9 Learning Disruption and Disruption of Worship

Noise associated with aircraft overflights and construction activities may disrupt learning and interfere with activities in places of worship. These effects are important to evaluate separately from land use compatibility because they are driven not only by long-term average noise exposure, but also by the timing, loudness, and frequency of individual noise events. As a result, annual-average metrics such as AADNL, while useful for evaluating broad long-term aircraft noise exposure patterns, do not fully characterize the potential for classroom disruption or interruption of worship services.

In educational settings, noise can interfere with verbal communication, concentration, listening comprehension, and classroom instruction. These effects are of particular concern for younger children, whose speech, language, and learning processes are still developing, and for students in settings where clear verbal communication is essential to instruction (Bradley, 1986; Shield and Dockrell, 2003). In places of worship, elevated noise may interfere with spoken communication, music, prayer, and quiet contemplation, thereby affecting the normal use of the facility even where the disturbance is temporary or intermittent (Kleiner et al., 2010).

For schools and similar educational uses, this analysis applies screening-level criteria derived from widely used indoor acoustic recommendations and the Yap-specific outdoor-to-indoor noise reduction assumption. ANSI/ASA S12.60 (ASA, 2010) recommends a maximum 1-hour indoor A-weighted equivalent sound level of 35 dB for classrooms serving pre-kindergarten through fifth grade. Higher indoor background noise levels, such as 40 dB for middle and high school classrooms and 45 dB for adult learning environments, are commonly used for older student populations. Assuming an OINRL of 15 dB, these indoor criteria correspond approximately to outdoor L_{eq} values of 50 dB, 55 dB, and 60 dB, respectively.

Because classroom disruption may also be caused by discrete loud events rather than average background noise alone, this analysis also uses an event-based screening metric for schools. Specifically, the analysis considers the number of events with outdoor L_{max} higher than 65 dB during the school day, expressed as NA65L_{max} over the applicable daytime school-hour period. Assuming an OINRL of 15 dB, an outdoor L_{max} of 65 dB corresponds approximately to an indoor L_{max} of 50 dB, a level associated with brief but potentially meaningful interruption of classroom communication and attention.

For places of worship, this analysis applies screening-level criteria derived from published indoor acoustic guidance and the same Yap-specific OINRL assumption. ASA S12.2-2019, *Criteria for Evaluating Room Noise* (ASA, 2019), recommends low indoor background noise levels for spaces where speech communication and quiet listening are important. In addition, acoustics references for worship spaces commonly recommend noise criteria (NC) values in the range of NC-25 to NC-30, which correspond approximately to A-weighted indoor sound levels on the order of 30 to 40 dB in typical conditions (Kleiner et al., 2010).Assuming an OINRL of 15 dB, this analysis uses an outdoor L_{eq} of 55 dB and the NA65L_{max} event count metric as screening-level indicators of the potential for disruption at places of worship.

These classroom and worship criteria are used as analytical screening tools to help identify conditions in which aircraft or construction noise may interfere with normal use of these receptors. They are not presented as regulatory thresholds and should not be interpreted as precise predictors of the extent of disruption in every case. Rather, they provide a consistent basis for comparing alternatives, identifying potentially affected receptors, and evaluating whether best management practices or mitigation may be warranted.

1.1.10 Hearing Impairment and Noise-Induced Hearing Loss

Hearing impairment and noise-induced hearing loss (NIHL) are not expected community noise impacts of the Proposed Action or the associated construction activities. This topic is addressed here both to identify the appropriate acoustic context for evaluating potential hearing damage risk and to clarify that off-site community exposures would not be of the type or duration associated with permanent hearing damage.

Unlike community response effects such as land use compatibility, sleep disturbance, learning disruption, or worship disruption, the potential for hearing impairment is not primarily evaluated using annual-average aircraft noise metrics such as AADNL or planning-based compatibility guidance. Rather, hearing-damage risk depends principally on the combination of sound level and exposure duration. Very high sound levels may be tolerated for short periods without permanent auditory injury, while lower levels may pose a risk only when exposure is sustained for extended durations and repeated over time.

For this reason, the most relevant benchmarks for evaluating potential hearing damage risk are duration-based exposure criteria such as occupational noise standards. The National Institute for Occupational Safety and Health (NIOSH) recommends an A-weighted exposure limit of 85 dB as an 8-hour time-weighted average (NIOSH, 1998). The Occupational Safety and Health Administration (OSHA) permissible exposure limit is 90 dB as an 8-hour time-weighted average shift (OSHA, 2004). These criteria are designed for occupational settings and are not community noise significance thresholds; however, they provide useful context for determining whether off-site noise exposure could plausibly approach levels associated with permanent hearing damage.

In the Proposed Action and Reduced Action scenarios and related construction scenarios, neither military aircraft operations nor off-site construction noise exposure at community receptors would be expected to approach these duration-adjusted exposure conditions. Military aircraft overflights may produce high short-duration maximum sound levels at some locations, but these events are transient and do not persist long enough to create the sustained exposure associated with NIHL. Similarly, although construction equipment may generate elevated sound levels near the source, sound levels attenuate with distance, and the duration of exposure experienced by off-site residents and other community receptors would be insufficient to approach occupational hearing damage benchmarks.

Accordingly, hearing impairment and NIHL are not treated as primary off-site impact endpoints in this analysis. The noise effects evaluated for community receptors focus on those more relevant to the expected exposure conditions, including land use compatibility, sleep disturbance, learning disruption, worship disruption, and wildlife disturbance. Occupational noise exposure for on-site construction workers and military personnel would be addressed separately in applicable occupational health and safety requirements and programs.

1.1.11 Military Aircraft Noise

Military aircraft generate several distinct types of noise, each with unique acoustic characteristics, spectral profiles, and propagation patterns. The environmental impact of these noise types depends heavily on aircraft type, engine type, phase of flight, and power settings. For the purposes of this analysis, military aircraft noise is broadly categorized into subsonic flight noise, supersonic noise, and ground operations noise.

1.1.11.1 Subsonic Aircraft Noise

Subsonic noise from an individual aircraft is a time-varying, continuous sound. It is first audible as the aircraft approaches, increases to a maximum when the aircraft reaches its closest point of approach, and then diminishes as it departs, as illustrated in Figure 5. The overall noise level depends on the altitude, speed, thrust setting, and specific flight track of the aircraft. In military jet aircraft (such as the F-15, F-16, F-22, and F-35), subsonic noise is primarily generated by two mechanisms:

- **Engine/exhaust noise:** The rapid mixing of high-velocity jet exhaust gases with the slower-moving ambient air produces a broadband, low-frequency roar. This is typically the dominant noise source during high-power maneuvers and takeoffs. The use of afterburners significantly amplifies this turbulent mixing, resulting in high-amplitude sound.

- **Aerodynamic/airframe noise**: As air flows rapidly over the fuselage, wings, and deployed control surfaces (such as landing gear, flaps, and speed brakes), it creates turbulent boundary layers and wakes. While often masked by engine exhaust during takeoff, aerodynamic noise becomes a major acoustic contributor during landing approaches when engines are throttled back.

1.1.11.2 Supersonic Aircraft Noise

Supersonic noise consists of sonic booms. A sonic boom is a transient, impulsive acoustic event generated when an aircraft travels faster than the speed of sound (Mach 1), creating a pressure shock wave that sweeps across the ground along the flight path. Unlike the continuous, gradual buildup of subsonic flight noise, a sonic boom is perceived as a sudden, sharp "crack" or double bang. While many modern military fighters are capable of supersonic flight, such operations are typically restricted to specifically authorized training airspace, often offshore or in designated high-altitude corridors, to avoid acute startle effects and potential structural damage in civilian communities.

1.1.11.3 Noise from Ground Run-up and Operations

Ground operations introduce a localized, steady-state noise to the environment immediately surrounding the airfield. Unlike transient flyovers, ground noise does not pass quickly; it can be sustained for several minutes to over an hour.

This category includes:

- **Engine run-ups:** High-power engine testing performed on the tarmac or in designated run-up areas following maintenance. Because the aircraft is stationary, the acoustic footprint is fixed, continuously exposing downwind receptors to high-intensity sound.

- **Taxiing and idle:** Lower-power engine operations as aircraft transit between parking aprons, arming areas, and active runways.

- **Auxiliary power units (APUs):** Small onboard turbine engines used to provide electrical power and pneumatic air to the aircraft while the main engines are shut down. APUs produce a distinct, high-pitched whine that can cause localized annoyance for nearby receptors.

1.1.12 Construction Noise

Construction noise is evaluated separately from military aircraft operations noise because it is temporary, location-dependent, and contingent on construction details that are not yet available, including final equipment selections, work sequencing, and daily schedules. Accordingly, this analysis uses a conservative screening-level approach rather than a detailed construction operations model.

Because project-specific equipment inventories, duty cycles, and exact work locations have not been developed, the analysis does not predict receptor-specific construction L_{eq} values. Instead, it evaluates potential construction noise using the estimated L_{max} from a representative high-noise piece of equipment assumed to operate at the construction-zone boundary nearest each receptor. Where useful, the analysis also identifies the construction-zone boundary L_{eq} that would be needed to avoid exceeding a specified receptor L_{eq} criterion. This information is used as a planning tool to support future BMP development, contractor controls, and mitigation planning once more detailed construction information becomes available.

This methodology is applied to airport, roadway, seaport, and dredging-related construction to assess their airborne noise effects on onshore receptors and terrestrial wildlife. Underwater sound generation and marine species effects are addressed separately, if applicable, in the relevant marine resources analysis.

2 NOISE MODELING

Military aircraft noise was modeled using specialized aviation noise tools capable of representing aircraft-specific performance, flight procedures, and noise exposure metrics relevant to environmental analysis. Construction noise was evaluated using a separate screening-level approach because detailed construction means and methods are not yet available, including final equipment selections, exact work locations, and daily operating schedules. The aircraft and construction analyses therefore use different modeling frameworks appropriate to the available data and the nature of the sources.

Figure 7 identifies the 29 receiver locations used in the noise analysis. These receiver locations represent residences, schools, churches, businesses, community facilities, hotels, and other land uses potentially affected by aircraft operations or construction activities. Receiver locations are identified by alphanumeric labels (e.g., R1, R2) and are described further in Table 2.

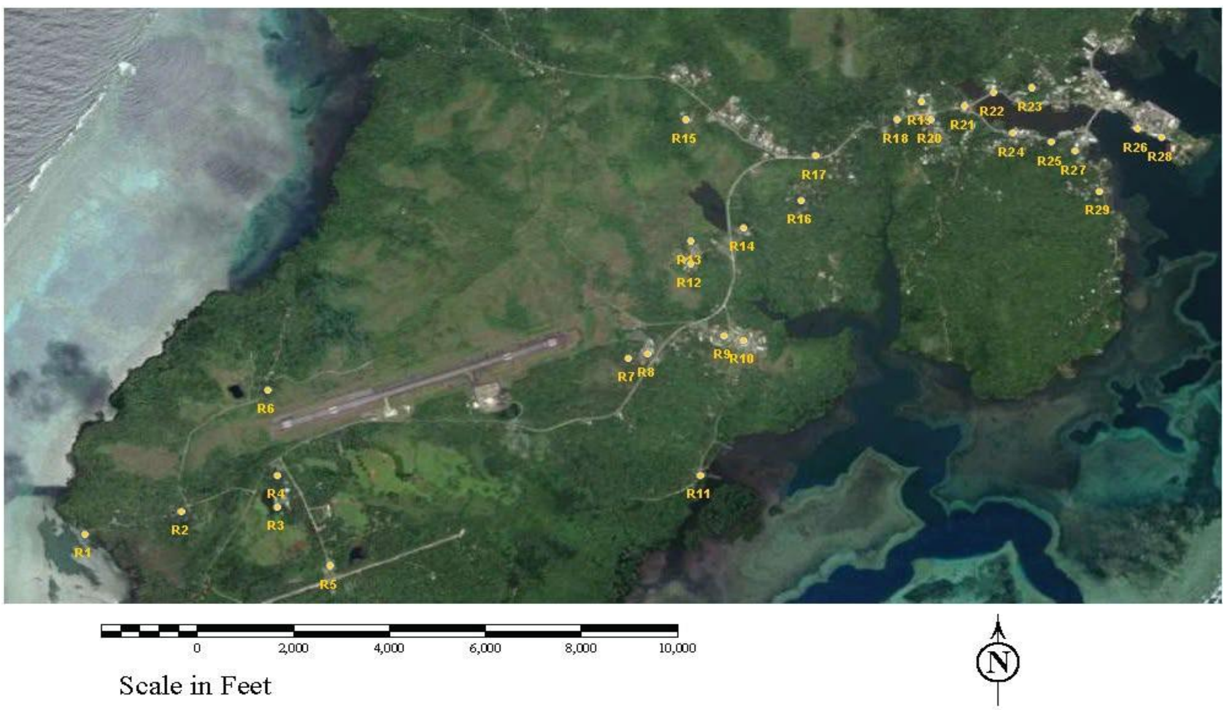

Figure 7: Locations of Receivers Used in Noise Modeling

Noise modeling for this analysis was conducted by the John A. Volpe National Transportation Systems Center. Detailed modeling inputs, assumptions, and results are documented in *Noise Technical Report for the Environmental Impact Statement for Infrastructure Improvements at the Yap International Airport and the Yap Seaport* (Volpe Center, 2026). That report identifies the aircraft types, flight tracks, operational profiles, and other modeling inputs used in the analysis. To avoid duplication, those detailed technical inputs are incorporated here by reference.

