Appendix J: Airspace Noise Analysis for the Olympic Military Operations Area

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APPENDIX J AIRSPACE NOISE ANALYSIS FOR THE OLYMPIC MILITARY OPERATIONS AREA

J.1 INTRODUCTION

This noise study is a component of the Northwest Training and Testing (NWTT) Supplemental Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (Supplemental). This study models the noise from aircraft while conducting training activities within the Olympic Military Operations Area (MOA) and Warning Area 237A (W-237A), and while transiting to and from the Olympic MOA and W-237A. The transit of aircraft to and from these areas is also discussed in the body of this Supplemental in Section 2.3.3.2 (Sea Space and Airspace Deconfliction), Section 3.0.3.1.3.1 (Navigation and Safety), and Section 3.12.3.2.1.1 (Impacts on Airborne Acoustics Under Alternative 1 for Training Activities). The noise model utilizes a database of measured aircraft noise levels under different flyover conditions. The results of this study were used throughout the body of this Supplemental to support the analysis and effects determinations for resources such as birds, cultural resources, American Indian and Alaska Native Traditional Resources, and socioeconomic resources and environmental justice.

Computer modeling is the preferred and most common method of analyzing the military noise environment. Computer modeling accurately predicts the noise environment for all military operations, using source data collected under strictly controlled conditions. For example, each measured sound level is associated with a specific operating condition, such as power, distance, and speed. In addition, noise models can account for widely varying environmental conditions. The models also can predict noise exposure from existing and proposed operations over vast geographic areas, such as the Olympic MOA.

The Department of Defense's (DoD) policy is to utilize modeling rather than monitoring for activities in special use airspace (SUA) such as a MOA. Operational/environmental noise scientists employ noise modeling to predict noise levels in SUA in a cost-effective, accurate manner. Noise modeling allows the prediction of noise levels at many locations for a given set of conditions, including current and proposed conditions (Federal Aviation Administration, 2015).

Noise monitoring is at best a sampling of activity. If that activity is highly predictable and repeatable, such as may be exhibited by aircraft flying in a landing pattern, then monitoring, over a period of time in different environmental conditions, can be of some value. While noise monitoring can provide actual sound levels, the results are valid only for that moment, in that location, in only the conditions occurring at that time. Monitoring cannot predict sound levels for proposed activities or for activities that will vary, such as aircraft maneuvering outside of a set pattern while operating in a MOA.

In order to best evaluate the potential impacts associated with the Navy's proposed activities in the Olympic MOA and while transiting to and from the Olympic MOA, the Navy must use a predictive methodology such as modeling. The noise model used, MOA and Route NoiseMap Model (MRNMap), is approved by the Federal Aviation Administration (FAA) for these types of analyses (Federal Aviation Administration, 2015).

J.2 PURPOSE

The purpose of this noise study is to document potential changes to the noise environment within and around the SUA of the Olympic MOA and W-237A for operations of the EA-18G Growler, P-3C Orion, P-8A Poseidon, and F-15 Eagle. This noise analysis is an update to the 2015 NWTT Final EIS/OEIS published in October of 2015. Therefore, this analysis serves to update the modeled noise environment between reference training activities based on historical data and a future proposed state. Changes to this analysis include new levels of flight activities in the MOA and inclusion of aircraft transits in the analysis of impacts. The Navy recognizes that aircraft operating within the MOA as well as transiting to and from the MOA can be audible outside the boundaries of the MOA (see Table J-15). Aircraft activities within the MOA and along transit routes are modeled as that is where the aircraft operations would be concentrated and therefore represent the worst-case scenario for aircraft noise impacts over the Olympic Peninsula.

The reference activities for the EA-18G, the P-3C, the P-8, and the F-15 were derived from a three-year average of actual aircraft flight information derived from 2015–2017 Sierra Hotel Aviation Readiness Program (SHARP) and Data Collection and Scheduling Tool (DCAST) data. SHARP enables aircrew to capture after-flight information for training as well as combat readiness data for calculating aircrew and squadron combat readiness levels for operational missions. DCAST is a web-based range complex scheduling system developed for use across all Commander, U.S. Pacific Fleet's (Fleet) training areas and ranges. DCAST provides the ability to schedule all training resources and Fleet range complex use in a standardized and efficient manner, while collecting data for the purpose of range sustainment (i.e., environmental stewardship and training area and range administration). The proposed future year activities include updates to both Navy training and testing requirements into the foreseeable future.

J.3 DESCRIPTION OF THE SPECIAL USE AIRSPACE

The SUA analyzed in this study includes the Olympic MOA and W-237A (Figure J-1).[1] The FAA established the Olympic MOA and W-237A in 1977 as components of the National Airspace System (NAS). The Olympic MOA begins approximately 53 nautical miles (NM) west of Seattle and extends 3 NM off the coast of Washington State. W-237A begins on the western edge of the Olympic MOA, and extends to the west offshore for approximately 50 NM.

The altitude range for the Olympic MOA airspace[2] begins at 6,000 ft. above mean sea level (MSL) and extends to an upper limit of up to but not including 18,000 ft. MSL. The 6,000 ft. MSL floor of the airspace is straightforward for the majority of the MOA, but in the eastern part of the MOA the terrain can rise several thousand feet above sea level, approaching the floor of the airspace. To account for this, a further restriction requires that aircraft operating over land in the Olympic MOA maintain an altitude of at least 1,200 ft. above ground level. This 1,200 ft. restriction would only affect flights over terrain located at the eastern edge of the MOA, where elevations could exceed 4,800 ft. MSL, which is less than 1 percent of the area beneath the MOA (see Figure J-2). Above the Olympic MOA, the Olympic Air Traffic Control Assigned Airspace (ATCAA) extends the upper altitude limit of the combined airspace to 35,000 ft. MSL. The altitude range for W-237A begins at sea level and extends to 50,000 ft. MSL (Naval Air Station Whidbey Island, 2016). While W-237A is not over land, it is included in this study to address noise from activities in this area.

[1] Warning Area W-237A has several other sections. However, all of these are located farther off shore, away from acoustically sensitive receptors on land, and thus were not considered in this noise analysis.

[2] FAA JO 7400.10B Feb 2020

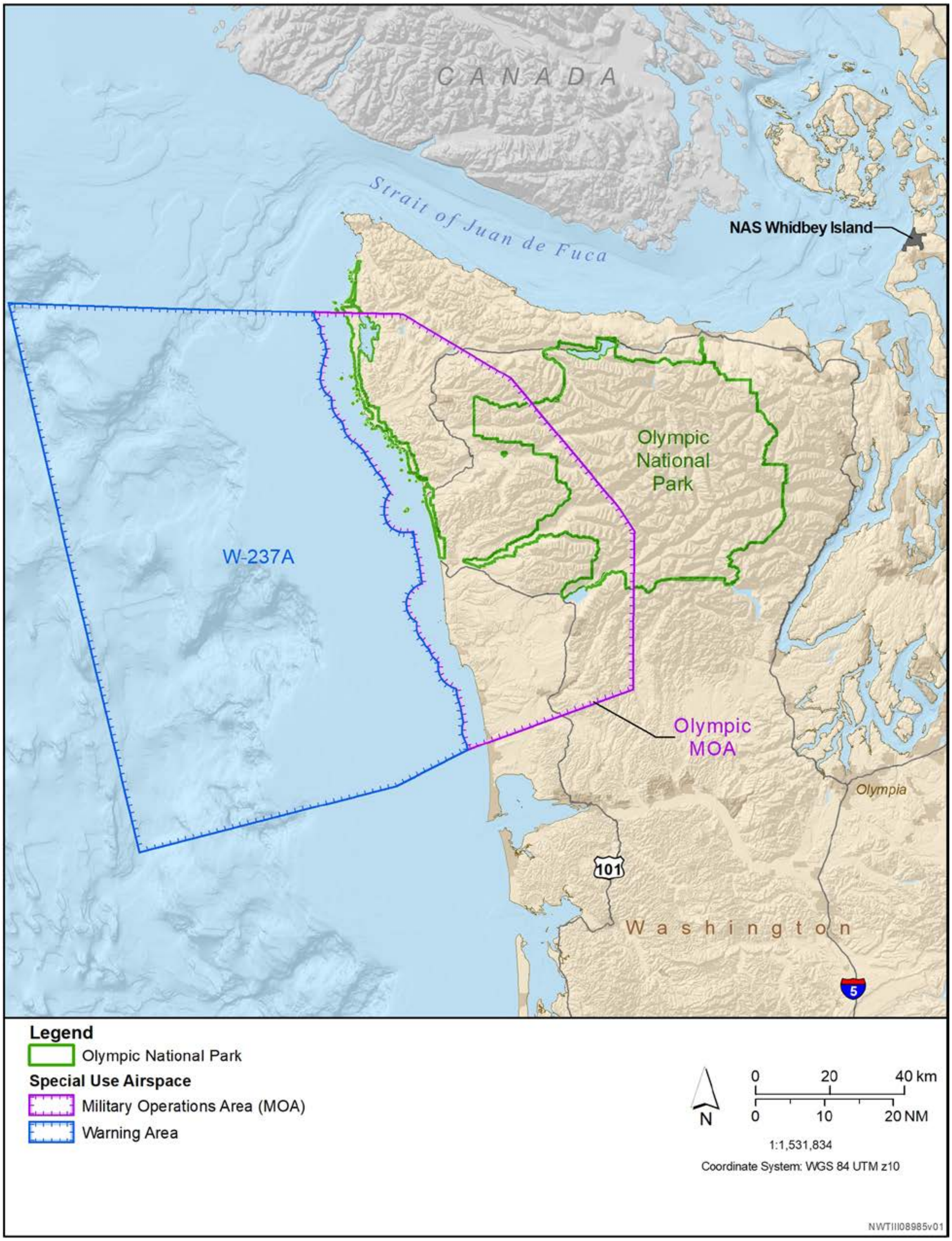

Figure J-1: Special Use Airspace Modeled in this Noise Analysis

To reduce the likelihood of exceeding the limits of these designated airspaces, aircrews specifically plan their flight maneuvers to avoid inadvertently flying outside of the airspace boundaries. For modeling purposes, a 3 NM offset was applied to the Warning Area and to the north, south, and east borders of the Olympic MOA, effectively restricting the modeled aircraft from flying within 3 NM of the edges of the airspace when conducting training activities. This offset is used to represent how the aircraft actually fly within the MOA. No offset was applied to the west portion of the Olympic MOA since aircraft often enter the warning areas from the MOA.