Table 2: Locations and Descriptions of Receivers

ID	Name	Category	Latitude N (Degrees)	Longitude E (Degrees)
R1	Daqabyuch Building	Private Residence	9.489722	138.063056
R2	Residences Southwest of Airport	Private Residences	9.491111	138.068611
R3	Yap Catholic High School	School	9.491389	138.074167
R4	Avi's Laundromat	Business	9.493333	138.074167
R5	Milew Community Center	Community Center	9.487778	138.077222
R6	Residence North of Airport	Private Residence	9.498611	138.073611
R7	Residences East of Airport	Private Residences	9.500556	138.094444
R8	GPPC Batch Plant	Industrial Zone	9.500833	138.095556
R9	College of Micronesia (Yap Campus)	School and Nearby Private Residences	9.501944	138.100000
R10	Yap High School	School	9.501667	138.101111
R11	Ohnn Church	Church	9.493333	138.098611
R12	Colonia Middle School	School	9.506389	138.098056
R13	Early Childhood Education	School and Nearby Private Residences	9.507778	138.098056
R14	YSPSC Water Plant	Light Industrial Zone	9.508611	138.101111
R15	Yap Seventh-day Adventist Church	Church	9.515278	138.097778
R16	Jesylene Googur	Private Residences	9.510278	138.104444
R17	Satawal Compound (housing complex)	Private Residences	9.513056	138.105278
R18	Yap Department of Agriculture and Forestry Complex	Government Office	9.515278	138.110000
R19	Gaanelay Elementary School	School	9.516389	138.111389
R20	The Church of Jesus Christ of Latter-Day Saints	Church	9.515278	138.111944
R21	Aces Mart 2	Business	9.516111	138.113889
R22	Aces Mart 1	Business	9.516944	138.115556
R23	Yap State Department of Education	Government Office	9.517222	138.117778
R24	ESA Bay View Hotel	Hotel	9.514444	138.116667
R25	Oceania Hotel	Hotel	9.513889	138.118889
R26	Yap Public Library	Public Library	9.514722	138.123889
R27	YCA Hardware	Business	9.513333	138.120278
R28	FSM National Police Yap Field Office	Government Office	9.514167	138.125278
R29	J&S Store	Business	9.510833	138.121667

2.1 AIRCRAFT NOISE MODELING

Aircraft operations noise at the twenty-nine receiver locations was modeled by the Volpe Center using NOISEMAP version 7.370, the currently approved model for military aircraft noise impact analysis. The model was used to estimate receiver-specific aircraft noise exposure metrics for baseline and exercise conditions, including daytime and nighttime L_{eq}, DNL/AADNL, and event-specific L_{max} and SEL values. From these modeled outputs, supplemental metrics were also derived for evaluating specific effects during nighttime, daytime, and school day periods, including maximum SEL, NA90SEL, and NA65L_{max}. In Table 3 through Table 6, arrivals and departures are listed separately; total operations for a scenario are the sum of arrivals and departures.

Aircraft noise was modeled for the No Action scenario and for the exercise conditions associated with the Proposed Action. Based on the Volpe modeling results, this analysis also evaluates two Reduced Action scenarios. For exercise-related operations, results were developed for both annual-average conditions and average exercise-day conditions, together with event-based SEL and L_{max} values for individual operations.

2.1.1 "No Action" Scenario

In the No Action scenario, the Volpe Center modeled baseline civilian operations at Yap International Airport. These baseline operations include regular civilian arrivals and departures by Boeing 737-800, Boeing 757, BE-20A, and BE 65-B80 aircraft. The modeled annual totals and average daily daytime and nighttime operations are summarized in Table 3.

Table 3: No Action Scenario Annual and Average Daily Flight Operations

		Arrivals			Departures			Average Daily Operations	
Group	**Aircraft**	**Day**	**Night**	**Total**	**Day**	**Night**	**Total**	**Daytime**	**Nighttime**
Civil	737-800	0	104	104	0	104	104	0.000	0.570
Civil	757	52	0	52	52	0	52	0.285	0.000
Civil	BE-20A	182	0	182	182	0	182	0.997	0.000
Civil	BE 65-B80	130	0	130	130	0	130	0.712	0.000
Total		**364**	**104**	**468**	**364**	**104**	**468**	**1.995**	**0.570**

2.1.2 "Proposed Action" Scenario

For the Proposed Action scenario, the Volpe Center modeled a 28-day exercise period that includes baseline civilian operations plus additional military flights. Modeled military aircraft include C-17, C-130, KC-46, KC-135, F-15, F-16, F-22, F-35, and a modified Navy Boeing 737-800. The modeled operation counts and average daily daytime and nighttime activity levels for this scenario are summarized in Table 4.

In the Proposed Action scenario, 90% of activities are assumed to occur during daytime hours (07:00 to 22:00) and 10% during nighttime hours (22:00 to 07:00).

Table 4: Proposed Action Annual Total and Average Daily Flight Operations

		Arrivals			Departures			Average Daily Operations	
Group	**Aircraft**	**Day**	**Night**	**Total**	**Day**	**Night**	**Total**	**Daytime**	**Nighttime**
Civil	737-800	0	104	104	0	104	104	0.000	0.570
Civil	757	52	0	52	52	0	52	0.285	0.000
Civil	BE-20A	182	0	182	182	0	182	0.997	0.000
Civil	BE 65-B80	130	0	130	130	0	130	0.712	0.000
Air Force Cargo	C-17	13	1	14	13	1	14	0.929	0.071
Air Force Cargo	C-130	25	3	28	25	3	28	1.786	0.214
Air Force Tanker	KC-46	25	3	28	25	3	28	1.786	0.214
Air Force Tanker	KC-135	25	3	28	25	3	28	1.786	0.214
Air Force Fighter	F-15	76	8	84	76	8	84	5.429	0.571
Air Force Fighter	F-16	76	8	84	76	8	84	5.429	0.571
Air Force Fighter	F-22	76	8	84	76	8	84	5.429	0.571
Air Force Fighter	F-35	76	8	84	76	8	84	5.429	0.571
Navy	Modified 737-800	54	6	60	54	6	60	0.296	0.033
Total		**810**	**152**	**962**	**810**	**152**	**962**	**30.290**	**3.603**

2.1.3 "Reduced Action" Scenarios

Based on the Volpe modeling results, this analysis also evaluates two Reduced Action scenarios: Reduced Action 1 (RA 1) and Reduced Action 2 (RA 2). These scenarios represent reduced levels of military activity compared to the Proposed Action and are intended to evaluate how changes in aircraft type mix and daytime/nighttime activity affect modeled noise exposure.

- **Reduced Action 1 (RA 1):** Reduces selected military aircraft operations relative to the Proposed Action.
- **Reduced Action 2 (RA 2):** Eliminates nighttime Air Force exercise activity and reduces selected daytime exercise operations relative to the Proposed Action.

The modeled annual totals and average daily operations for these scenarios are presented in Table 5 (RA 1) and Table 6 (RA 2).

Table 5: Reduced Action 1 (RA 1) Annual Total and Average Daily Flight Operations

		Arrivals			Departures			Average Daily Operations	
Group	**Aircraft**	**Day**	**Night**	**Total**	**Day**	**Night**	**Total**	**Daytime**	**Nighttime**
Civil	737-800	0	104	104	0	104	104	0.000	0.570
Civil	757	52	0	52	52	0	52	0.285	0.000
Civil	BE-20A	182	0	182	182	0	182	0.997	0.000
Civil	BE 65-B80	130	0	130	130	0	130	0.712	0.000
Air Force Cargo	C-17	7	1	8	7	1	8	0.500	0.071
Air Force Cargo	C-130	14	1	15	14	1	15	1.000	0.071
Air Force Tanker	KC-46	7	1	8	7	1	8	0.500	0.071
Air Force Tanker	KC-135	7	1	8	7	1	8	0.500	0.071
Air Force Fighter	F-15	25	2	27	25	2	27	1.786	0.143
Air Force Fighter	F-16	25	2	27	25	2	27	1.786	0.143
Air Force Fighter	F-22	25	2	27	25	2	27	1.786	0.143
Air Force Fighter	F-35	25	2	27	25	2	27	1.786	0.143
Navy	Modified 737-800	54	6	60	54	6	60	0.296	0.033
Total		**553**	**122**	**675**	**553**	**122**	**675**	**11.933**	**1.460**

Table 6: Reduced Action 2 (RA 2) Annual Total and Average Daily Flight Operations

		Arrivals			Departures			Average Daily Operations	
Group	**Aircraft**	**Day**	**Night**	**Total**	**Day**	**Night**	**Total**	**Daytime**	**Nighttime**
Civil	737-800	0	104	104	0	104	104	0.000	0.570
Civil	757	52	0	52	52	0	52	0.285	0.000
Civil	BE-20A	182	0	182	182	0	182	0.997	0.000
Civil	BE 65-B80	130	0	130	130	0	130	0.712	0.000
Air Force Cargo	C-17	14	0	14	14	0	14	1.000	0.000
Air Force Cargo	C-130	28	0	28	28	0	28	2.000	0.000
Air Force Tanker	KC-46	28	0	28	28	0	28	2.000	0.000
Air Force Tanker	KC-135	28	0	28	28	0	28	2.000	0.000
Air Force Fighter	F-15	56	0	56	56	0	56	4.000	0.000
Air Force Fighter	F-16	56	0	56	56	0	56	4.000	0.000
Air Force Fighter	F-22	56	0	56	56	0	56	4.000	0.000
Air Force Fighter	F-35	56	0	56	56	0	56	4.000	0.000
Navy	Modified 737-800	54	6	60	54	6	60	0.296	0.033
Total		**740**	**110**	**850**	**740**	**110**	**850**	**25.290**	**0.603**

2.2 CONSTRUCTION NOISE MODELING

Construction noise associated with the airport, seaport, roadway, and dredging components was evaluated using a conservative screening-level approach because detailed construction plans are not yet available. Specifically, final equipment selection, exact daily work locations, concurrent equipment usage, and construction schedules have not been developed. As a result, the analysis does not predict receptor-specific construction L_{eq} values.

To support this screening-level analysis, the Volpe Center used Traffic Noise Model (TNM) version 3.2, including Roadway Construction Noise Model (RCNM) version 2.0, to obtain representative source sound levels for anticipated construction equipment. These source levels were then used to estimate receptor sound levels from representative high-noise equipment operating near the construction-zone boundary closest to each receiver.

For screening purposes, the analysis assumes that the loudest representative single piece of equipment operates at the construction-zone boundary nearest the receptor being evaluated. For airport construction, that source was represented by an auger drill; for seaport construction, it was represented by a pile driver. Using the reference sound level for the equipment at 50 feet and standard distance attenuation relationships, the analysis estimates the resulting L_{max} at each receptor. Because actual work would typically occur inside the site and would shift over time, this assumption is intended to represent a conservative upper-bound screening condition for individual construction noise events.

Because detailed equipment inventories, duty cycles, and schedules are not available, the analysis does not model multiple pieces of equipment operating simultaneously and does not calculate construction L_{eq} at receivers. However, the analysis may identify the construction-zone boundary L_{eq} that would be needed to avoid exceeding a specified L_{eq} criterion at a receptor. This information is used as a planning benchmark to inform future BMPs, contractor controls, and mitigation planning when more detailed construction information becomes available.

The construction screening analysis includes several simplifying assumptions that affect the interpretation of results. The assumption that the loudest equipment operates at the nearest construction-zone boundary tends to overpredict receptor sound levels. The use of simple spherical spreading likewise tends to be conservative because it does not account for additional attenuation from shielding, ground effects, vegetation, or other site-specific factors. By contrast, the omission of simultaneous equipment operations may underpredict noise in some localized conditions. On balance, the analysis is intended to represent a conservative screening-level estimate of potential construction noise exposure rather than a precise prediction of actual construction conditions.

This section addresses only the airborne noise effects of construction and dredging on onshore receptors.

3 AIRCRAFT NOISE MODELING RESULTS AND IMPACT ASSESSMENT

This section presents the results of the aircraft noise analysis and evaluates the potential effects of aircraft and airport operations in the No Action, Proposed Action, and Reduced Action scenarios. The analysis compares the existing airport conditions and current operations in the No Action scenario with conditions following airport improvements, including baseline civilian operations and increased military activity during periodic exercise periods, of the Proposed Action. Two Reduced Action scenarios, RA 1 and RA 2, are also evaluated to examine how reduced exercise activity would affect noise exposure.

For purposes of this analysis, non-military aircraft operations are assumed to remain the same in all scenarios. Accordingly, the assessment does not assume additional civilian growth, increased civilian flight frequency, or introduction of larger civilian aircraft that could otherwise occur because of airport improvements.

Aircraft noise impacts are evaluated using two complementary exposure frameworks. First, annual average day-night sound level (AADNL) is used to assess long-term aircraft noise exposure and land use compatibility. Second, average exercise day (AED) event-based metrics are used to evaluate the noise conditions experienced by the community during the exercise periods themselves. These AED-based metrics include daytime or nighttime SEL, L_{max}, L_{eq}, and event-count metrics such as NA65L_{max} and NA90SEL, as appropriate to the impact endpoint being evaluated. This distinction is important because AADNL reflects annualized long-term exposure, whereas AED metrics better characterize short-term but potentially consequential noise effects during the exercise periods.

3.1 LAND USE COMPATIBILITY ASSESSMENT BASED ON AIRCRAFT NOISE

As discussed in the methodology, LUC is a planning-based assessment used to evaluate the relationship between long-term aircraft noise exposure and surrounding land uses. LUC is commonly applied in airport planning, airport expansion, and land use planning near airports. For this project, LUC remains an important analytical tool because the Proposed Action would increase aircraft noise exposure compared to existing conditions. However, because the principal change in operations is associated with periodic, high-intensity exercise activity rather than a sustained year-round increase in routine daily operations, LUC is not the sole basis for impact assessment. Instead, it is used with supplemental event-based metrics that better characterize short-term effects, such as sleep disturbance, learning disruption, and worship disruption.

Consistent with the methodology, the LUC analysis uses AADNL because land use compatibility is based on long-term average aircraft noise exposure rather than short-term response to individual events. Figure 8 shows the AADNL contour plot for the No Action scenario with the 65 dB contour shown in blue. In No Action conditions, the 65 dB contour remains limited to the immediate runway end areas, and all evaluated receivers remain below 65 dB AADNL.

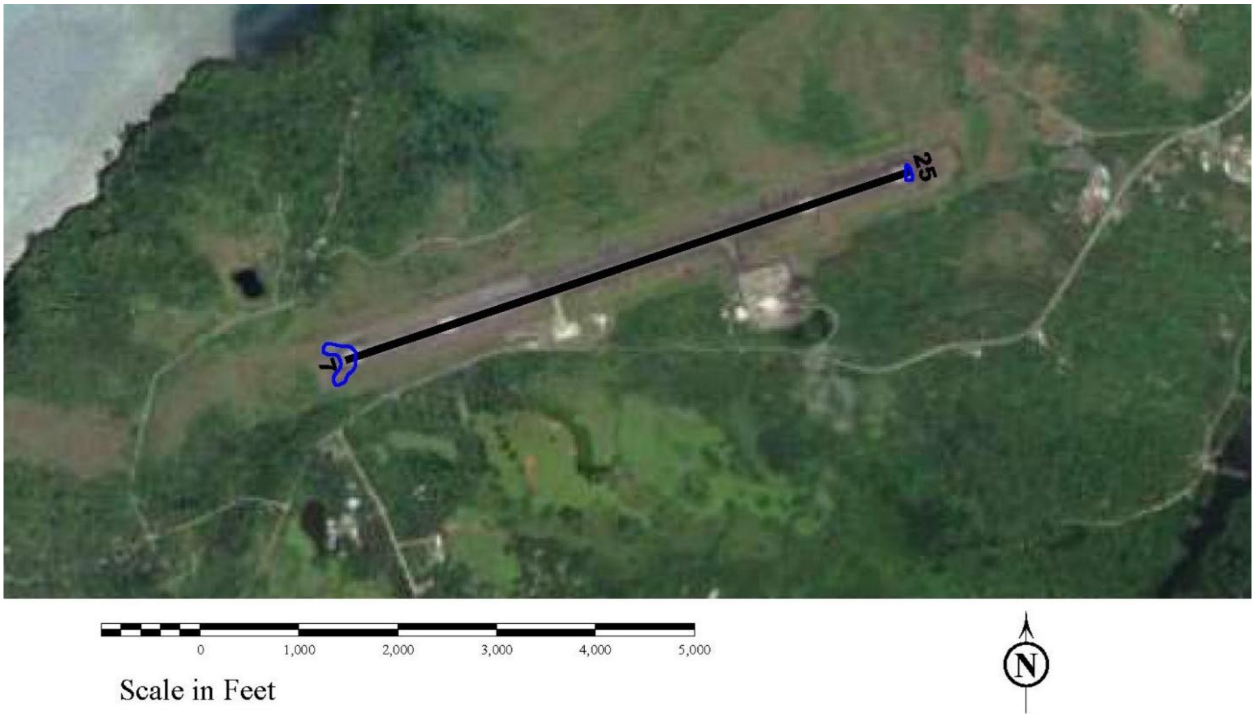

Figure 8: AADNL Contours for the No Action Scenario

Figure 9 shows the AADNL contours for the Proposed Action scenario. In the Proposed Action, the contours extend beyond the immediate airfield, and several receptors are located in areas with modeled AADNL in the 65 to 70 dB and 70 to 75 dB ranges. Volpe did not generate contour figures for the Reduced Action scenarios; however, because those scenarios include reduced exercise activity relative to the Proposed Action, the general contour pattern would be expected to remain similar in shape but somewhat reduced in extent.

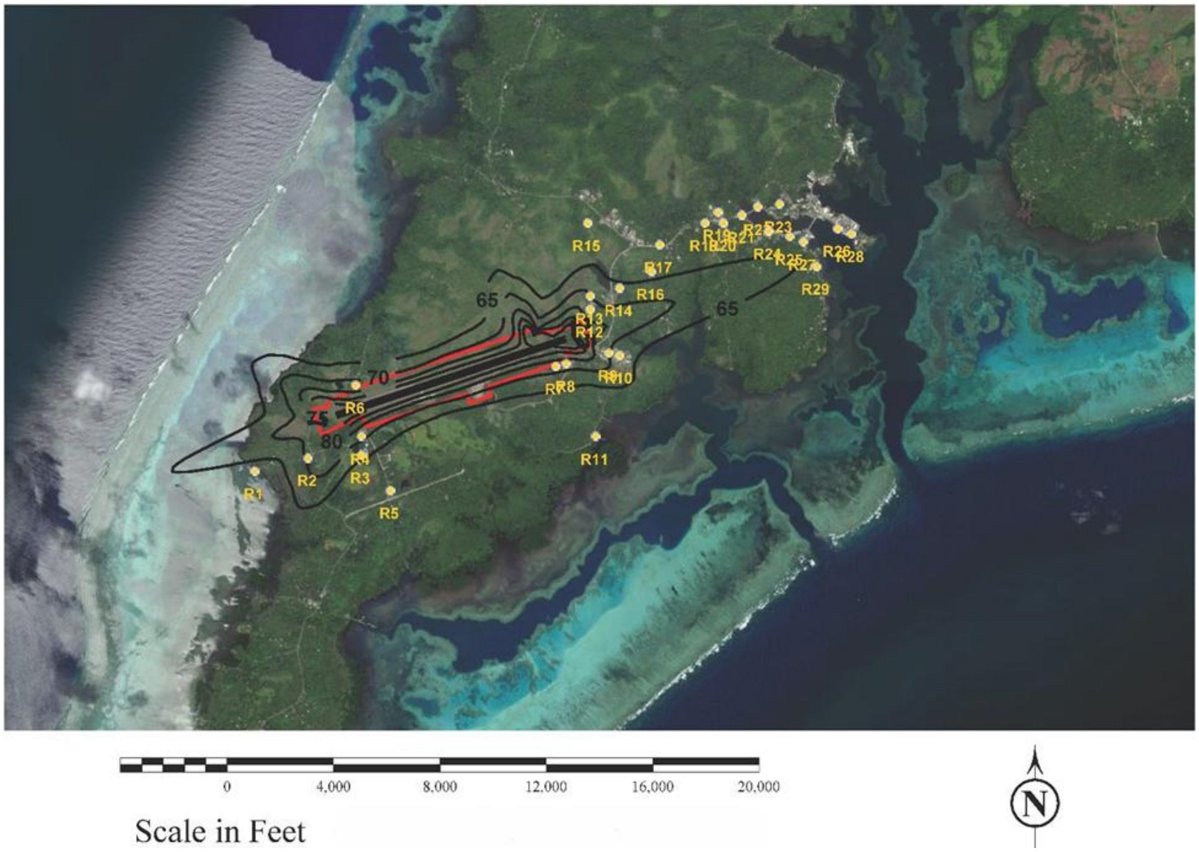

Figure 9: AADNL Contours for the Proposed Action

Residences, transient lodging, schools, and hospitals are among the land uses most commonly considered in LUC assessments because they include activities that are particularly sensitive to aircraft noise, including rest, sleep, learning, and other routine indoor uses. Table 7 summarizes the AADNL results and corresponding LUC determinations for residential and transient lodging receptors.

In the No Action scenario, all evaluated residential and transient lodging receptors remain below 65 dB AADNL and are land use compatible without restrictions. In the Proposed Action scenario, receptors R1, R16, R17, R24, and R25 remain compatible without restrictions, while receptors R2, R6, R7, R9, and R13 fall within ranges where compatibility would require a reduction in aircraft noise, increased outdoor-to-indoor noise reduction, or both. As shown in Table 7, these receptors would require measures sufficient to achieve an effective OINRL of 30 dB in the Proposed Action scenario. In the RA 1 and RA 2 scenarios, AADNL decreases compared to the Proposed Action levels, and the affected receptors would require an OINRL of 25 dB rather than 30 dB to meet the applicable compatibility guidance.

Table 7: DNL and Land Use Compatibility for Residential and Transient Lodging Properties

	DNL (dB)				Land Use Compatibility (LUC)			
ID	**NA**	**PA**	**RA 1**	**RA 2**	**NA**	**PA**	**RA 1**	**RA 2**
R1	47	63	58	58	Y	Y	Y	Y
R2	47	70	65	66	Y	OINRL=30	OINRL=25	OINRL=25
R6	50	71	66	67	Y	OINRL=30	OINRL=25	OINRL=25
R7	49	73	69	69	Y	OINRL=30	OINRL=25	OINRL=25
R9	47	70	66	66	Y	OINRL=30	OINRL=25	OINRL=25
R13	45	70	66	66	Y	OINRL=30	OINRL=25	OINRL=25
R16	43	63	59	60	Y	Y	Y	Y
R17	40	60	55	56	Y	Y	Y	Y
R24	40	61	56	57	Y	Y	Y	Y
R25	41	62	57	58	Y	Y	Y	Y

Notes:
Y (Yes) means the land use and related structures are compatible without restrictions.
N (No) means the land use and related structures are not compatible and should be prohibited.
"OINRL=25" and "OINRL=30" indicate that the receiver would be compatible with the incorporation of measures sufficient to achieve an OINRL of at least 25 or 30 dB, respectively.