When the Olympic MOA is not being used by the military, the airspace becomes available for the FAA to use for commercial and private aircraft.

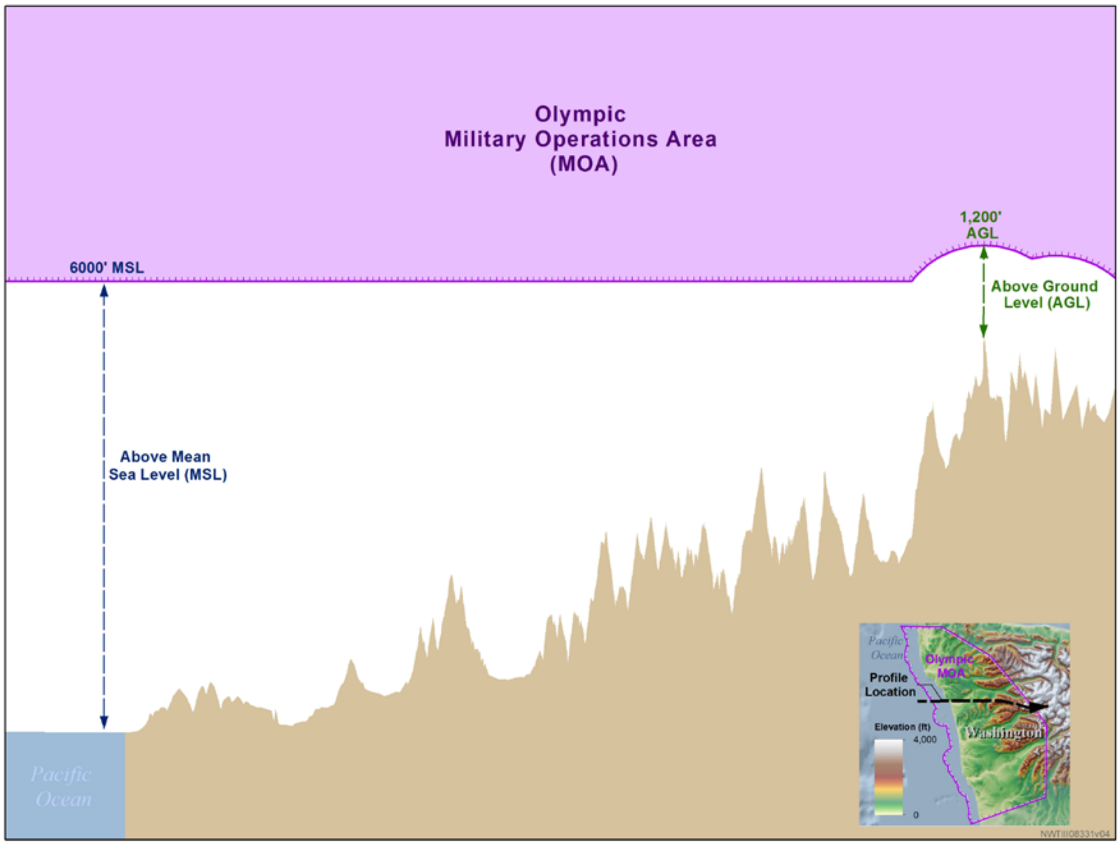

Figure J-2: Floor of the Olympic MOA Airspace

J.4 NOISE METRICS

Noise is one of the most prominent environmental issues associated with military training activities. The noise environment at military bases and training areas can include various types of noise sources that can either be classified as intermittent time varying noise (e.g., on-base vehicular traffic and aircraft training activities), or impulsive noise (e.g., weapons firing or detonation of explosives). Not all of these noise sources are directly associated with military training, such as civilian vehicular traffic or building heating, ventilation, and air conditioning system noise. However, military training activities may dominate the noise environment around military bases and training areas.

Analyzing aircraft noise requires an understanding of the type of aircraft activities to be analyzed, either at an airfield or in SUA. Aircraft noise generated in SUA requires the use of different noise metrics than those associated with airfield activities. As opposed to patterned or routine overflight over a specific area associated with airfields, overflights within SUA and along transit routes can be highly variable in occurrence and location, making it impractical to develop noise contour maps. When in SUA, aircrew are presented with a scenario to complete in order to accomplish training required for that flight. In addition to a number of different scenarios for each type of training event, each aircrew will respond uniquely. As a result, aircraft will maneuver within established boundaries (including a floor, or lowest altitude permissible), but are unpredictable as to where within those boundaries they will fly. Likewise, power settings and aircraft aspect relative to any given observer follow no set patterns.

Noise abatement routes to and from SUA have been established by the FAA to minimize overflight of populated areas while maximizing the efficiency and orderly flow of all air traffic (military, commercial and civil). All military aircraft (including the EA-18G) are subject to the rules and regulations of the FAA while flying in the NAS, but may deviate from established routes from time to time based on various factors that may be dictated by air traffic control. In the Puget Sound area, military use of the NAS is a small percent (about 7 percent) of the total overall air traffic in the region.

For this study, the standard noise metric, Day-Night Average Sound Level (DNL), is utilized as well as supplemental metrics (e.g., maximum noise level [L_{max}], audibility), to provide information on noise events that would occur within the Olympic MOA or while transiting to or from the Olympic MOA.

J.4.1 Day-Night Average Sound Level

DNL has been determined to be a reliable measure of long-term community annoyance from aircraft noise and has become the standard noise metric used as a federal standard for measuring noise impacts. The DNL metric is the industry standard methodology, supported by guidance from the FAA, U.S. Environmental Protection Agency (EPA), DoD, Federal Interagency Committee on Noise (FICON), American National Standards Institute (ANSI), and the World Health Organization, among others, and is the most accurate and valid method for evaluating the impacts of noise under current and future conditions. As a federal standard, the DNL metric is used by many state and local governments.

In 1979, the Federal Interagency Committee on Urban Noise (FICUN) was established, and they published “Guidelines for Considering Noise in Land-Use Planning and Control” (FICUN, 1980). These guidelines complement federal agency criteria by providing for the consideration of noise in all land-use planning and interagency/intergovernmental processes. The FICUN established DNL as the most appropriate descriptor for all noise sources in land-use planning. In 1982, the EPA published “Guidelines for Noise Impact Analysis” to provide all types of decision-makers with analytic procedures to uniformly express and quantify noise impacts (EPA, 1982). The ANSI endorsed DNL in 1990 as the “acoustical measure to be used in assessing compatibility between various land uses and outdoor noise environment” (ANSI, 2003). In 1992, FICON reaffirmed the use of DNL as the principal aircraft noise descriptor in the document entitled “Federal Agency Review of Selected Airport Noise Analysis Issues” (FICON, 1992). For aviation noise analyses, the FAA has determined that the cumulative noise energy exposure of individuals to noise resulting from aviation activities must be established in terms of yearly DNL, the FAA’s primary noise metric (Federal Aviation Administration, 2015). In general, scientific studies and social surveys have found a high correlation between the percentages of groups of people highly annoyed and the level of average noise exposure measured in DNL (Schultz, 1974; Fidell et al., 1991; Finegold et al., 1994).

The DNL is a noise measure used for assessing cumulative sound levels. This measure accounts for the exposure of all noise events in an average 24-hour period. DNL (which is also denoted as L_{dn}) is an average sound level, expressed in decibels (dB), which is commonly used to assess aircraft noise exposures in communities in the vicinity of airfields and under SUA (FICUN, 1980; EPA, 1982; ANSI, 2005). DNL values are related to compatible/incompatible land uses and do not directly relate to any singular sound event a person may hear. DNL includes a 10 dB adjustment for acoustical nighttime noise events. Acoustical daytime is defined as the period from 7 a.m. to 10 p.m. local, and acoustical nighttime is the period from 10 p.m. to 7 a.m. the following morning. The 10 dB penalty accounts for the generally lower background sound levels and greater community sensitivity to noise during nighttime hours.

Individual military overflight events also differ from typical airfield noise events in that noise from a low-altitude, high-airspeed flyover can have a sudden onset (i.e., exhibiting a rate of increase in sound level [onset rate] of up to 15 to 150 dB per second). To represent these differences, the conventional DNL metric is adjusted to account for the "surprise" effect of the sudden onset of aircraft noise events on humans. This adjustment is applied by adding a noise penalty of up to 11 dB above the normal Sound Exposure Level (Stusnick et al., 1993, ANSI, 2005). Onset rates between 15 to 150 dB per second require an adjustment penalty of 0 to 11 dB, while onset rates below 15 dB per second require no adjustment. The adjusted DNL is designated as the onset-rate adjusted day-night average sound level (DNL_r or L_{dnr}).

Because DNL takes into account both the amount of noise from each aircraft operation as well as the total number of operations flying throughout the day, there are many ways in which aircraft noise can add up to a specific DNL. Small numbers of relatively loud operations can result in the same DNL as large numbers of relatively quiet operations.

To assess accurately the impacts on humans from different types of noise events, the DNL metric is used along with weighting factors that emphasize certain parts of the audio frequency spectrum. The normal human ear detects sounds in the range from 20 hertz (Hz) to 20,000 Hz, but our ears are most sensitive to sounds in the 1,000 to 4,000 Hz range. Community noise is therefore assessed using a filter that approximates the frequency response of the human ear, adjusting low and high frequencies to match the sensitivity of the ear. This "A-weighting" filter is used to assess most community noise sources. Noise defined with the "A-weighting" filter uses the decibel designation dBA.

A-weighting best replicates human hearing and is the most appropriate for the assessment of annoyance from aircraft noise. A-weighted sound levels form the basis of the DNL metric, which is the best available metric to relate aircraft noise to long-term annoyance. The FICON found that "There are no new descriptors or metrics of sufficient scientific standing to substitute for the present DNL cumulative noise exposure metric" (Federal Aviation Administration, 2015). An alternative measurement methodology using C-weighting increases the emphasis on lower frequencies when compared with A-weighting. C-weighting is most appropriate for impulsive or repetitive sounds, such as blast noise and machine gun fire, which contain significant low-frequency noise, as well as continuous noise sources such as pumps and compressors. The FAA continues to recommend and utilize DNL and A-weighting for aircraft noise studies, and the DoD methodology used in this Supplemental is consistent with all applicable federal standards.