Table 8 summarizes the AADNL results and LUC determinations for school receptors. In the No Action scenario, all evaluated school receptors are land use compatible without restrictions. In the Proposed Action scenario, several school receptors fall within AADNL ranges where compatibility would require increased OINRL. Based on the values shown in Table 8, receptors R3 and R10 would require an OINRL of 25 dB in the Proposed Action scenario, while receptors R9, R12, and R13 would require an OINRL of 30 dB. In the Reduced Action scenarios, AADNL generally decreases compared to the Proposed Action levels, reducing the degree of indoor noise reduction needed to meet the compatibility guidance at some school receptors. For purposes of this analysis, rounded modeled AADNL values at category boundaries were interpreted using the higher compatibility category shown in Table 1.

Table 8: DNL and Land Use Compatibility for Schools

	DNL (dB)				Land Use Compatibility (LUC)			
ID	**NA**	**PA**	**RA 1**	**RA 2**	**NA**	**PA**	**RA 1**	**RA 2**
R3	45	66	61	62	Y	OINRL=25	Y	Y
R9	47	70	66	66	Y	OINRL=30	OINRL=25	OINRL=25
R10	46	68	63	64	Y	OINRL=25	OINRL=25	Y
R12	47	72	68	69	Y	OINRL=30	OINRL=25	OINRL=25
R13	45	70	66	66	Y	OINRL=30	OINRL=25	OINRL=25
R19	38	57	52	53	Y	Y	Y	Y

Notes: See the footnotes in Table 7.
All other evaluated receptors are land use compatible in No Action, Proposed Action, and Reduced Action scenarios.

3.2 SLEEP DISTURBANCE FROM AIRCRAFT NOISE

To assess sleep disturbance, this analysis evaluated the maximum nighttime sound exposure level (SEL), the number of nighttime events with an SEL over 90 dB (NA90SEL), and the screening-level probability of being awakened by the maximum nighttime event, assuming an OINRL of 15 dB. These metrics were computed for residential and transient lodging receiver locations in the No Action, Proposed Action, RA 1, and RA 2 scenarios and are summarized in Table 9.

Table 9: Sleep Awakening Probability for Residential and Transient Lodging Locations in the No Action (NA), Proposed Action (PA), Reduced Action 1 (RA 1), and Reduced Action 2 (RA 2) Scenarios

	Max. Nighttime SEL (dB)				Nighttime NA90SEL				$P_{Awakening}$[1]			
ID	**NA**	**PA**	**RA 1**	**RA 2**	**NA**	**PA**	**RA 1**	**RA 2**	**NA**	**PA**	**RA 1**	**RA 2**
R1	92	117	117	91	0.2	2.2	0.7	0.1	8%	18%	18%	8%
R2	92	122	122	91	0.2	2.4	0.7	0.1	9%	21%	21%	8%
R6	94	122	122	93	0.2	2.2	0.7	0.1	9%	21%	21%	9%
R7	94	125	125	94	0.2	2.2	0.8	0.3	9%	22%	22%	9%
R9	92	124	124	92	0.2	2.1	0.8	0.2	9%	21%	21%	9%
R13	91	124	124	90	0.2	2.0	0.7	0.2	8%	22%	22%	8%
R16	89	114	114	89	0.0	1.6	0.4	0.0	8%	17%	17%	8%
R17	86	109	109	85	0.0	1.3	0.3	0.0	7%	15%	15%	7%
R24	86	112	112	88	0.0	1.2	0.3	0.0	7%	16%	16%	7%
R25	87	114	114	90	0.0	1.2	0.3	0.0	7%	17%	17%	8%

1 $P_{awakening}$ is computed using Eqn. 1 and the maximum nighttime SEL at the receiver location, assuming an OINRL of 15 dB.

The results show maximum nighttime SEL ranges from 86 to 94 dB in the No Action scenario, 109 to 125 dB in the Proposed Action scenario, 109 to 125 dB in the RA 1 scenario, and 85 to 94 dB in the RA 2 scenario. Nighttime NA90SEL values range from 0.0 to 0.2 in the No Action scenario, 1.2 to 2.4 in the Proposed Action scenario, 0.3 to 0.8 in the RA 1 scenario, and 0.0 to 0.3 in the RA 2 scenario. These higher nighttime SEL values in the Proposed Action and RA 1 scenarios are reflected in substantially higher screening-level single-event awakening probabilities, increasing from 7% to 9% in the No Action and RA 2 scenarios to 15% to 22% in the Proposed Action and RA 1 scenarios.

However, although the RA 1 scenario produces single-event awakening probabilities similar to those of the Proposed Action scenario, because the maximum nighttime SEL is similar, the number of loud nighttime events is lower in the RA 1 scenario. As a result, the RA 1 scenario would be expected to have lower overall sleep-disturbance potential than the Proposed Action.

Even if BMPs were implemented to reduce nighttime SEL in the Proposed Action and RA 1 scenarios, and mitigation measures were implemented at affected receivers, nighttime exercise activity involving loud aircraft would still be expected to create the potential for sleep disturbance. The RA 2 scenario, which eliminates nighttime Air Force exercise activity but retains baseline nighttime civilian activity and limited Navy nighttime operations, would be expected to have substantially lower sleep-related impacts than the Proposed Action or RA 1 scenarios.

3.3 LEARNING DISTURBANCE FROM AIRCRAFT NOISE

To assess the potential impacts of aircraft noise on learning activities, this analysis evaluated daytime L_{eq}, daytime L_{max}, and the number of events with outdoor L_{max} above 65 dB during school hours (NA65L_{max}) at schools and the Yap Public Library (R26) in the No Action, Proposed Action, RA 1, and RA 2 scenarios. Assuming an OINRL of 15 dB, an outdoor NA65L_{max} corresponds approximately to an indoor NA50L_{max}. The results for schools and the Yap Public Library are shown in Table 10.

Table 10: Daytime L_{eq}, L_{max}, and NA65L_{max} for Schools and the Yap Library

	Daytime L_{eq} (dB)				Max. Daytime L_{max} (dB)				NA65L_{max} During School Hours			
ID	**NA**	**PA**	**RA 1**	**RA 2**	**NA**	**PA**	**RA 1**	**RA 2**	**NA**	**PA**	**RA 1**	**RA 2**
R3	40	76	72	75	83	106	106	106	0.7	13.5	5.4	11.2
R9	40	81	75	79	88	112	112	112	0.9	11.4	5.0	9.7
R10	39	78	73	77	86	110	110	110	0.9	10.9	4.6	9.1
R12	41	83	77	80	88	114	114	114	0.9	11.7	5.3	10.0
R13	39	81	75	78	85	109	109	109	0.7	11.5	5.2	9.7
R19	31	67	62	65	75	99	99	99	0.2	10.2	4.2	8.4
R26	36	72	67	71	78	108	108	108	0.7	9.5	4.0	7.9

In the No Action scenario, daytime L_{eq} is below 40 dB at nearly all locations. Although occasional loud events occur, as indicated by maximum L_{max} values of approximately 75 to 88 dB, these events are infrequent. NA65L_{max} ranges from 0.2 to 0.9, indicating on average less than one event per school day at each receptor. This represents minimal disruption from current airport activities.

In the Proposed Action scenario, daytime outdoor L_{eq} increases to approximately 67 to 83 dB. RA 1 and RA 2 scenarios are somewhat lower, ranging from approximately 62 to 77 dB and 65 to 80 dB, respectively. Assuming windows and doors are closed and an OINRL of 15 dB is achieved, estimated interior L_{eq} values would still range from approximately 47 to 68 dB, which is well above the 35 to 45 dB recommendations for learning spaces. Accordingly, exercise days in the Proposed Action and both Reduced Action scenarios would be expected to create the potential for learning disruption.

Event-based metrics show a similar pattern. Maximum daytime L_{max} increases from approximately 75 to 88 dB in the No Action scenario to approximately 99 to 114 dB in the Proposed Action and both Reduced Action scenarios. The number of school hour events exceeding 65 dB outdoors, which corresponds approximately to indoor events exceeding 50 dB, assuming an OINRL of 15 dB, increases from approximately 0.2 to 0.9 in the No Action scenario to approximately 9.5 to 13.5 in the Proposed Action scenario. These results suggest roughly one or more potentially disruptive events per hour during the school day in the Proposed Action scenario. Event counts are lower in RA 1 scenario, generally by about half of those in the Proposed Action scenario, while the RA 2 scenario falls between the Proposed Action and RA 1 scenarios.

These analyses indicate that the Proposed Action and both Reduced Action scenarios have the potential to disrupt learning during exercise days, with the Proposed Action scenario generally producing the greatest impacts, RA 1 the lowest among the action alternatives, and RA 2 intermediate impacts.

3.4 WORSHIP DISTURBANCE FROM AIRCRAFT NOISE

To assess the potential impacts of aircraft noise on worship and cultural activities, this analysis evaluated daytime outdoor L_{eq}, maximum daytime L_{max}, and NA65L_{max} during a representative 1.5-hour long worship or cultural event. These results are summarized in Table 11.

Table 11: Daytime L_{eq}, L_{max}, and NA65L_{max} for Worship Spaces

	Daytime L_{eq} (dB)				Max. Daytime L_{max} (dB)				NA65L_{max} During Worship Hours			
ID	NA	PA	RA 1	RA 2	NA	PA	RA 1	RA 2	NA	PA	RA 1	RA 2
R5	32	68	63	66	73	96	96	96	0.1	2.2	1.2	1.8
R11	31	67	61	64	73	94	94	94	0.0	1.7	0.9	1.4
R15	30	69	64	67	71	94	94	94	0.0	1.7	0.9	1.4
R20	32	68	63	67	76	101	101	101	0.0	1.9	1.0	1.6

In the No Action scenario, L_{eq} ranges from 30 to 32 dB, maximum daytime L_{max} ranges from 71 to 76 dB, and NA65L_{max} ranges from 0.0 to 0.1. These values indicate that daytime aircraft activity in the No Action scenario would not be expected to disrupt worship or cultural activities.

In the Proposed Action scenario, daytime L_{eq} increases to approximately 67 to 69 dB, which is well above the recommended levels for worship spaces. RA 1 and RA 2 scenarios are somewhat lower but remain elevated compared to the No Action scenario. Maximum daytime L_{max} in the Proposed Action and both Reduced Action scenarios ranges from approximately 94 to 101 dB. During a representative 1.5-hour worship period, NA65L_{max} increases to approximately 1.7 to 2.2 in the Proposed Action scenario, indicating clear potential for disruption of worship activities. NA65L_{max} is lower in the RA 1 scenario, ranging from approximately 0.9 to 1.2, and intermediate in the RA 2 scenario, ranging from approximately 1.4 to 1.8. These values indicate lower disruption potential than the Proposed Action but continued potential for disturbance.

As with schools, BMPs and mitigation measures that only reduce the noise level of individual events would not necessarily eliminate disruption. However, scheduling exercise activities to reduce the number of loud events during primary service hours on worship days could substantially reduce the potential for disruption.

3.5 NOISE MANAGEMENT BEST PRACTICES AND MITIGATION

The best management practices (BMPs) described below are intended to reduce the frequency, timing, and intensity of aircraft noise exposure at sensitive receptors during exercise periods. These measures may reduce, but might not eliminate, the potential for sleep disturbance, learning disruption, worship disruption, and wildlife disturbance.

3.5.1 Pre-Operational Measurement to Support BMP Selection

To support the selection of appropriate BMPs before exercise operations begin, the DoW should collect aircraft noise measurements in and near the Yap flying fox roost-use zone as soon as practicable. If possible, these measurements should include representative military aircraft during takeoff and landing. At a minimum, measurements should be obtained for existing civilian jet takeoff and landing operations, together with measurements at nearby receptors R5 and R11 and at several locations within or immediately adjacent to the mangrove canopy. These measurements would help characterize actual sound levels in the area and provide an empirical basis for estimating the degree to which the current screening-level contour method may overpredict canopy-level exposure. The results should be used to refine the understanding of aircraft noise propagation near the roost-use zone and to inform the selection of flight planning, scheduling, and other BMPs before routine exercise operations commence.

3.5.2 Operational Scheduling

Scheduling measures can reduce exposure during the most noise-sensitive periods, including nighttime, school hours, and worship hours, and provide predictable breaks from high-noise activity.