The EA-18G Growler aircraft generates the greatest sound pressure levels at frequencies between 200 and 4,000 Hz, consistent with the sound pressure levels of many commercial jetliners, and noise impact analyses for these commercial jetliners utilize A-weighted DNL measurements.

Common complaints associated with low-frequency vibrations depend on the individual perceiving the noise, but they could include annoyance/fright, concerns about structural effects on homes, or potential health effects.

J.4.2 Maximum Noise Level

Another noise metric that can provide supplemental information about the noise environment is the L_{max}. For SUA noise analysis, the L_{max} metric provides the maximum noise level from the single loudest event potentially occurring within the SUA. The L_{max} is unaltered by the number of training activities. However, an observer might not necessarily experience that event depending on where the observer was located in relation to the aircraft overflight. Because the flight activities within SUA are dispersed throughout the airspace, this means an observer would need to be directly below an aircraft as it flew at the lowest possible altitude to experience the maximum level of noise. See Table J-1 for maximum levels of common noise sources.

Table J-1: Examples of Various Sound Levels

dBA	*Example*	*Home and Yard Appliances*	*Workshop and Construction*
0	Healthy hearing threshold	-	-
10	A pin dropping	-	-
20	Rustling leaves	-	-
30	Whisper	-	-
40	Babbling brook	Computer	-
50	Light traffic	Refrigerator	-
60	Conversational speech	Air conditioner	-
70	Shower	Dishwasher	-
75	Toilet flushing	Vacuum cleaner	-
80	Alarm clock	Garbage disposal	-
85	Passing diesel truck	Snow blower	-
90	Squeeze toy	Lawn mower	Arc welder
95	Inside subway car	Food processor	Belt sander
100	Motorcycle (riding)	-	Handheld drill
105	Sporting event	-	Table saw
110	Rock band	-	Jackhammer

Source: Berger et al., 2015

J.4.3 Audibility

In the late 1980s, Congress directed the Department of Interior to investigate public concerns about aircraft noise within national parks and wilderness areas. The Department of Interior directed the National Park Service (NPS) to investigate these concerns. One of the results of the NPS's investigation was the introduction of audibility as a way of assessing the impact of transportation noise on natural quiet. The prediction of audibility estimates the ability of a human to hear a noise within the ambient soundscape. However, no uniform criteria nor threshold on percent time audible has been established to determine a potential noise impact within national parks or wilderness areas. In Section J.7 (Acoustic Monitoring Report), a 2010 National Park Service acoustic monitoring study, in which percent time audible data are provided, will be discussed. The Navy also reviewed a study of aircraft noise on the

Olympic Peninsula that was prepared by Laura Kuehne, a research scientist at the University of Washington's College of the Environment, School of Aquatic and Fishery Sciences (Kuehne, 2019); however, the information contained in this report had limited applicability and does not apply to the FAA-recommended methodology for analyzing aircraft noise.

J.4.4 NOISE METRICS USED IN THIS ANALYSIS

In this analysis, noise from aircraft training activities within the Olympic MOA was assessed using noise metrics recommended by the DoD, the Federal Interagency Committee on Aviation Noise (FICAN),[3] ANSI, and the FAA. Aircraft flight noise was assessed using the A-weighted L_{dn} and the L_{dnr}. Table J-2 provides the noise level limits associated with land use planning (DoD, 2011; Navy, 2008). In general, most land uses are considered compatible within Noise Zone 1. For Noise Zone 2, some land uses are incompatible with the noise. Within Noise Zone 3, most land uses are incompatible.

Table J-2: Noise Zone Definitions

Noise Zone	*Noise Limit L_{dn} (dBA)*	*Potential Impacts*
1	<65	Lesser
2	65 – 75	Moderate
3	75+	Highest

Notes: L_{dn} = Day-Night Average Sound Level, dBA = A-Weighted Sound Pressure Level

In addition to using the A-weighted L_{dn} and the L_{dnr}, the analysis provides L_{max} levels from the EA-18G to aid in the assessment of noise intrusions into the natural soundscape areas underneath and outside of the SUA. Because of the relatively low number of daily transits conducted to and from the Olympic MOA, L_{dnr} modeling results would be below the minimum value that MRNMap can calculate (35 dBA). Therefore, aircraft transits were also analyzed using L_{max} levels.

J.4.5 COMPUTERIZED NOISE EXPOSURE MODELS

Analyses of aircraft noise exposures and compatible land uses around and underneath SUA are normally accomplished using MRNMap (Ikelheimer & Downing, 2013). The United States Air Force developed this general-purpose computer model for calculating noise exposures occurring away from airbases, since aircraft noise is also an issue within MOAs and ranges, as well as along Military Training Routes (MTRs). This model expands the calculation of noise exposures away from airbases by using algorithms from both NoiseMap (Moulton, 1992; Czech & Plotkin, 1998) and ROUTEMAP (Bradley, 1996). NoiseMap is the DoD noise model to assess aircraft noise in and around airfields, and ROUTEMAP is a legacy DoD prediction model for cumulative noise underneath and near MTRs. MRNMap leverages the algorithms in these DoD noise models to predict cumulative noise levels underneath and near SUA. MRNMap uses two primary noise models to calculate the noise exposure: track and area operations. Track operations are for training activities that have a well-defined flight track, such as MTRs, aerial refueling, and strafing tracks. Area operations are for training activities that do not have well defined tracks, but occur within a defined area, such as air combat maneuvers within a MOA. The Navy used MRNMap – area operations for this noise study as it is ideally suited to analyze aircraft noise in MOAs.

For area operations, the model allows flexibility. If little is known about the airspace utilization within a MOA, then the MOA boundaries can simply be used, and the training activities are uniformly distributed

[3] FICAN was established in 1993 as the successor to FICON.

within the defined area. However, if more is known about how and where the aircraft fly within the MOA, subareas can be defined within the MOA to refine the modeled noise exposure.

Once the airspace is defined, the user must describe the different types of missions occurring within each airspace segment. Individual aircraft missions include the altitude distribution, airspeed, and engine power settings. These individual profiles are coupled with airspace components and annual operational rates.

The noise model MRNMap uses the airspace and operational parameters defined to calculate the desired noise metrics. The model calculates these noise metrics either for a user-defined grid or at user-defined specific points. The specific point calculation, used for this analysis in order to consider the changing elevation, generates a table that provides the noise exposure, as well as the top contributors to the noise exposure. The noise model MRNMap is the FAA-approved model for conducting a detailed noise analysis in MOAs and other SUA, such as the airspace over the Olympic Peninsula, military training routes, and other DoD airspace.

J.5 AIRSPACE TRAINING AND TESTING ACTIVITIES

Flight training activities conducted within the Olympic MOA and W-237A include a range of aircraft and mission types. Specific mission types and associated aircraft for these missions are defined in the Tables J-3 through J-10. Mission definitions are broken out into the reference training missions, based on historical data, and the proposed training missions projected to occur in the foreseeable future. Additional details on the modeled activities can be found in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions) of the Supplemental. The numbers reflected in the following tables are based on the number of aircraft sorties, which is more useful in analyzing actual noise events, while the numbers in the 2015 NWTT Final EIS/OEIS are the number of activity events; therefore, a comparison between the two sets of data is not easily made. One aircraft sortie could result in the completion of multiple training events, as a sortie is simply a single operational flight by one aircraft. Similarly, in some cases, one event could include multiple aircraft sorties. For example, Naval Air Systems Command would conduct comparatively few testing events that involve only P-8A and Triton aircraft. For the purposes of this analysis, the events would be conducted in the same manner and locations as Fleet training events.

Aircraft modeled include the primary user of the airspace units, EA-18G, along with other users: P-3C, P-8A, and F-15. The EA-18G activities were modeled with the F/A-18E/F aircraft with the F414-GE-400 engines, which is the same engine used in the EA-18G. The F-15 activities were modeled with the Pratt and Whitney F100-PW-229 engines. For the P-8A (a modified Boeing 737), the Boeing 737-700 with a CFM56-7B-24 engine was selected for the reference noise database within MRNMap. These engine selections were made to provide the loudest available variants of these aircraft for the noise modeling.

The noise model relies on performance parameters (airspeed, altitude, and power settings) provided by the aircrews, who fly these missions. Because the actual locations of any given event are unpredictable due to variables such as weather and others described above in Section J.4, the model assumes that the aircraft events, over time, would be uniformly distributed throughout the SUA within the 3 NM offset with a diminishing distribution from the offset to the SUA boundary.

J.5.1 Reference Missions

Table J-3: Reference Training Mission Descriptions for the EA-18G

	EA-18G - Reference							
	Olympic MOA (including ATCAA)	W-237A	Olympic MOA (including ATCAA)	W-237A	Olympic MOA (including ATCAA)	W-237A	Olympic MOA (including ATCAA)	W-237A
Name/Identifier	Entry/Exit: Ingress & Egress Routes[3]		Suppress Enemy Air Defenses[1]		Electronic Warfare Close Air Support[1]		Air to Air Counter Tactics[2]	
# Aircraft/Year	4448	0	1194	187	318	92	712	132
% Day (0700L-2159L)	94%	0%	99%	98%	99%	99%	96%	100%
% Night (2200L-0659L)	6%	0%	1%	2%	1%	1%	4%	0%
Avg Minutes in Airspace/Aircraft	NA	NA	90	90	90	90	60	60
Avg Power Setting in % NC	75	NA	80	80	82	82	89	89
Avg Speed (Knots indicated)	250	NA	265	265	298	298	342	342
Altitude MSL	Percent of total time spent at these altitudes.		Percent of total time spent at these altitudes.		Percent of total time spent at these altitudes.		Percent of total time spent at these altitudes.	
FLR - 2,000 ft				1.6%		1.6%		
2,000 - 4,000 ft				1.6%		1.6%		
4,000 - 6,000 ft				1.6%		1.6%		2.3%
6,000 - 8,000 ft		2.0%	2.0%	5.0%	2.0%	5.0%	3.2%	7.5%
8,000 - 10,000 ft		5.0%	5.0%		5.0%		6.6%	
10,000 - 12,000 ft				16.0%		16.0%		
12,000 - 14,000 ft		24.0%	24.0%		24.0%		55.2%	55.2%
14,000 - 16,000 ft	100.0%							
16,000 - 18,000 ft								
18,000 - 20,000 ft				4.2%		4.2%		
20,000 - 23,000 ft		64.0%	64.0%	65.0%	64.0%	65.0%	35.0%	35.0%
23,000 - 30,000 ft								
30,000 - 40,000 ft *		5.0%	5.0%	5.0%	5.0%	5.0%		
Total % Time	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

*Olympic MOA activities are all at or below 35,000 feet MSL, with over 95% of activities at or above 10,000 feet MSL.

[1] Suppress Enemy Air Defenses and Electronic Warfare Close Air Support are two types of Electronic Warfare activities.

[2] Electronic Warfare (EW) and Air to Air Counter Tactics (AACT) 3-year average of data was 68% EW and 32% AACT – this ratio of events was used for this study. Air to Air Counter Tactics is the primary type of Air Combat Maneuver (ACM) activity addressed throughout the Supplemental.

[3] Entry/Exit number is 2x 1 for entry 1 for exit. W-237A entry/exit are zero because the EA-18G enters the warning area from the MOA.

Notes: ATCAA = Air Traffic Control Assigned Airspace, Avg = Average, NC = Compressor Stage Rotations Per Minute (a measure of jet engine power setting), FLR = Floor, MSL = Mean Sea Level, NA = Not Applicable

Table J-4: Reference Training Mission Descriptions for the P-3C

	P-3C/EP-3 - Reference			
	Olympic MOA (including ATCAA)	W-237A	Olympic MOA (including ATCAA)	W-237A
Name/Identifier	Entry/Exit		Intelligence, Surveillance and Reconnaissance	
# Aircraft/Year Avg FY 15-17 (SHARP)	0	155	0	155
% Day (0700L-2159L)	90%	90%	90%	90%
% Night (2200L-0659L)	10%	10%	10%	10%
Avg Minutes in Airspace/Aircraft	NA	NA	180	180
Avg Power Setting in ESHP	2500	2500	2000	2000
Avg Speed (Knots indicated)	260	260	220	220
Altitude MSL	Percent of total time spent at these altitudes.		Percent of total time spent at these altitudes.	
FLR - 2,000 ft				5%
2,000 - 4,000 ft				
4,000 - 6,000 ft				
6,000 - 8,000 ft				
8,000 - 10,000 ft				5%
10,000 - 12,000 ft	100%	100%	10%	10%
12,000 - 14,000 ft				
14,000 - 16,000 ft				10%
16,000 - 18,000 ft				
18,000 - 20,000 ft			90%	70%
Total % Time	100.0%	100.0%	100.0%	100.0%

Notes: ATCAA = Air Traffic Control Assigned Airspace, SHARP = Sierra Hotel Aviation Readiness Program, Avg = Average, ESHP = Equivalent Shaft Horsepower, FLR = Floor, MSL = Mean Sea Level, NA = Not Applicable

Table J-5: Reference Training Mission Descriptions for the P-8A

	P-8A - Reference			
	Olympic MOA (including ATCAA)	W-237A	Olympic MOA (including ATCAA)	W-237A
Name/Identifier	Entry/Exit		Intelligence, Surveillance and Reconnaissance	
# Aircraft/Year Avg FY 15-17 (SHARP)	0	64	0	32
% Day (0700L-2159L)	90%	90%	90%	90%
% Night (2200L-0659L)	10%	10%	10%	10%
Avg Minutes in Airspace/Aircraft	NA	NA	180	180
Avg Power Setting in ESHP	6000	6000	5500	5500
Avg Speed (Knots indicated)	260	260	240	240
Altitude MSL	Percent of total time spent at these altitudes.		Percent of total time spent at these altitudes.	
FLR - 2,000 ft				5%
2,000 - 4,000 ft				
4,000 - 6,000 ft				
6,000 - 8,000 ft				
8,000 - 10,000 ft				5%
10,000 - 12,000 ft	100%	100%	10%	10%
12,000 - 14,000 ft				
14,000 - 16,000 ft				10%
16,000 - 18,000 ft				
18,000 - 20,000 ft			90%	70%
Total % Time	100.0%	100.0%	100.0%	100.0%

Notes: ATCAA = Air Traffic Control Assigned Airspace, SHARP = Sierra Hotel Aviation Readiness Program, Avg = Average, ESHP = Equivalent Shaft Horsepower, FLR = Floor, MSL = Mean Sea Level, NA = Not Applicable

Table J-6: Reference Training Mission Descriptions for the F-15

	F-15 - Reference					
	Olympic MOA (including ATCAA)	W-237A	Olympic MOA (including ATCAA)	W-237A	Olympic MOA (including ATCAA)	W-237A
Name/Identifier FY Avg FY15-17	Entry/Exit		Basic Fighter Maneuvers		Air Combat Maneuvers	
# Aircraft/Year	24	42	6	10	6	11
% Day (0700L-2159L)	100%	100%	100%	100%	100%	100%
% Night (2200L-0659L)	0%	0%	0%	0%	0%	0%
Avg Minutes in Airspace/Aircraft	NA	NA	25	25	30	25
Avg Power Setting in % NC	75	75	88	88	88	88
Avg Speed (Knots indicated)	250	250	375	375	375	375
Altitude MSL	Percent of total time spent at these altitudes.		Percent of total time spent at these altitudes.		Percent of total time spent at these altitudes.	
FLR - 2,000 ft						
2,000 - 4,000 ft						
4,000 - 6,000 ft						
6,000 - 8,000 ft		10%	10%	10%	10%	10%
8,000 - 10,000 ft		10%	10%	10%	10%	10%
10,000 - 12,000 ft		10%	10%	10%	10%	10%
12,000 - 14,000 ft		20%	20%	20%	20%	20%
14,000 - 16,000 ft	100%	20%	20%	20%	20%	20%
16,000 - 18,000 ft		20%	20%	20%	20%	20%
18,000 - 20,000 ft		10%	10%	10%	10%	10%
Total % Time	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Notes: ATCAA = Air Traffic Control Assigned Airspace, Avg = Average, NC = Compressor Stage Rotations Per Minute (a measure of jet engine power setting), FLR = Floor, MSL = Mean Sea Level, NA = Not Applicable

J.5.2 PROPOSED MISSIONS

Table J-7: Proposed Training Missions for the EA-18G

<table>
<tr><th></th><th colspan="8">EA-18G - Proposed</th></tr>
<tr><th></th><th>Olympic MOA (including ATCAA)</th><th>W-237A</th><th>Olympic MOA (including ATCAA)</th><th>W-237A</th><th>Olympic MOA (including ATCAA)</th><th>W-237A</th><th>Olympic MOA (including ATCAA)</th><th>W-237A</th></tr>
<tr><td>Name/Identifier</td><td colspan="2">Entry/Exit:Ingress & Egress Routes[3]</td><td colspan="2">Suppress Enemy Air Defenses[1]</td><td colspan="2">Electronic Warfare Close Air Support[1]</td><td colspan="2">Air to Air Counter Tactics[2]</td></tr>
<tr><td># Aircraft/Year</td><td>5048</td><td>0</td><td>1201</td><td>319</td><td>515</td><td>137</td><td>808</td><td>214</td></tr>
<tr><td>% Day (0700L-2159L)</td><td>94%</td><td>0%</td><td>99%</td><td>98%</td><td>99%</td><td>99%</td><td>96%</td><td>100%</td></tr>
<tr><td>% Night (2200L-0659L)</td><td>6%</td><td>0%</td><td>1%</td><td>2%</td><td>1%</td><td>1%</td><td>4%</td><td>0%</td></tr>
<tr><td>Avg Minutes in Airspace/Aircraft</td><td>NA</td><td>NA</td><td>90</td><td>90</td><td>90</td><td>90</td><td>60</td><td>60</td></tr>
<tr><td>Avg Power Setting in % NC</td><td>75</td><td>NA</td><td>80</td><td>80</td><td>82</td><td>82</td><td>89</td><td>89</td></tr>
<tr><td>Avg Speed (Knots indicated)</td><td>250</td><td>NA</td><td>265</td><td>265</td><td>298</td><td>298</td><td>342</td><td>342</td></tr>
<tr><td>Altitude MSL</td><td colspan="2">Percent of total time spent at these altitudes.</td><td colspan="2">Percent of total time spent at these altitudes.</td><td colspan="2">Percent of total time spent at these altitudes.</td><td colspan="2">Percent of total time spent at these altitudes.</td></tr>
<tr><td>FLR - 2,000 ft</td><td></td><td></td><td></td><td>1.6%</td><td></td><td>1.6%</td><td></td><td></td></tr>
<tr><td>2,000 - 4,000 ft</td><td></td><td></td><td></td><td>1.6%</td><td></td><td>1.6%</td><td></td><td></td></tr>
<tr><td>4,000 - 6,000 ft</td><td></td><td></td><td></td><td>1.6%</td><td></td><td>1.6%</td><td></td><td>2.3%</td></tr>
<tr><td>6,000 - 8,000 ft</td><td></td><td>2.0%</td><td>2.0%</td><td rowspan="2">5.0%</td><td>2.0%</td><td rowspan="2">5.0%</td><td>3.2%</td><td rowspan="3">7.5%</td></tr>
<tr><td>8,000 - 10,000 ft</td><td></td><td rowspan="2">5.0%</td><td rowspan="2">5.0%</td><td rowspan="2">5.0%</td><td rowspan="2">6.6%</td></tr>
<tr><td>10,000 - 12,000 ft</td><td></td><td rowspan="4">16.0%</td><td rowspan="4">16.0%</td></tr>
<tr><td>12,000 - 14,000 ft</td><td></td><td rowspan="4">24.0%</td><td rowspan="4">24.0%</td><td rowspan="4">24.0%</td><td rowspan="4">55.2%</td><td rowspan="4">55.2%</td></tr>
<tr><td>14,000 - 16,000 ft</td><td>100.0%</td></tr>
<tr><td>16,000 - 18,000 ft</td><td></td></tr>
<tr><td>18,000 - 20,000 ft</td><td></td><td>4.2%</td><td>4.2%</td></tr>
<tr><td>20,000 - 23,000 ft</td><td></td><td rowspan="2">64.0%</td><td rowspan="2">64.0%</td><td rowspan="2">65.0%</td><td rowspan="2">64.0%</td><td rowspan="2">65.0%</td><td rowspan="2">35.0%</td><td rowspan="2">35.0%</td></tr>
<tr><td>23,000 - 30,000 ft</td><td></td></tr>
<tr><td>30,000 - 40,000 ft *</td><td></td><td>5.0%</td><td>5.0%</td><td>5.0%</td><td>5.0%</td><td>5.0%</td><td></td><td></td></tr>
<tr><td>Total % Time</td><td>100.0%</td><td>100.0%</td><td>100.0%</td><td>100.0%</td><td>100.0%</td><td>100.0%</td><td>100.0%</td><td>100.0%</td></tr>
</table>