- **Limit nighttime activities**: Reduce nighttime activity as much as practicable, especially for louder aircraft. When nighttime operations are unavoidable, schedule the quietest feasible activities at night. This approach is reflected in RA 2.

- **Provide recovery nights**: Alternate high-impact nights with lower-impact nights so residents periodically receive "recovery nights" with improved sleep opportunity.

- **Apply event-based management**: Establish a predetermined threshold for loud nighttime events; if operations exceed that threshold, limit additional high-noise events for the remainder of the night, when practicable.

- **Concentrate high-noise events in less sensitive hours:** When feasible, schedule the loudest events within a consistent set of daytime or evening hours and avoid school hours to the extent practicable.

- **Avoid seasonally sensitive periods**: When practicable, schedule exercises to avoid high-sensitivity periods such as school examination weeks and major cultural or community holidays.

- **Avoid worship hours**: When practicable, schedule high-noise events outside primary service hours on Sundays and other holy days.

3.5.3 Flight Planning

Use flight planning measures, including flight tracks, altitude, profiles, runway use, and aircraft configuration, to reduce noise exposure at noise-sensitive receptors. Apply these measures routinely and prioritize implementation during school hours and nighttime hours, where practicable.

- **Route tracks away from noise-sensitive areas**: Plan tracks to avoid high-sensitivity locations, such as schools during daytime hours and residences at night, to the extent feasible.

- **Increase minimum altitudes**: Raise minimum departure and arrival altitudes where safety and mission requirements allow. Maintain the highest practicable flight altitude over known or suspected roost-use areas to reduce the intensity of aircraft noise reaching roosting bats.

- **Use steeper climb profiles:** Climb more steeply when feasible to gain altitude sooner and reduce ground-level noise exposure.

- **Select runway directions to reduce community noise exposure**: Choose approach and departure directions that minimize impacts on schools during school hours and residences at night, when operationally feasible.

- **Limit reverse thrust and high-power ground operations:** Reduce reverse thrust use and other high-power ground operations, especially during nighttime hours.

- **Minimize afterburner use**: Avoid or reduce afterburner use to the maximum extent feasible.

- **Reduce taxi and run-up noise during sensitive periods**: Minimize taxi noise and engine run-ups at night and during school hours when practicable.

Note: Depending on aircraft type, flight profile, altitude, and receptor location, flight-planning measures may reduce noise levels substantially in some areas. Reductions of about 5 to 10 dB may be achievable in favorable conditions, while larger reductions may occur in limited cases.

3.5.4 Community Engagement

Community engagement can reduce avoidable disruption and may improve acceptance of unavoidable noise by providing timely, specific, and actionable information to affected residents and institutions.

- **Provide advance notice with specific details**: Share schedules and expected noise conditions in plain language, including the anticipated dates, hours, and types of louder activity.
- **Publish a predictable calendar:** Publish planned exercise schedules as early as practicable and update them as needed.
- **Coordinate with schools:** Work with schools to avoid the noisiest activities during examinations and other critical instructional periods, to the extent practicable**.**
- **Coordinate with religious institutions**: Work with churches and other worship facilities to avoid high-noise activity during primary service times and other major religious events, where practicable.
- **Provide responsive complaint handling:** Offer multiple ways for the public to submit noise complaints, then acknowledge receipt promptly, track complaints to resolution, and communicate follow-up actions as described in recent guidance on noise complaint management.
- **Designate a Community Noise Liaison**: Identify a primary point of contact to support two-way communication among the military, local officials, schools, churches, and affected residents.
- **Consider alternate venues for noise-sensitive activities:** Where high-noise periods cannot be avoided, consider use of alternate venues for especially noise-sensitive instructional, worship, or community activities, where practicable.
- **Consider targeted noise monitoring where warranted**: In addition to the pre-operational measurements described in Section 3.6.1, targeted operational noise monitoring may be considered at particularly noise-sensitive locations if recurring issues arise or if additional data are needed to support adaptive management.

3.5.5 Building-Level Mitigation

Where operational BMPs do not reduce noise exposure sufficiently at noise-sensitive receptors, building-level mitigation may further reduce indoor noise levels:

- **Window and door improvements:** Use upgraded windows, doors, seals, and related envelope improvements to reduce sound transmission indoors.
- **Ventilation or air conditioning**: Where keeping windows closed is necessary for acoustical performance, provide ventilation or air conditioning as needed to maintain usable indoor conditions.
- **Targeted treatment of noise-sensitive rooms**: Prioritize bedrooms, classrooms, libraries, and other spaces where quiet conditions are especially important.

- **Temporary relocation or alternate venues**: For particularly noise-sensitive activities during short high-noise periods, consider temporary alternate locations where practicable.

4 AIRPORT CONSTRUCTION NOISE MODELING RESULTS AND IMPACTS

The proposed airport expansion involves a comprehensive eight-year construction schedule. While construction is permitted 24 hours per day, 7 days per week, the anticipated schedule would typically be 16 hours per day, 6 days per week. Key activities include:

- Extending the east and west runway ends.
- Trenching, ground leveling, and substantial fill operations.
- Constructing an auxiliary taxiway.
- Operating-high impact on-site industrial facilities including asphalt and concrete batch plants and rock crushing/chipping operations.

At this time, the project does not include a detailed equipment inventory or the specific operating locations and times needed to model construction noise using equivalent sound levels (L_{eq}) or to estimate the number of events of L_{max} exceeding a given threshold. The Volpe Center report therefore used a conservative screening approach and estimated L_{max} based on the loudest likely piece of equipment located at the closest point on the construction-zone boundary to each receiver. Figure 10 shows an airport construction map with the airport construction-zone boundary, and the earth staging area.

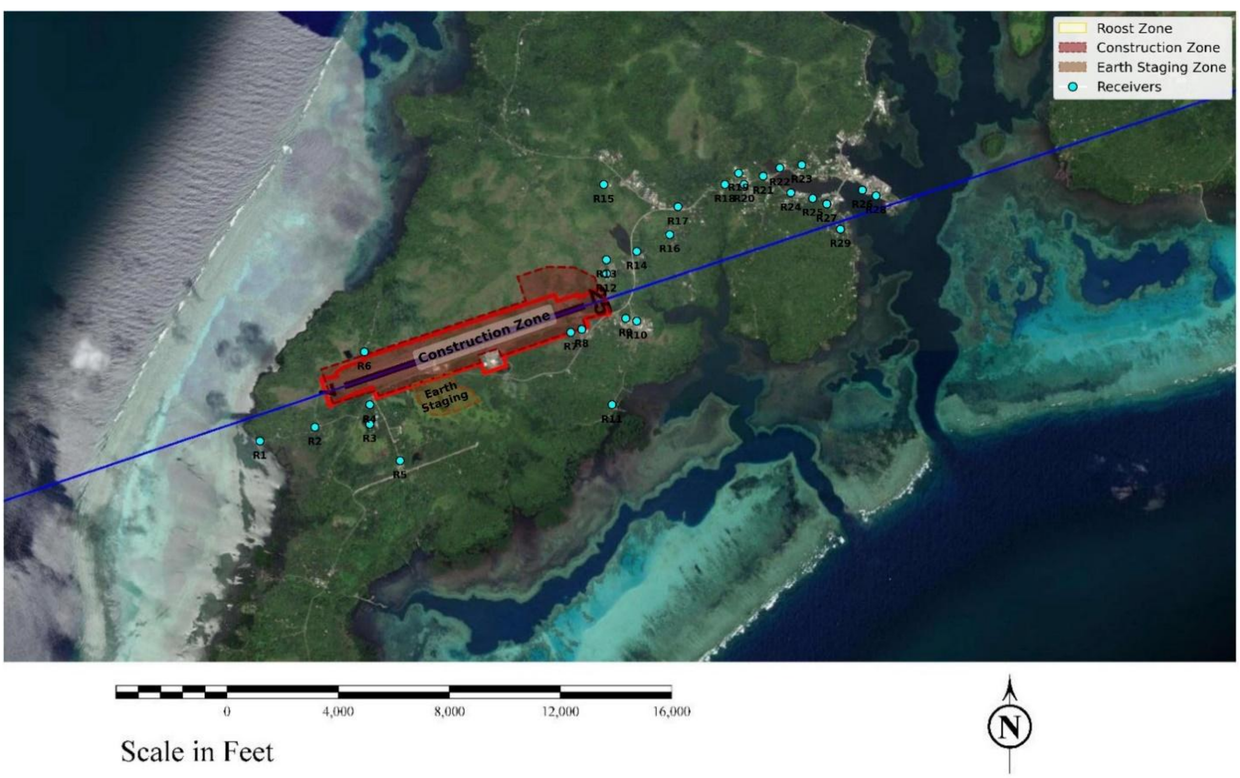

Figure 10: Airport Construction Map

4.1 AIRPORT CONSTRUCTION NOISE IMPACTS

4.1.1 Classroom and Worship Space Impacts from Airport Construction Noise

Learning and worship environments are highly noise-sensitive receptors because they require low ambient background noise. Unlike aircraft flyover noise, which is transient, construction noise at this site will occur more continuously during daylight and early evening hours on most workdays throughout the eight-year construction period. As a result, construction activities cannot be scheduled to completely avoid school hours or weekday worship service hours.

To protect learning and worship environments, this analysis uses target interior noise equivalent noise levels (L_{eq}) of 35-45 dB, as discussed in Section 1.1.9. Using the construction-noise propagation analysis from the Volpe Center report, this analysis calculates the maximum allowable 1-hour L_{eq} at the construction-zone boundary closest to the receptor needed to meet the interior targets, assuming an OINRL of 15 dB. If standard construction-zone BMPs cannot consistently achieve the required boundary levels, additional receptor-specific mitigations, such as window upgrades and/or temporary barriers at the receptor, may be required to increase the effective OINRL to 20 or 25 dB.

As shown in Table 12, the required maximum 1-hour L_{eq} at the construction-zone boundary is 82 dB or higher for four of the six schools, a level that construction-zone BMPs can likely achieve (see 4.1.3). The library is sufficiently far from the airport that construction noise is not expected to affect interior conditions. Two schools, R12, a middle school, and R13, an early childhood education center, are quite close to the airport and would require a maximum 1-hour L_{eq} of approximately 74-75 dB at the construction-zone boundary. Aggressive construction-zone BMPs may achieve these limits at times; however, receptor-specific mitigation at R12 and R13 would help ensure that airport construction noise does not interfere with learning.

Table 12: Classroom and Library Interior Target L_{eq} and Maximum Construction-Zone Boundary L_{eq}

ID	Distance from Receiver to Construction-Zone Boundary (ft)	Max Interior 1-hour L_{eq} (dB)	Max 1-hour L_{eq} at Boundary (dB)[1]	Notes[2]
R3	1,005	45	86	BMP Likely Enough
R9	668	45	82	BMP Likely Enough
R10	1,079	45	86	BMP Likely Enough
R12	480	40	74	BMP & Maybe Mitigation
R13	906	35	75	BMP & Maybe Mitigation
R19	6,462	35	92	BMP Likely Enough
R26	10,134	45	106	No BMP needed

Notes:

1 This is the required maximum L_{eq} at the construction-zone boundary to meet the maximum target interior L_{eq}, assuming OINRL = 15 dB.

2 **BMP Likely Enough** means that the boundary L_{eq} requirement would likely be met with construction-zone BMPs alone. **BMP & Maybe Mitigation** means that while construction-zone BMPs alone might be enough,

additional mitigation at the receptor site may be needed to increase the effective OINRL (e.g., to 25 dB) so that construction-zone BMPs achieve the target interior L_{eq}.

As shown in Table 13, the community center and worship spaces are sufficiently far from the construction area that the maximum allowable construction-zone boundary level L_{eq} exceeds 90 dB, which is higher than the boundary limits required for most of the schools. Standard construction site BMPs would be expected to reduce the airport construction site noise to levels that avoid impacts at these receptors. In addition, worship activities most commonly occur on Sundays when construction activities are less likely to occur.

Table 13: Community Center and Worship Space Interior Target L_{eq} and Maximum Construction-Zone Boundary L_{eq}

ID	Distance from Receiver to Construction-Zone Boundary (ft)	Max Interior 1-hour L_{eq} (dB)	Max 1-hour L_{eq} at Boundary (dB)[1]	Notes[2]
R5	2,139	45	92	BMP Likely Enough
R11	3,008	40	90	BMP Likely Enough
R15	3,540	40	90	BMP Likely Enough
R20	6,379	40	97	BMP Likely Enough

Notes:

1 This is the required maximum L_{eq} at the construction-zone boundary to meet the maximum target interior L_{eq}, assuming OINRL = 15 dB.

2 **BMP Likely Enough** means that the boundary L_{eq} requirement would likely be met with construction-zone BMPs alone**.**

4.1.2 Residential Space Impacts from Construction Noise

Residents are sensitive to construction noise; however, residential and transient lodging spaces generally have less stringent acoustic requirements than educational or worship spaces. For analysis of these spaces, the target interior 1-hour L_{eq} is 60 dB, which corresponds to a maximum exterior 1-hour L_{eq} of 75 dB at the receiver location, assuming an OINRL of 15 dB. Because the residential criterion is higher than the classroom criterion, the allowable noise levels at the construction-zone boundary are correspondingly higher.

As shown in Table 14, the required maximum 1-hour L_{eq} levels would likely be met with little or no construction site BMPs at most residential receptors, except R7, which is located directly adjacent to the construction-zone boundary. At that receptor, combined construction-zone BMPs and site-specific mitigation would help minimize construction noise impacts.

Table 14: Residential and Transient Lodging Interior Target and Maximum Construction-Zone Boundary L_{eq}

ID	Distance from Receiver to Construction-Zone Boundary (ft)	Max Interior 1-hour L_{eq} (dB)	Max 1-hour L_{eq} at Boundary (dB)[1]	Notes[2]
R1	2,824	60	110	No BMP Needed
R2	896	60	100	BMP Likely Enough
R6	180	60	86	BMP Likely Enough
R7	45	60	74	BMP & Maybe Mitigation
R9	668	60	97	BMP Likely Enough
R13	906	60	100	BMP Likely Enough
R16	3,125	60	111	No BMP needed
R17	4,014	60	113	No BMP needed

Notes:

1 This is the required maximum L_{eq} at the construction-zone boundary to meet the maximum target interior L_{eq}, assuming OINRL = 15 dB.

2 **BMP Likely Enough** means that the boundary L_{eq} requirement can likely be met with construction-zone BMPs alone. **BMP & Maybe Mitigation** means that construction-zone BMPs may be enough, but additional mitigation at the receptor site may be needed to increase the OINRL (e.g., to 25 dB) so that construction-zone BMPs achieve the target interior L_{eq}.

4.1.3 Airport Construction Best Management Practices and Mitigation

Airport construction at Yap is unusual because several noise-sensitive buildings are located close to the existing runway and the planned expansion area. At these receptors, distance provides limited noise attenuation. Accordingly, the project should apply a strong set of construction-zone BMPs and, where needed, receptor-specific mitigation measures.

BMP implementation should be made enforceable by requiring the contractor to prepare and follow a noise management plan. The plan should identify planned BMPs, document which BMPs are implemented, define noise monitoring procedures, and establish response actions for exceedances and community complaints. Requiring the contractor to develop and maintain this plan would ensure that site noise sensitivity is fully understood and that noise management is treated as a core project requirement.

4.1.3.1 Contractor Requirements and Noise Management Plan

The contractor should manage construction noise through planning, scheduling, equipment selection, and documentation. The following measures should be incorporated to the extent practicable:

- **Limit noise during services and holy days**: Minimize construction noise near churches during weekend services and on holy days, when practicable, unless sufficient BMPs are implemented to avoid impacts.

- **Coordinate with schools**: Implement additional noise controls on testing days and during other high-sensitivity school activities, particularly for work occurring near the construction-zone boundary closest to schools, when practicable.

- **Establish core hours and noisy hours:** Establish core hours for most construction activities and designate limited noisy hours in the late afternoon or early evening, outside of school hours, for the loudest activities occurring close to schools.

- **Reduce rock crushing and batch-plant operations outside noisy hours:** Limit these operations outside designated noisy hours, when practicable, unless sufficient BMPs are implemented to avoid impacts.

- **Limit dumping, stockpile building, and loader bucket clanging during core hours**: Reduce these activities during core hours, when practicable.

- **Specify quietest available equipment:** Include quietest available equipment requirements in contract specifications where practicable.

- **Require an equipment inventory**: Maintain an inventory that includes sound power data for major noise sources and the BMPs used to control them, such as certified silencers and broadband backup alarms.

- **Implement preventive maintenance plans:** Maintain mufflers, silencers, and other noise-control measures and routinely inspect lubrication and worn parts that may increase noise.

- **Publish and update schedules**: Post planned construction activity schedules in advance.

- **Establish a complaint response plan**: Define actions and timelines for responding to exceedances and community complaints, including cases where measured levels remain below formal limits.

4.1.3.2 General Construction Site Best Management Practices

Control noise at the source to reduce impacts at all receivers and minimize the need for building-level mitigation.

- **Install barriers at noise sources:** Use shields/barriers around aggregate handling where practicable and place temporary barriers around localized noisy activities.

- **Reduce metal-on-metal noise:** Minimize bucket clanging and other impact noise through operating practices and liners, where feasible.

- **Use quieter backup alarms:** Require broadband (“white noise”) backup alarms in place of tonal alarms where practicable. Broadband backup alarms have been shown to maintain worksite safety while reducing noise relative to conventional tonal alarms (Vaillancourt et al., 2013).

- **Control vehicle speeds:** Establish and enforce low speed limits on unpaved and paved worksite roads.
- **Ban impulsive noise sources:** Prohibit air horns except where required for safety, and prohibit engine braking on site, where practicable.
- **Reduce truck-bed impacts:** Use rubber-lined truck beds and bed mats where feasible.
- **Prefer rubber tires:** Use rubber-tired equipment instead of steel-tracked equipment where feasible.
- **Use electric power where practicable:** Replace internal combustion engines with electric motors or pumps when feasible, and connect to grid power when available to reduce the need for generators with internal combustion engines.
- **Require effective mufflers/silencers:** Install manufacturer-approved mufflers/silencers on all internal combustion engines and keep them functional.
- **Build temporary barriers near noise-sensitive receptors:** Construct temporary noise barriers between active work zones and the closest noise-sensitive receivers, especially R12, where practicable.

The equipment types below can be especially noisy. Where such equipment is used, apply equipment-specific BMPs to reduce source levels. In some cases, properly implemented controls may reduce source levels by 5 to 15 dB.

4.1.3.3 Rock Crusher

- **Enclose the crusher:** Place the crusher inside a lined acoustic enclosure/major barrier where practicable, with at least three sides enclosed and openings only as needed for material conveyance.
- **Line transfer points:** Install rubber liners in hoppers and chutes.
- **Reduce drop heights**: Minimize drop heights at each material transfer.
- **Use high-performance silencers**: Install high-performance silencers or mufflers on rock crusher engines and fans.

4.1.3.4 Asphalt and Concrete Plant

- **Silence major fans/blowers**: Install silencers on burners, silos blowers, and other fans.

- **Enclose key components**: Enclose or shield baghouse fans, compressors, and generator sets.

- **Barriers around aggregate handling**: Install shields or barriers around aggregate handling and mixing drums.

- **Isolate vibration sources**: Add vibration isolation for rotating equipment.

4.1.3.5 Concrete Saws

- **Use quieter blades**: Use diamond blade saws rather than abrasive blades where concrete saws are necessary.

- **Use water-cooled cutting**. Use water-cooled cutting where practicable to reduce blade noise and control dust.

- **Install barriers**: Erect portable acoustic screens around concrete sawing areas where feasible.

4.1.3.6 Auger Drills

- **Pre-bore when feasible**: Use smaller, quieter augers for pre-boring before full-size auger operations, where practicable.

- **Prefer electric/hydraulic drives**: Use electric or hydraulic augers rather than diesel powered units where practicable.

- **Maintain drill bits**: Replace or service worn drill bits to reduce required force and noise.

- **Install barriers**: Erect portable acoustic screens around the drill rig where feasible.

4.1.3.7 Jackhammer

- **Limit continuous operation**: Limit continuous jackhammer operation to 30 minute intervals with 10 minute breaks to reduce cumulative annoyance.

- **Wet the demolition area**: Wet demolition areas where practicable to reduce dust and modestly reduce noise.

4.1.3.8 Dump Trucks

- **Reduce impact noise**: Require rubber bed liners and tailgate cushions to reduce metal-on-metal and rock-on-metal impact noise.

- **Reduce dumping drop height**. Use ramps or lower dump positions to minimize drop height when dumping aggregate.

- **Prevent tailgate slams**: Require hydraulic or controlled closing gates where practicable.

- **Locate idling and queuing away from receptors**: Designate truck idling and queuing areas to be as far from noise-sensitive receptors as practicable.

4.1.3.9 Power Generators

- **Use grid power**: Connect to grid power where practicable.

- **Use low-noise units**: Specify low-noise power generators, typically enclosed units rated at less than 65 dB at 25 ft.

- **Place generators strategically**: Locate generators behind barriers, inside enclosures, and as far from noise-sensitive receptors as practicable.

4.2 ROAD CONSTRUCTION

Road construction includes roadway improvements and realignments near the airport, improvements along the roadway connecting the airport to the seaport, and roadway improvements in the seaport area. These activities typically move along the roadway and generate high noise levels only when crews and equipment are operating near a given location. As a result, roadway construction impacts at any individual receptor are expected to be short-lived, ranging from days to weeks, compared with the multi-year airport construction program.

Because detailed equipment usage, exact work locations, and hour-by-hour schedules are not available, this analysis assesses roadway construction impacts using the Volpe Center's estimated maximum sound levels (L_{max}) without additional processing.

Figure 11 highlights the roadway segments included in the road construction analysis. The loudest pieces of equipment are expected to be dump trucks, concrete saws, and excavators with assumed sound levels of 94 dB, 90 dB and 90 dB at 50 ft, respectively. Using the roadway map shown in Figure 11, the Volpe Center report estimated the minimum distance from each noise-sensitive receptor to a representative construction location on the roadway and calculated the resulting L_{max} estimates shown in
Table 15 to Table 19.

Figure 11: Roadway Construction Map

4.2.1 Community Impacts from Roadway Construction Noise

Residences and Transient Lodging

Table 15 summarizes the L_{max} levels at residential and transient lodging locations. Because roadway work is expected to occur primarily during daytime hours, construction noise is not expected to affect nighttime sleep for most residences. However, it may disturb daytime rest at transient lodging facilities. Three receptors, R17 and the two hotels, R24 and R25, are adjacent to the planned roadway work and could experience high daytime noise. When working near those locations, contractors should maintain a predictable daily schedule (e.g., avoid late work hours) and provide advance notice so occupants can plan around the loudest activities.

Table 15: L_{max} Levels at Residences and Transient Lodging from Roadway Construction Noise

ID	Name	Minimum Source Distance (ft)	L_{max} (dB)
R1	Daqabyuch Building	2,212	61
R2	Residences Southwest of Airport	201	82
R6	Residence North of Airport	221	81
R7	Residences East of Airport	497	74
R9	College of Micronesia and Nearby Residences	455	75
R13	Early Childhood Education and Nearby Residences	763	71
R16	Jesylene Googur	930	69
R17	Satawal Compound (housing complex)	78	91
R24	ESA Bay View Hotel	49	95
R25	Oceania Hotel	70	91

Table 16 summarizes roadway construction L_{max} levels at schools and the library. Because roadway work is expected to occur primarily during the day, construction noise may disrupt learning, worship-related activities, and speech communication.

At most schools, exterior L_{max} is generally below 80 dB. Assuming an OINRL of 15 dB, the corresponding indoor L_{max} would generally remain under 65 dB but above 50 dB. These levels suggest the potential for elevated but localized short-term disruption of learning when roadway construction occurs nearby.

The Yap Public Library (R26) shows higher predicted levels and may experience more noticeable disruption. While the library is not a classroom, it functions as a quiet-use community learning space; therefore, contractors should use BMPs and provide clear public notice of days and times when noisy work will occur nearby.