*Olympic MOA activities are all at or below 35,000 feet MSL, with over 95% of activities at or above 10,000 feet MSL.
[1] Suppress Enemy Air Defenses and Electronic Warfare Close Air Support are two types of Electronic Warfare activities.
[2] Electronic Warfare (EW) and Air to Air Counter Tactics (AACT) 3-year average of data was 68% EW and 32% AACT – this ratio of events was used for this study. Air to Air Counter Tactics is the primary type of Air Combat Maneuver (ACM) activity addressed throughout the Supplemental.
[3] Entry/Exit number is 2x 1 for entry 1 for exit. W-237A entry/exit are zero because the EA-18G enters the warning area from the MOA.
Notes: ATCAA = Air Traffic Control Assigned Airspace, Avg = Average, NC = Compressor Stage Rotations Per Minute (a measure of jet engine power setting), FLR = Floor, MSL = Mean Sea Level, NA = Not Applicable

Table J-8: Proposed Training Missions for the P-3C

	P3/EP-3 - Proposed			
	Olympic A & B (including ATCAA)	W-237 A & B	Olympic A & B (including ATCAA)	W-237 A & B
Name/Identifier	Entry/Exit		Intelligence, Surveillance and Reconnaissance	
# Aircraft/Year	4	94	2	47
% Day (0700L-2159L)	90%	90%	90%	90%
% Night (2200L-0659L)	10%	10%	10%	10%
Avg Minutes in Airspace/Aircraft	NA	NA	180	180
Avg Power Setting in ESHP	2500	2500	2000	2000
Avg Speed (Knots indicated)	260	260	220	220
Altitude MSL	Percent of total time spent at these altitudes.		Percent of total time spent at these altitudes.	
FLR - 2,000 ft				5%
2,000 - 4,000 ft				
4,000 - 6,000 ft				
6,000 - 8,000 ft				
8,000 - 10,000 ft				5%
10,000 - 12,000 ft	100%	100%	10%	10%
12,000 - 14,000 ft				
14,000 - 16,000 ft				10%
16,000 - 18,000 ft				
18,000 - 20,000 ft			90%	70%
Total % Time	100.0%	100.0%	100.0%	100.0%

Notes: ATCAA = Air Traffic Control Assigned Airspace, Avg = Average, ESHP = Equivalent Shaft Horsepower, FLR = Floor, MSL = Mean Sea Level, NA = Not Applicable

Table J-9: Proposed Training Missions for the P-8A

	P-8A - Proposed			
	Olympic A & B (including ATCAA)	W-237 A & B	Olympic A & B (including ATCAA)	W-237 A & B
Name/Identifier	Entry/Exit		Intelligence, Surveillance and Reconnaissance	
# Aircraft/Year	4	778	2	389
% Day (0700L-2159L)	90%	90%	90%	90%
% Night (2200L-0659L)	10%	10%	10%	10%
Avg Minutes in Airspace/Aircraft	NA	NA	180	180
Avg Power Setting in ESHP	6000	6000	5500	5500
Avg Speed (Knots indicated)	260	260	240	240
Altitude MSL	Percent of total time spent at these altitudes.		Percent of total time spent at these altitudes.	
FLR - 2,000 ft				5%
2,000 - 4,000 ft				
4,000 - 6,000 ft				
6,000 - 8,000 ft				
8,000 - 10,000 ft				5%
10,000 - 12,000 ft	100%	100%	10%	10%
12,000 - 14,000 ft				
14,000 - 16,000 ft				10%
16,000 - 18,000 ft				
18,000 - 20,000 ft			90%	70%
Total % Time	100.0%	100.0%	100.0%	100.0%

Notes: ATCAA = Air Traffic Control Assigned Airspace, Avg = Average, ESHP = Equivalent Shaft Horsepower, FLR = Floor, MSL = Mean Sea Level, NA = Not Applicable

Table J-10: Proposed Training Missions for the F-15

	F-15 - Proposed					
	Olympic MOA (including ATCAA)	W-237A	Olympic MOA (including ATCAA)	W-237A	Olympic MOA (including ATCAA)	W-237A
Name/Identifier	Entry/Exit		Air Combat Maneuvers		Basic Fighter Maneuvers	
# Aircraft/Year	24	48	6	12	6	12
% Day (0700L-2159L)	100%	100%	100%	100%	100%	100%
% Night (2200L-0659L)	0%	0%	0%	0%	0%	0%
Avg Minutes in Airspace/Aircraft	10	10	30	25	25	25
Avg Power Setting in % NC	75	75	88	88	88	88
Avg Speed (Knots indicated)	250	250	375	375	375	375
Altitude MSL	Percent of total time spent at these altitudes.		Percent of total time spent at these altitudes.		Percent of total time spent at these altitudes.	
FLR - 2,000 ft						
2,000 - 4,000 ft						
4,000 - 6,000 ft						
6,000 - 8,000 ft		10%	10%	10%	10%	10%
8,000 - 10,000 ft		10%	10%	10%	10%	10%
10,000 - 12,000 ft		10%	10%	10%	10%	10%
12,000 - 14,000 ft		20%	20%	20%	20%	20%
14,000 - 16,000 ft	100%	20%	20%	20%	20%	20%
16,000 - 18,000 ft		20%	20%	20%	20%	20%
18,000 - 20,000 ft		10%	10%	10%	10%	10%
Total % Time	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Notes: ATCAA = Air Traffic Control Assigned Airspace, Avg = Average, NC = Compressor Stage Rotations Per Minute (a measure of jet engine power setting), FLR = Floor, MSL = Mean Sea Level, NA = Not Applicable

J.6 Projected Aircraft Noise Exposure

This section describes the results of the noise modeling that was completed for flights conducted in the Olympic MOA and W-237A (J.6.1), and for aircraft transits to and from these areas (J.6.2).

J.6.1 Olympic MOA and W-237A

The operational parameters described in Section J.5 (Airspace Training and Testing Activities) were used as inputs to MRNMap to calculate the noise exposures around the Olympic Peninsula from aircraft operations conducted within the Olympic MOA and W-237A.

J.6.1.1 Terrain

The area beneath the Olympic MOA includes mountainous terrain. The Olympic MOA has a 3 NM boundary offset, which was applied to the north, south, and east boundaries. The offset was not applied to the west boundary as aircraft often cross the boundary when traversing between the MOA and warning area. The elevation distributions were calculated in both the area inside of the 3 NM boundary offset (where most of the operations will take place), and the area between the MOA boundary and the 3 NM boundary offset (fewer operations occur in this area).

Area inside of the 3 NM boundary offset:

- 14.47 percent of the MOA’s area lies above terrain with an elevation range between 0 and 5 ft. (MSL),
- 46.87 percent between 5 and 500 ft. MSL,
- 18.53 percent between 500 and 1,000 ft. MSL,
- 7.87 percent between 1,000 and 1,500 ft. MSL,
- 5.32 percent between 1,500 and 2,000 ft. MSL,
- 3.86 percent between 2,000 and 2,500 ft. MSL,
- 2.13 percent between 2,500 and 3,000 ft. MSL,
- 0.78 percent between 3,000 and 3,500 ft. MSL,
- 0.15 percent between 3,500 and 4,000 ft. MSL,
- 0.02 percent between 4,000 and 4,500 ft. MSL,
- 0.00 percent between 4,500 and 4,800 ft. MSL, and
- 0.00 percent between 4,800 and 5,000 ft. MSL.

Area between the MOA boundary and the 3 NM boundary offset:

- 5.75 percent of the MOA’s area lies above terrain with an elevation range between 0 and 5 ft. (MSL),
- 29.17 percent between 5 and 500 ft. MSL,
- 20.98 percent between 500 and 1,000 ft. MSL,
- 12.30 percent between 1,000 and 1,500 ft. MSL,
- 8.42 percent between 1,500 and 2,000 ft. MSL,
- 7.86 percent between 2,000 and 2,500 ft. MSL,
- 6.81 percent between 2,500 and 3,000 ft. MSL,
- 4.62 percent between 3,000 and 3,500 ft. MSL,
- 2.88 percent between 3,500 and 4,000 ft. MSL,
- 1.01 percent between 4,000 and 4,500 ft. MSL,
- 0.16 percent between 4,500 and 4,800 ft. MSL, and
- 0.04 percent between 4,800 and 5,000 ft. MSL.

More than 82 percent of the Olympic MOA area is inside of the 3 NM boundary offset, and the other 18 percent of the area is between the MOA boundary and the 3 NM boundary offset. The elevation distributions are shown graphically in Figure J-3.

To further refine the analysis (since the highest elevations are closer to the MOA boundary than the 3 NM offset), the 3 NM offset area (the area between the 3 NM offset and the MOA boundary) was split in half (at the 1.5 NM offset of the MOA boundary) and the probability of aircraft within each portion of the 3 NM offset and the area inside of the 3 NM offset was calculated.

J.6.1.2 Day-Night Average Sound Level Results

The current version of MRNMap, which uses the best available science to calculate noise within SUA, does not have the capability to model complex terrain. Therefore, noise maps of the predicted sound levels cannot be produced. However, the model can accurately estimate the noise exposure at different elevations by varying the modeled ground elevation. For the Olympic MOA, noise was modeled with different reference ground elevations from 0 ft. MSL to 4,500 ft. MSL to represent the expected noise exposures for the lowest and the highest ground elevations within the MOA. The results are presented in Table J-11. As described above in Section J.4 (Noise Metrics), the results presented from MRNMap consider an average 24-hour period with a 10 dB penalty added for activities occurring at night (L_{dn}) and an additional 11 dB penalty added to adjust for “surprise” effects of the sudden onset of aircraft noise (L_{dnr}).

Table J-11: Cumulative Noise Metrics Values for Baseline and Proposed Aircraft Activities

Terrain Height (feet above MSL)	Baseline L_{dnr} (dBA)	Proposed L_{dnr} (dBA)
0–5	<35	<35
5–500	<35	<35
500–1,000	<35	<35
1,000–1,500	<35	<35
1,500–2,000	<35	<35
2,000–2,500	<35	35.6
2,500–3,000	35.5	36.0
3,000–3,500	36.1	36.7
3,500–4,000	35.7	36.2
4,000–4,500	35.4	36.0

MSL = Mean Sea Level, L_{dn} = Day-Night Average Sound Level,
dBA = A-Weighted Sound Pressure Level

For the cumulative noise metrics (L_{dnr}), the noise modeling results show that the area underneath the Olympic MOA would experience a cumulative noise exposure of less than 37 dBA for both the reference (current) activities and the proposed activities. The slightly higher noise levels for the proposed activities are a reflection of the 13.5 percent projected increase in sorties over the current level of activities (an increase from approximately 2,300 to 2,600). For the lower ground elevations, the computed noise levels are correspondingly lower, as the distance would increase between the airborne source and the receptor on

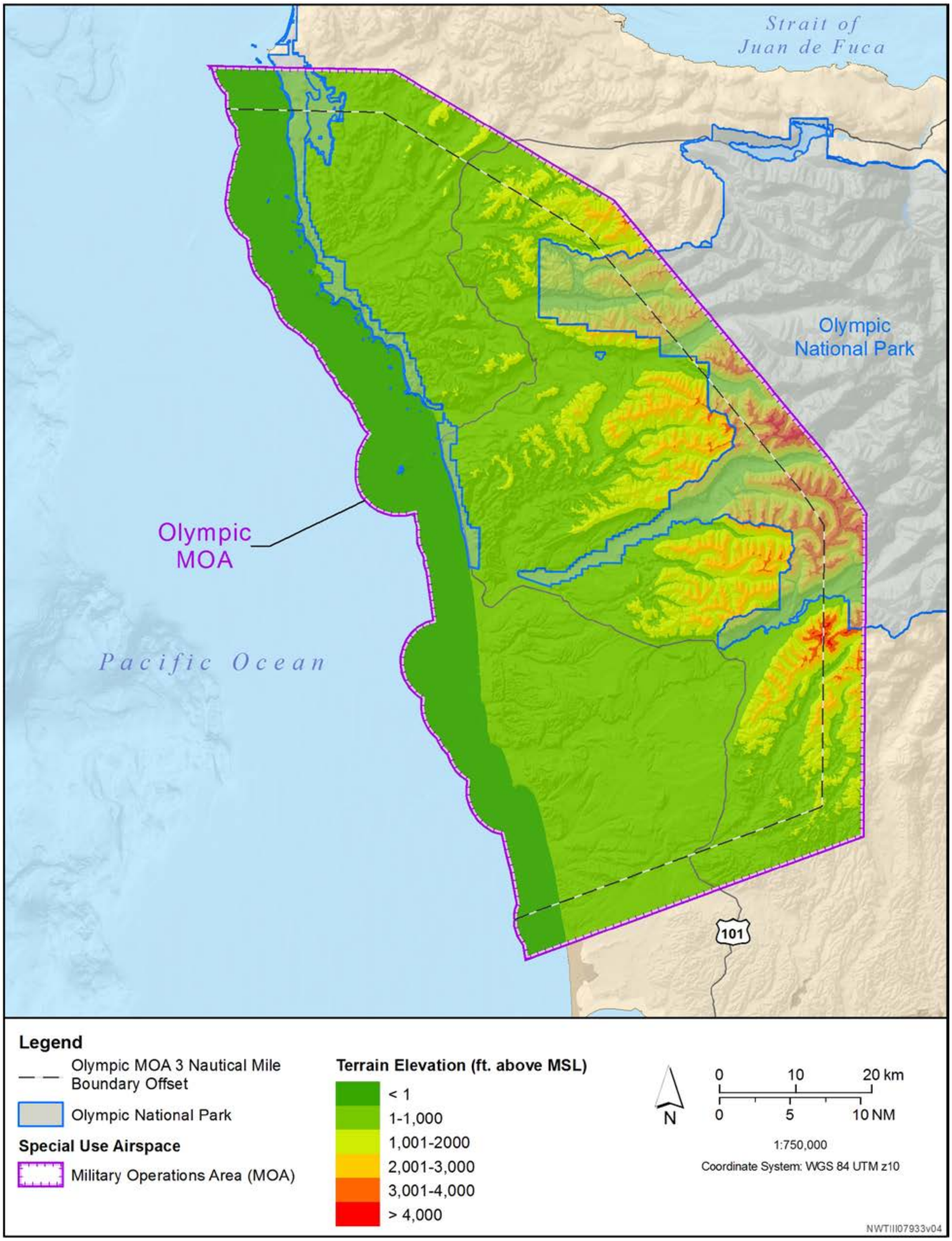

Figure J-3: Elevation Distributions Within the Olympic MOA

the ground (see Figure J-2 and Table J-11). For comparison, 35 dBA would be considered the natural ambient noise level of a wilderness area, and 39 dBA the level of a rural residential area. In a 2010 monitoring study conducted at five locations beneath or near the Olympic MOA, natural daytime ambient acoustic baselines were measured at between 23.1 dBA and 35.6 dBA (NPS, 2016). The peak cumulative noise exposures shown in Table J-11 are predicted to occur at 3,000–3,500 ft. terrain height, and not at the highest terrain elevations above 3,500 ft. This reduced cumulative noise exposure is because those higher elevations occur near the boundaries of the MOA, where aircraft seldom fly and noise events are less likely to occur. Similarly, areas beyond the boundaries of the MOA would experience lower cumulative noise exposure from flights conducted within the MOA.

As described above in Section J.4.1 (Day-Night Average Sound Level), there are many ways in which aircraft noise can add up to a specific DNL. Small numbers of relatively loud operations can result in the same DNL as large numbers of relatively quiet operations. Any one location beneath the MOA could reach a 35 dBA level from several high-noise events, while another location would experience the same average with no high-noise events, but a number of barely audible jet flyovers.

The analysis also considered cumulative noise at locations where air traffic is most common and predictable, beneath specific points that aircraft use to enter or exit the MOA (see Section J.6.2, Transit to/from the Olympic MOA, for a description of aircraft transit procedures and entry/exit points). Directly under the entry and exit routes to the MOA and Warning Area, the highest level of noise exposure was computed to be 36 dBA for both reference activities and proposed activities. These L_{dnr} and L_{dn} noise levels are well below 65 dBA, meaning that the entire area beneath the Olympic MOA falls within Noise Zone 1.

One of the reasons for these low DNL levels is that the EA-18G spends, on average, more than 95 percent of flight time at or above 10,000 ft. MSL while in the Olympic MOA. In addition, the P-8A stays at or above 10,000 ft. MSL 100 percent of the flight time. This higher altitude translates into lower cumulative noise levels on the ground. The area beneath W-237A is computed to have cumulative noise levels below 35 dBA.

These calculated noise exposures are based on the average annual operational tempo, as defined in Section J.5 (Airspace Training and Testing Activities). If the training tempo for an active month were twice the annual average, the expected noise exposure would increase by 3 dB. In this situation, the higher elevations within the Olympic MOA would be exposed to an L_{dn} (and L_{dnr}) of 40 dBA for the proposed activities, which is still within Noise Zone 1 limits.

While these noise zones are applicable to most situations, special consideration needs to be given to the evaluation of significance of noise impacts on noise-sensitive areas such as national parks and historic sites that could include traditional cultural resources (Federal Aviation Administration, 2015). With these noise-sensitive areas in mind, it is notable that the noise exposure for more than 91 percent of the area beneath the Olympic MOA would be less than 35 dBA, which is considered the natural ambient noise level of a wilderness area. Also, an additional analysis was conducted in which maximum noise levels are considered.

J.6.1.3 Maximum Noise Level

Cumulative noise metrics, such as DNL, are well suited for general land use planning, but fall short of providing an understanding of the experience from individual events. In contrast, the L_{max} provides a simple metric to describe single noise events from flights conducted within the Olympic MOA that people on the Olympic Peninsula may experience. For the modeled missions defined in Section J.5.1

(Reference Missions), the loudest event in terms of L_{max} occurs during the EA-18G Air-to-Air Counter Tactics (see Table J-3 and Table J-7). This situation only occurs when the aircraft is at a relatively high engine power (89 percent Compressor Stage Rotations Per Minute [NC]), flying at the lowest altitudes (6,000 ft. to 8,000 ft. MSL), and flying over the highest elevations. Aircraft performing these training activities only spend 3.2 percent of their flight time at this lowest altitude band across the entire airspace (Table J-3 and Table J-7). Combining this operational distribution with the terrain altitude distributions, the noise analysis provides an estimate of the time that areas beneath the Olympic MOA will experience noise at a given maximum level. The results for the EA-18G, P-3/P-8, and F-15 are shown in Tables J-12, J-13, and J-14, respectively. The levels experienced outside the boundaries of the Olympic MOA from flights conducted within the MOA would be lower.