Table 16: Roadway Construction Noise L_{max} Levels at Schools and Library

ID	Name	Minimum Source Distance (ft)	L_{max} (dB)
R3	Yap Catholic High School	534	74
R9	College of Micronesia (Yap Campus)	455	75
R10	Yap High School	771	71
R12	Colonia Middle School	377	77
R13	Early Childhood Education	763	71
R19	Gaanelay Elementary School	320	78
R26	Yap Public Library	113	87

Table 17 summarizes roadway construction L_{max} levels at churches and the community center. Because roadway work is expected to occur primarily during the day, construction noise may disrupt worship activities. The results show that only one church, R20 (the Church of Jesus Christ of Latter-day Saints), is expected to experience notably elevated noise levels from roadway construction. While primary worship occurs on Sundays, when road construction is less likely to occur, religious education and other activities may occur on weekday evenings. When work occurs near R20, contractors should limit the duration of the daily work window (e.g., 8-12 hours) and coordinate schedules to avoid conflicts within planned church activities where practicable.

Table 17: Roadway Construction Noise L_{max} Levels at Churches and Community Center

ID	Name	Minimum Source Distance (ft)	L_{max} (dB)
R5	Milew Community Center	2,230	61
R11	Ohnn	2,203	62
R15	Yap Seventh-day Adventist Church	1,753	64
R20	The Church of Jesus Christ of Latter-day Saints	97	89

4.2.1.1 Government buildings and businesses

Table 18 and Table 19 summarize roadway construction L_{max} levels at government buildings and businesses. These uses are generally less noise-sensitive than residences, schools, and churches, but high sound levels may still cause annoyance and disrupt communication. Two government locations, R18 and R28, and two businesses, R21 and R22, show predicted L_{max} levels that may exceed 85 dB during nearby work. Because roadway activities near any one site are expected to be short in duration (typically several days), construction schedule changes are generally not necessary. However, contractors should still implement BMPs and coordinate with building owners and occupants so they can prepare for periods of elevated noise.

Table 18: Roadway Construction Noise L_{max} Levels at Government Buildings

ID	Name	Minimum Source Distance (ft)	L_{max} (dB)
R18	Yap Department of Agriculture and Forestry Complex	27	100
R23	Yap State Department of Education	419	76
R28	FSM National Police Yap Field Office	108	88

Table 19: Roadway Construction Noise L_{max} Levels at Businesses

ID	Name	Minimum Source Distance (ft)	L_{max} (dB)
R4	Avi's Laundromat	221	81
R21	Aces Mart 2	47	95
R22	Aces Mart 1	41	96
R27	YCA Hardware	364	77
R29	J&S Store	1,372	66

4.2.1.2 Road Construction Best Management Practices

Road construction typically moves along the roadway in short-duration work zones. Because the noise source is mobile, stationary temporary noise barriers are often impractical and provide limited benefit. Mitigation should focus on scheduling, proactive communication, and equipment or other source controls to reduce disruption at noise-sensitive receptors.

4.2.1.3 Scheduling and Timing

Schedule the loudest activities to avoid noise-sensitive receptors during their most critical hours.

- **Coordinate with schools:** Contractors should coordinate with schools (R3, R9, R10, R12, R13, R19) to avoid high-impact activities during testing periods or critical outdoor activities to the extent practicable. When feasible, prioritize work near schools during school vacations.

- **Coordinate with churches:** Coordinate with the Church of Jesus Christ of Latter-day Saints (R20) to avoid noisy operations during weekday evening education or worship activities. Maintain Sunday avoidance of construction to the extent practicable.

- **Reduce impacts at transient lodging**: For hotels directly adjacent to the roadway (R24 and R25), avoid the loudest activities during early morning hours when guests may be sleeping, and concentrate higher-noise work in midday when practicable.

4.2.1.4 Communication and Engagement

Provide clear, specific information so occupants can anticipate noise and adjust activities, which could reduce annoyance and complaints.

- **Provide targeted advance notice:** Notify the most highly impacted locations, such as the Satawal Compound (R17), the Department of Agriculture (R18), and the Police Field Office (R28) in advance, detailing specific dates, anticipated work hours, and the expected high-noise activities.

- **Predictable work zones schedules:** Post a weekly rolling map/schedule of active work zones so the public knows where noise will be concentrated.

- **Adhere to announced schedules:** Once a schedule has been communicated to noise-sensitive receptors, such as the Yap Public Library (R26) or nearby businesses (R21 and R22), follow that schedule as closely as practicable so disruptions remain as brief as planned. If conditions change, update affected parties promptly.

4.2.1.5 Operational Controls

Reduce baseline noise by applying equipment-specific BMPs, with emphasis on the loudest equipment expected for roadway work (dump trucks, concrete saws, and excavators).

- **Manage truck noise:** Use rubber bed liners and tailgate cushions to reduce impact noise. Prohibit tailgate slamming and avoid engine braking near noise-sensitive receivers.

- **Control concrete sawing noise:** Utilize water-cooled diamond blade saws where practicable to reduce both blade noise and dust.

- **Apply standard equipment noise controls:** Maintain manufacturer-approved mufflers on all internal combustion engines and use broadband (white noise) backup alarms instead of tonal beepers.

4.3 SEAPORT CONSTRUCTION AND OPERATION NOISE

The seaport expansion would involve demolition of an existing warehouse, improvement of the existing wharf, and construction of a new wharf extension, as shown in Figure 12. The primary construction noise sources include installing steel piles for mooring dolphins (marine mooring structures used to secure vessels), the wharf, and the roll-on/roll-off ramp, as well as performing ground improvements using drilled shafts.

Because the Yap Seaport is an industrial environment, nearby receptors likely experience higher ambient background sound levels, approximately 55 to 65 dB, than receptors in many other parts of the island. However, pile driving produces impulsive, repetitive sound peaks that can be more annoying and more disruptive to concentration than continuous noise at the same average level. For that reason, this analysis recommends pile-driving-specific BMPs.

The Volpe Center report provides screening-level construction noise estimates for seaport activities that may occur concurrently with airport and roadway construction. Volpe applied the same conservative approach used for the airport and roadway analyses (spherical spreading from the loudest equipment, with no BMPs assumed). Accordingly, the seaport results represent a **worst-case scenario**. Note: This section only evaluates potential airborne noise impacts on nearby land-based receptors; it does not evaluate underwater acoustic impacts on marine biota.

Figure 12: Seaport Construction Activity Areas

4.3.1 Seaport Construction Impacts

Volpe identified seaport construction as one of the loudest project elements, with maximum sound levels reaching approximately 108 dB L_{max} at 50 ft for some equipment. Most receptors benefit from distance; however, two nearby receptors may experience substantial impacts during pile driving:

- R26 (Yap Public Library): up to 86 dB L_{max}.
- R28 (FSM National Police Yap Field Office): up to 96 dB L_{max}.

These levels could cause substantial outdoor and indoor speech interference during active pile driving, and at R28 could severely disrupt radio dispatch, phone calls, and routine office communication. Table 20 summarizes the predicted L_{max} levels; R26 and R28 are the most affected receptors.

To reduce disruption, the project should, when practicable, confine pile driving to a limited and predictable midday work window and coordinate that schedule with library and police operations.

Table 20: Predicted L_{max} Levels During Seaport Construction

ID	Name	Source Distance (ft)	L_{max} (dB)
R1	Daqabyuch Building	24,294	54
R2	Residences Southwest of Airport	22,248	55
R3	Yap Catholic High School	20,366	56
R4	Avi's Laundromat	20,090	56
R5	Milew Community Center	19,960	56
R6	Residence North of Airport	19,643	56
R7	Residences East of Airport	12,340	60
R8	GPPC Batch Plant (private property)	11,933	60
R9	College of Micronesia (Yap Campus)	10,310	61
R10	Yap High School	9,995	62
R11	Ohnn Church	12,382	60
R12	Colonia Middle School	10,399	61
R13	Early Childhood Education	10,274	61
R14	YSPSC Water Plant	9,134	62
R15	Yap Seventh-day Adventist Church	10,118	62
R16	Jesylene Googur	7,836	64
R17	Satawal Compound (housing complex)	7,419	64
R18	Yap Department of Agriculture and Forestry Complex	5,722	67
R19	Gaanelay Elementary School	5,270	67
R20	The Church of Jesus Christ of Latter-day Saints	5,024	68
R21	Aces Mart 2	4,365	69
R22	Aces Mart 1	3,842	70
R23	Yap State Department of Education	3,112	72
R24	ESA Bay View Hotel	3,307	71
R25	Oceania Hotel	2,507	74
R26	Yap Public Library	734	86
R27	YCA Hardware	2,027	76
R28	FSM National Police Yap Field Office	204	96
R29	J&S Store	1,927	76

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4.3.2 Seaport Construction Best Management Practices

Pile driving is the dominant noise source during seaport construction and can cause speech interference at noise-sensitive receptors over large distances. Pile-driving-specific BMPs should be applied to reduce peak levels, limit the duration of the highest-noise activities, and provide predictable and transparent scheduling for the most affected facilities (especially R26 and R28). The following BMPs are suggested to reduce noise impacts:

- **Use vibratory pile driving where feasible**: Use vibratory pile drivers instead of impact hammers where soil and structural requirements allow to reduce impulsive ("rhythmic peak") noise.

- **Install acoustics shrouds for impact driving**: When impact driving is required, enclose the hammer and the top of the pile with acoustic shrouds or bellows. Prioritize shrouds when work occurs near **R28**.

- **Use cushion (dolly) blocks**: Place sacrificial nylon or wood cushion blocks on pile heads to reduce metal-on-metal contact noise between the hammer and pile head.

- **Implement soft-start procedures:** Begin pile driving with a "soft-start" sequence, a series of low-energy strikes, to provide an audible warning to the community and wildlife before full-power operations.

- **Restrict pile driving to limited work windows**: Confine pile driving to a short, predictable daily window, when practicable, and select hours that minimize disruption at the Yap Public Library (R26) and the FSM National Police Yap Field Office (R28).

- **Sequence high noise equipment**: Avoid operating the pile driver concurrently with other high-noise equipment, such as hoe rams or auger drills, in the same area, when practicable, to reduce cumulative noise levels.

- **Provide "high-impact" schedules to affected facilities**: Issue weekly schedules identifying expected high-noise work periods to the library and police field office so staff can plan meetings, quiet activities, and critical communications outside the loudest planned periods.

4.4 SEAPORT DREDGING

The Proposed Action includes dredging of the waterway, as shown in Figure 13, to accommodate larger vessels. The dredging footprint includes the primary navigation channel and the turning basin adjacent to the seaport. This section evaluates only the airborne noise impacts of dredging on nearby land-based receptors and terrestrial wildlife; potential underwater acoustic impacts on marine biota are addressed separately, if applicable.

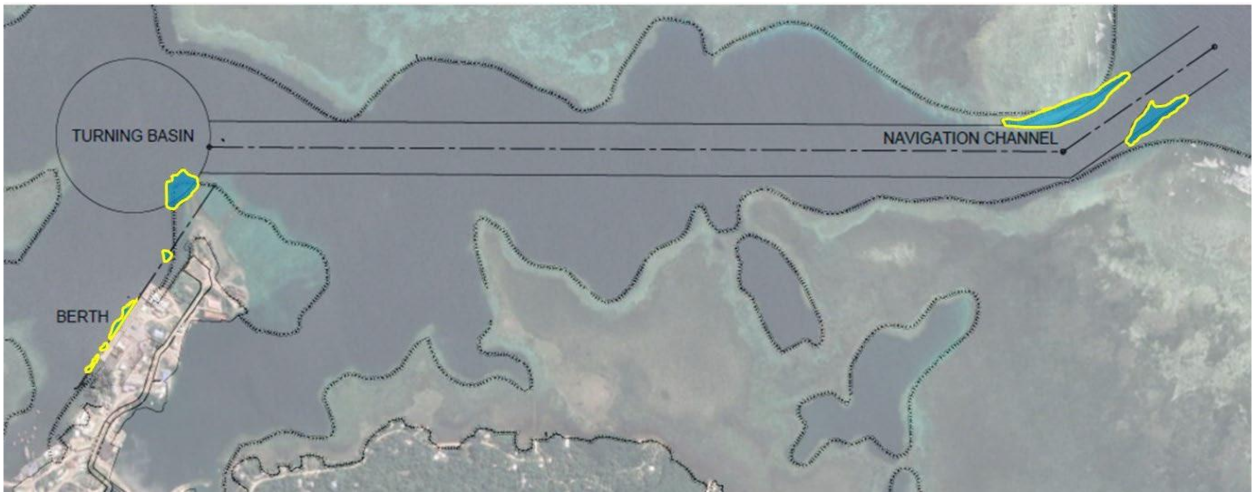

Figure 13: Seaport Dredging Activity Areas

4.4.1 Impacts of Dredging Noise on the Community

Dredging activities can generate high maximum sound levels, sometimes exceeding 90 dB L_{max} at 50 ft. However, at Yap, most dredging activity occurs at substantial distances from occupied structures. The Volpe Center identified only two receptors with predicted 15-minute equivalent levels exceeding 60 dB: R26 (Yap Public Library) and R28 (FSM National Police Yap Field Office). In addition, dredging noise is typically dominated by continuous engine and pump noise, which is generally less disruptive than impulsive sources such as pile driving. Based on these screening-level results, dredging is expected to result in minimal community noise impacts and is unlikely to require receptor-specific mitigation. The BMPs below would help keep noise levels as low as reasonably achievable and to minimize disruptions at the most exposed facilities.