Table J-12: Estimated L_{max} Duration for EA-18G Training Operations Within the Olympic MOA

Terrain Elevation (MSL)	*Probability Distribution within the MOA*	*L_{max} (dBA)*	*Time at this L_{max} (min) per EA-18G SEAD and EWCAS Mission Sortie (1)*	*Time at this L_{max} (min) per EA-18G AACT Mission Sortie (2)*	*Time at this L_{max} (min) per Year for all Combined Missions*	
					Baseline	*Proposed Action*
0 –5	13.67%	81.5	0.246	0.262	558	634
5–500	45.15%	82.9	0.813	0.867	1847	2096
500–1,000	18.77%	84.4	0.338	0.360	767	871
1,000–1,500	8.23%	86.0	0.148	0.158	336	382
1,500–2,000	5.66%	87.8	0.102	0.109	232	263
2,000–2,500	4.28%	89.7	0.077	0.082	175	198
2,500–3,000	2.60%	91.8	0.047	0.050	107	121
3,000–3,500	1.15%	94.2	0.021	0.022	47	54
3,500–4,000	0.40%	97.1	0.007	0.008	16	18
4,000– 4,500	0.09%	100.6	0.002	0.002	4	5

(1) For SEAD and EWCAS missions, 2% of the mission flight time is spent at the lowest altitude that results in this L_{max} (6,000–8,000 ft. MSL)
(2) For AACT missions, 3.2% of the mission time is spent at the lowest altitude that results in this L_{max} (6,000-8,000 ft. MSL)
Notes: MOA = Military Operations Area, MSL = Mean Sea Level, dBA = A-Weighted Sound Pressure Level, L_{max} = Maximum Received Noise Level, SEAD = Suppression of Enemy Air Defenses, EWCAS = Electronic Warfare Close Air Support, AACT = Air to Air Counter Tactics, min = minutes, ISR = Intelligence Surveillance Reconnaissance

Table J-13: Estimated L_{max} Duration for P-3 and P-8 Training Operations Within the Olympic MOA

Terrain Elevation (feet above MSL)	*Probability Distribution within the MOA*	*P-3 L_{max} (dBA)*	*P-8 L_{max} (dBA)*	*Time at this L_{max} (min) per ISR Mission Sortie (1)*	*Time at this L_{max} (min) per Year for all Combined Missions*	
					Baseline	*Proposed Action*
0–5	13.67%	51.6	51.2	2.461	0	10
5–500	45.15%	53.0	52.5	8.127	0	33
500–1,000	18.77%	53.7	53.3	3.379	0	14
1,000–1,500	8.23%	54.3	53.9	1.481	0	6
1,500–2,000	5.66%	55.4	55.0	1.019	0	4
2,000–2,500	4.28%	56.4	56.0	0.770	0	3
2,500–3,000	2.60%	57.3	56.9	0.468	0	2
3,000–3,500	1.15%	58.2	57.7	0.207	0	1
3,500–4,000	0.40%	59.2	58.7	0.072	0	<1
4,000–4,500	0.09%	59.8	59.3	0.016	0	<1

(1) For ISR missions, 10% of the mission flight time is spent at the lowest altitude that results in this L_{max} (10,000–12,000 ft. MSL)

Notes: MOA = Military Operations Area, MSL = Mean Sea Level, dBA = A-Weighted Sound Pressure Level, L_{max} = Maximum Received Noise Level, min = minutes, ISR = Intelligence Surveillance Reconnaissance

Table J-14: Estimated L_{max} Duration for F-15 Training Operations Within the Olympic MOA

Terrain Elevation (feet above MSL)	*Probability Distribution within the MOA*	*L_{max} (dBA)*	*Time at this L_{max} (min) per F-15 ACM Mission Sortie (1)*	*Time at this L_{max} (min) per F-15 BFM Mission Sortie (1)*	*Time at this L_{max} (min) per Year for all Combined Missions*	
					Baseline	*Proposed Action*
0–5	13.67%	80.8	0.410	0.342	5	5
5–500	45.15%	82.3	1.355	1.129	15	15
500–1,000	18.77%	83.6	0.563	0.469	6	6
1,000–1,500	8.23%	85.0	0.247	0.206	3	3
1,500–2,000	5.66%	86.6	0.170	0.142	2	2
2,000–2,500	4.28%	88.3	0.128	0.107	1	1
2,500–3,000	2.60%	90.2	0.078	0.065	1	1
3,000–3,500	1.15%	92.4	0.035	0.029	<1	<1
3,500–4,000	0.40%	95.0	0.012	0.010	<1	<1
4,000–4,500	0.09%	98.1	0.003	0.002	<1	<1

(1) For ACM and BFM missions, 10% of the mission flight time is spent at the lowest altitude that results in this L_{max} (6,000–8,000 ft. MSL)

Notes: MOA = Military Operations Area, MSL = Mean Sea Level, dBA = A-Weighted Sound Pressure Level, L_{max} = Maximum Received Noise Level, min = minutes, ISR = Intelligence Surveillance Reconnaissance, ACM = Air Combat Maneuver, BFM = Basic Fighter Maneuver

The maximum noise levels (L_{max}) perceived on the ground are dependent on the elevation of the terrain below the aircraft. Because the terrain elevation bands of 4,500–4,800 ft. MSL and 4,800–5,000 ft. MSL occur in the outermost area between the 1.5 NM offset and the MOA boundary, the probability of aircraft flying over these altitudes approaches 0 (less than 0.001 percent). Thus, the time each aircraft spends over these terrain heights is 0.

Beneath W-237A, the L_{max} is 88.6 dBA. This is a lower L_{max} than the L_{max} beneath the MOA because the warning areas are completely over the ocean (0 ft. MSL elevation) and the distance from the surface of the water to the aircraft flying above is greater than the distance from the higher elevations in the MOA to the aircraft. The L_{max} is the same for the Proposed Action as the Baseline since the individual mission profiles do not change.

Table J-12 provides the duration that the specified EA-18G L_{max} occurs within the MOA for an average sortie above the specified terrain height. For areas with ground elevations between 4,000 ft. MSL and 4,500 ft. MSL, for example, the L_{max} values of 100.6 dBA are estimated to occur for 0.12 seconds on average for each EA-18G mission type. Using this average time per sortie provides a cumulative time of five minutes over the course of an entire year for the proposed activities. To clarify this table, it does not suggest that the entire area beneath the MOA will experience noise at these levels for each sortie. Rather, somewhere within the MOA the noise could reach these levels as aircraft fly directly overhead, and these aircraft will not fly over these higher altitude areas for every mission. The total time is the accumulation of all events for the entire area over the course of a year. Thus, the likelihood of someone experiencing these maximum sound levels is low. Additionally, the L_{max} occurs when the aircraft is flying in the lowest altitude band distribution for that mission. At some locations beneath the MOA, L_{max} above 81.5 would occur, for a total duration of 4,642 minutes (approximately 77 hours or less than 1 percent of the time) throughout the year. 81.5 dBA equates roughly to a truck driving by at 50 ft. While the time at L_{max} would be brief, the noise would build up for a period of time, reach L_{max}, then decrease for a period of time.

As an example, suppose a hiker is beneath the Olympic MOA at a terrain elevation of 300 ft. This is a likely situation, as 45.15 percent of the Olympic MOA is over terrain between 0 and 500 ft. (Table J-12). If an EA-18G Growler aircraft flew directly overhead at full power, at the lowest permissible altitude (the floor of the MOA airspace, 6,000 ft. MSL), the hiker would experience an 82.9 dBA exposure to the jet noise (referred to as L_{max} in Table J-12). That is roughly the sound level the hiker might experience 5 meters from a busy roadway. However, the sound of the jet would be at this level for only an instant, decreasing rapidly as the jet flew away from the hiker, just as the sound of a truck would be at its peak noise level only for an instant, then decrease as it drove away. Tables J-13 and J-14 provide similar information for the P-3/P-8 and F-15, respectively, but Table J-12 was chosen as it represents the loudest aircraft of the three.

As the hiker climbs in elevation, the loudest possible noise exposure from an EA-18G would increase as the hiker is moving up in elevation, closer to the floor of the MOA airspace. If the hiker was at 4,500 ft. terrain height, the noise level could potentially be as loud as 100.6 dBA. The likelihood of louder noise exposures grows increasingly unlikely for four reasons:

1. Most of the terrain beneath the Olympic MOA (more than 77 percent) is 1,000 ft. or lower, thereby creating a buffer of at least 5,000 ft. between the hiker and the jet (when the jet is flying at its lowest permissible altitude). Only 0.09 percent of the area beneath the Olympic

MOA is above 4,000 ft. elevation (Table J-12), where the 100.6 dBA exposure is possible and, for more than 77 percent of the area, the maximum noise level would be 84.4 dBA (Table J-12).

2. The highest terrain beneath the Olympic MOA is found at the eastern most border of the MOA, where aircraft presence is unlikely due to the 3 NM offset used by aircrew to avoid accidentally spilling out of the airspace.
3. The highest terrain areas on the Olympic peninsula are extremely remote, where few people are likely to be present (Figure J-3).
4. As shown in Table J-12, the 100.6 dBA noise level would occur somewhere beneath the MOA for only five minutes in any year under the proposed level of activities.

J.6.1.4 Audibility

An audibility metric is also calculated to estimate the potential intrusion on the natural quiet of the area. Calculating audibility is a complex process that requires detailed information about where the aircraft fly and under what conditions, as well as details about the existing ambient sound environment. Audibility estimates can, however, be made using Noise Model Simulation (NMSim) by applying simplifying assumptions. For this analysis, the “Suppress Enemy Air Defenses” mission for the EA-18G was used as the operational state, along with the simplifying assumptions of the aircraft flying straight and level over flat ground. The calculations were repeated for several different aircraft altitudes. With these assumed conditions, the National Park Service’s NMSim model was used to predict the distance at which the aircraft are just audible.

For this analysis, the EA-18G was assumed to fly at 298 knots straight and level at several different altitudes from 2,000 ft. MSL to 40,000 ft. MSL and assumed to operate at 82 percent NC. For background noise levels, a single ambient sound environment provided with NMSim was selected. Noise contours were then generated, and the distances to 0 percent audibility were calculated. These results are provided in Table J-15. Because of the complex terrain in and around the Olympic MOA, noise contour figures could not be produced. In general, this simple audibility analysis shows that the maximum distance of audibility of the EA-18G is approximately 16 NM.

Table J-15: Estimates of the Lateral Distance of Audibility for the EA-18G

Aircraft Height	***Distance to edge of audibility (NM)***
2,000 ft. AGL	11.5
5,000 ft. AGL	14.2
10,000 ft. AGL	15.5
15,000 ft. AGL	15.6
20,000 ft. AGL	15.6
30,000 ft. AGL	14.1
40,000 ft. AGL	12.8

Note: AGL = Above Ground Level

This audibility analysis is a rough estimate of the distance to audibility and does not include any of the details of the local terrain, local ambient noise levels, or weather conditions. This analysis also does not provide any quantification of the durations that the aircraft would be audible. Without more detailed tracking information and data on the operating state of the aircraft, such information is difficult to calculate accurately. Past research has shown that, even at high altitudes, aircraft will tend to be audible over long distances. Research on high-altitude commercial jet noise at the Grand Canyon has suggested that these aircraft are audible approximately 34 percent of the time (Ross et al., 2004). In contrast, if all of the proposed EA-18G activities were audible for all of their time in the Olympic MOA, they would be audible for approximately 26 percent of the time over the course of a year.