4.4.2 Seaport Dredging Best Management Practices

4.4.2.1 Dredging Equipment and Operations

- **Use effective mufflers/silencers:** Equip all internal combustion engines on dredges, tugs, and barges with high-performance mufflers/silencers and keep them functional.
- **Enclose noisy deck equipment:** Use portable acoustic enclosures around particularly loud deck equipment (e.g., generators and pumps) where practicable.
- **Maintain equipment to prevent tonal noise:** Implement routine maintenance (including lubrication) to prevent squeal, rattle, and other avoidable mechanical noise.
- **Operate at the lowest practical power:** Run engines at the lowest speed needed to perform the task and minimize rapid speed fluctuations where practicable.

- **Reduce unnecessary idling:** Avoid unnecessary idling of marine support vessels and land-based trucks.

- **Control clamshell bucket handling (if used):** Lower buckets slowly into the water rather than dropping them to reduce impact noise.

- **Reduce drop heights during loading:** Minimize the height from which dredged material drops into barges.

- **Line barge floors:** Line metal barge floors with sand or rubber matting to reduce impact noise from falling material.

4.5 SEAPORT OPERATIONS NOISE IMPACTS

The Volpe Center reported that naval activities in the Proposed Action would consist of approximately one annual visit lasting 7 to 14 days and would be unlikely to introduce new, significant noise impacts. Accordingly, operational seaport noise impacts from exercises are expected to be negligible based on the limited frequency and duration of those activities, and additional BMPs or mitigation measures are not anticipated.

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Yap Airport and Seaport Noise Supplemental Analysis

Environmental Science Division

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ANL-26/13A

Yap Airport and Seaport Noise Supplemental Analysis

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Energy Systems and Infrastructure Analysis Division

MARCH 2026

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1 INTRODUCTION

This supplemental report documents three additional analyses performed for the Yap project: projection of aircraft noise L_{max} levels into the Yap flying fox roost zone, projection of airport construction noise into the Yap flying fox roost zone, and estimation of seaport construction noise at two locations not included in the original analysis

2 AIRCRAFT NOISE L_{MAX} PROJECTION INTO YAP FLYING FOX ROOST ZONE

To understand the potential impacts of aircraft noise on the Yap flying fox, an estimate of noise levels within the roost zone was developed. The Volpe Center did not generate contour maps of L_{max} levels from aircraft noise; however, the shape of L_{max} contours typically mimics that of DNL contours, and Volpe did generate DNL contours. One method for estimating peak sound levels in the roost zone is to propagate the general shape of the DNL curves through the roost zone, scaled by the average difference between L_{max} and DNL values at the closest receptors to the roost zone.

The DNL contours were propagated into the roost zone by fitting a decay curve to the 75-, 70-, and 65-dB DNL contours and extending that decay perpendicularly to the DNL contours into the roost zone. The projected DNL contours were converted to L_{max} contours using the average 26-dB difference between L_{max} and DNL at receivers R4 and R11, the closest receptors to the roost zone; the resulting contours are shown in Figure 1. This propagation conservatively assumes spherical spreading without any additional absorption from air or foliage, so the projected contours can be considered an upper limit for L_{max} in the region.

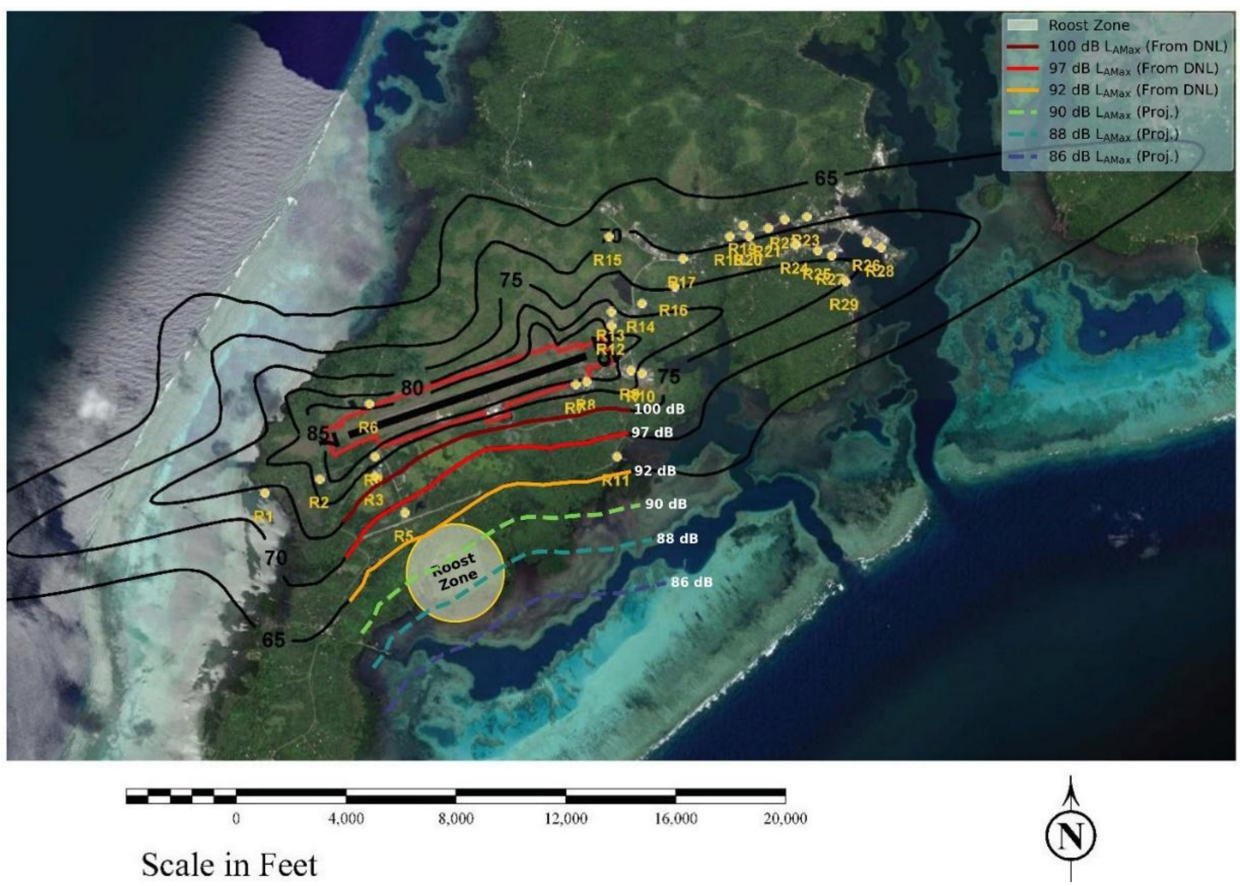

Figure 1: Projected L_{max} Contours over the Yap Flying Fox Roost Zone

3 CONSTRUCTION NOISE L_{MAX} PROJECTION INTO ROOST ZONES

To evaluate potential airport construction noise exposure in the Yap flying fox roost-use zone, a contour map of L_{max} levels from airport construction noise was developed around the construction zone boundary using same methodology for estimating construction noise at the specific receptor locations described in the main report. For this analysis, we used a representative loudest construction source that would be located at the southern construction border, the auger drill, with a source level of 103 dB at 50 ft and assuming spherical spreading only. No additional attenuation from air absorption, terrain, shielding, or vegetation was included. The resulting contours, shown in Figure 2, represent a conservative upper-bound estimate of maximum construction noise levels in areas surrounding the airport construction site zone.

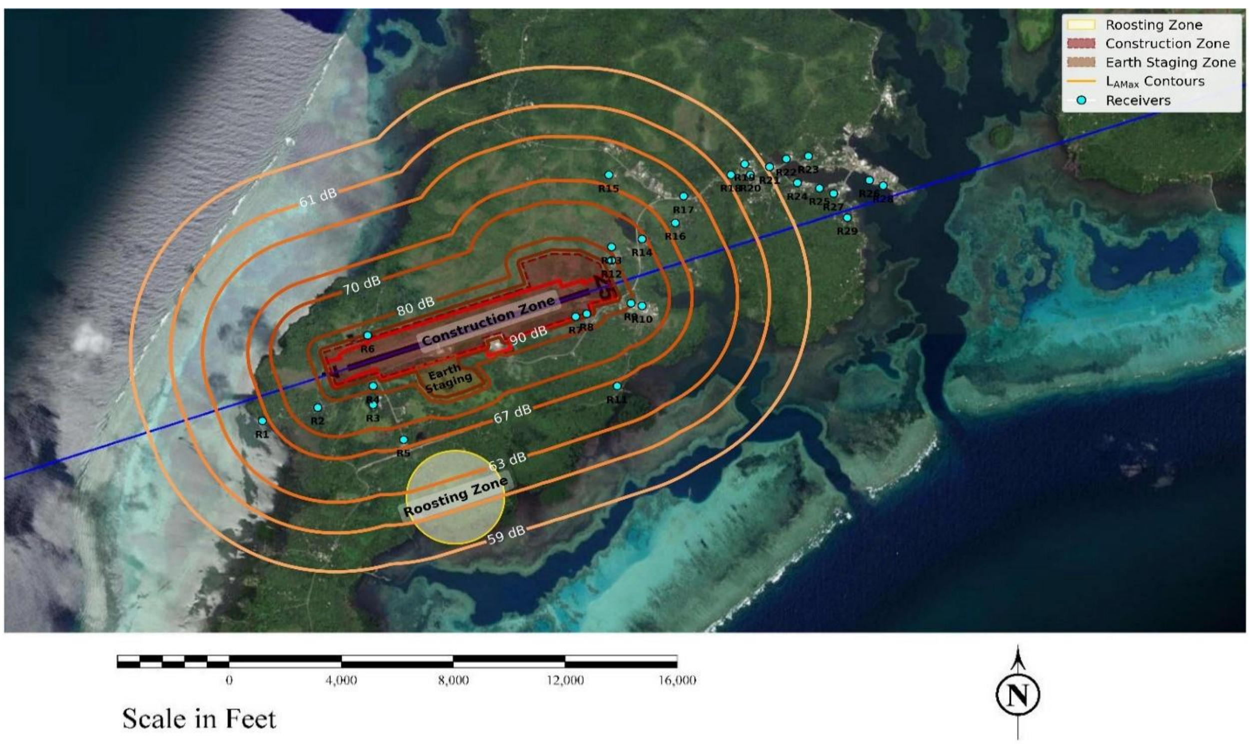

Figure 2: Airport Construction L_{max} Contours Near the Yap Flying Fox Roost Zone

4 SEAPORT CONSTRUCTION NOISE ESTIMATES AT ADDITIONAL LOCATIONS

Maximum outdoor sound level estimates for two additional locations close to the seaport construction activities were computed as shown in Figure 3. For these locations, the peak sound level will be dominated by vibratory pile driving, which has a peak sound level of 108 dB at 50 ft, assuming no best management practices to reduce generated noise levels. The noise from pile driving was propagated to the additional locations assuming simple spherical spreading with no additional absorption or noise shielding from intervening structures. As a result, these can be considered worst case scenario maximum levels. The results of the analysis are shown below in Table 1.

Figure 3: Seaport Construction Activity Areas

Table 1: Predicted L_{max} Levels During Seaport Construction

Name	Closest Source Distance (ft)	L_{max} (dB)
Yap State Legislature	400	90
Yap Government Administration	270	93

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