Due to the relatively long range of audibility of the EA-18G, and the potential for aircraft to maneuver (as opposed to flying in a straight line), it is likely that an aircraft could be audible for a minute or more in a single event.

J.6.2 Transit to/from the Olympic MOA

The operational parameters described in Section J.5 (Airspace Training and Testing Activities) were used as inputs to MRNMap to calculate the noise exposures around the Olympic Peninsula from EA-18G Growler aircraft transiting to and from the Olympic MOA and W-237A.

Aircraft departing Naval Air Station (NAS) Whidbey Island en route to the Olympic MOA or W-237A typically fly to the navigation point MCCUL then on to the point designated NUW233065 (Figure J-4 and Table J-16). As shown on Table J-16, EA-18G aircraft typically fly this segment at 15,000 ft. MSL. Once within the Olympic MOA, the aircraft are permitted to maneuver as required by their training requirements, and that noise analysis is captured in Section J.6.1 (Olympic MOA and W-237A). As described above in Section J.4 (Noise Metrics), aircraft do not always remain on their routes. However, a study of FAA historical radar tracks indicates that most EA-18G aircraft transiting to the Olympic MOA do remain on the established route and altitude.

When aircraft have completed their activities in the MOA and contact the FAA for the return to NAS Whidbey Island, the FAA controller will typically provide them clearance from their current location within the MOA direct to the navigation fix YETII (Figure J-4 and Table J-16). A study of radar tracks shows that aircraft fly from any point (typically near the central area of the Olympic MOA) direct to YETII. Aircraft are to intercept YETII at or above 10,000 ft. MSL. Because this is lower than the altitude of the aircraft when they depart the Olympic MOA (approximately 14,000 ft. MSL), the aircraft are descending along this segment of their route, as supported by historical radar tracks.

J.6.2.1 Terrain

The area beneath the transit routes includes terrain that varies from sea level (e.g., Strait of Juan de Fuca) to mountainous (e.g., Mount Olympus, Hurricane Ridge). Several notable locations on the Olympic Peninsula below or near aircraft transits are included below along with their elevation:

- Mount Olympus – 9,570 ft.
- Hurricane Ridge – 5,242 ft.
- Glacier Meadows Campground – 4,180 ft.
- Sol Duc Falls – 2,047 ft.
- Hoh Rain Forest Visitor Center – 583 ft.
- Lake Crescent – 580 ft.
- Olympic National Park Visitor Center (Port Angeles) – 350 ft.

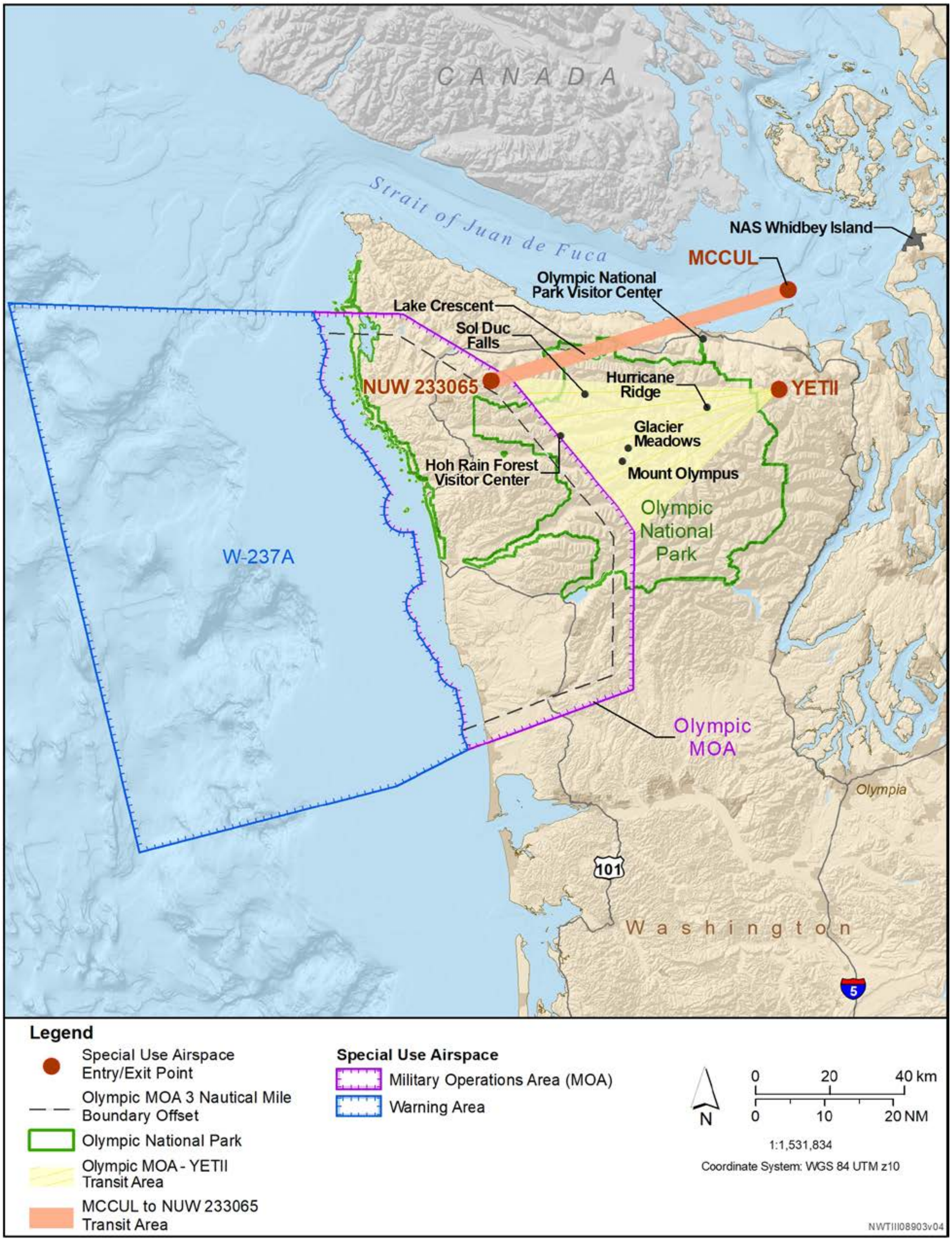

Figure J-4: EA-18G Growler Entry and Exit Routes to/from Olympic MOA and W-237A

Table J-16: Entry and Exit Routes to/from Olympic MOA and W-237A

Aircraft	*Entry/Exit to Area*	*Point Number*	*Fix*	*Altitude (feet above MSL)*	*Airspeed (knots)*
EA-18G	Navigation Point to Olympic MOA	1	MCCUL	15,000	250
	Entry to Olympic MOA	2	NUW 233065	15,000	250
	Exit from Olympic MOA	1	HQM 360040	14,000	250
	Navigation Point to NASWI	2	YETII	At or above 10,000	250
F-15	Departure Point to Olympic MOA	1	KPDX	At or above 10,000	250
	Entry to Olympic MOA	2	HQM001035	14,000–16,000	250
	Exit from Olympic MOA	1	HQM001035	25,000–27,000	250
	Reporting point returning to KPDX	2	KEIKO	At or above 10,000	250
	Departure Point to Olympic MOA	1	KPDX	25,000	250
	Reporting Point for Entry to W-237A	2	HQM	25,000	250
	First Navigation Fix after Exit from W-237A	1	HQM	25,000	250
	Reporting Point Returning to KPDX	2	KEIKO	25,000	250
P-3 / P-8	1st Navigation Point to W-237A	1	MCCUL	10,000–12,000	260
	2nd Navigation Point to W-237A	2	HQM	10,000–12,000	260
	Entry to W-237A	3	HQM270030	10,000–12,000	260
	Exit from W-237A	1	HQM270030	10,000–12,000	260
	1st Navigation Point to NASWI	2	HQM	10,000–12,000	260
	Reporting Point Returning to NASWI	3	YETII	10,000–12,000	260
	1st Navigation Point to W-237A	1	MCCUL	10,000–12,000	260
	2nd Navigation Point to W-237A	2	NUW233035	10,000–12,000	260
	3rd Navigation Point to W-237A	3	TOU	10,000–12,000	260
	Entry to W-237A	4	TOU210030	10,000–12,000	260
	Exit from W-237A	1	TOU210030	10,000–12,000	260
	1st Navigation Point to NASWI	2	TOU	10,000–12,000	260
	2nd Navigation Point to NASWI	3	NUW233035	10,000–12,000	260
	Reporting Point Returning to NASWI	4	MCCUL	10,000–12,000	260

Notes: MOA = Military Operations Area, MSL = Mean Sea Level, NASWI = Naval Air Station Whidbey Island

J.6.2.2 Maximum Noise Level

The analysis considered maximum noise levels for aircraft transiting to and from the Olympic MOA and W-237A. Like all aircraft, the EA-18G produces varied sound output under different conditions, as indicated in Table J-17. The distance listed in this table is the total distance to the aircraft, and the engine power represents the maximum and minimum power conditions as identified in Table J-3 and Table J-7. This table is useful as a general guide to the maximum noise levels from this aircraft and can be used to estimate maximum noise levels for different activities.

Table J-17: Maximum Noise Level from the EA-18G for Different Distances and Engine Power

Distance to aircraft (ft.)	*Engine Pwr 75% NC*	*Engine Pwr 89% NC*
	Airspeed: 250 knots	*Airspeed: 342 knots*
	L_{max} (dBA)	*L_{max} (dBA)*
2,000	81.0	97.2
3,000	76.0	92.1
4,000	71.8	87.9
5,000	68.6	84.5
6,000	66.1	81.8
7,000	63.7	79.4
8,000	61.2	76.7
9,000	59.6	75.1
10,000	57.3	72.7
11,000	56.0	71.4
12,000	54.4	69.7
13,000	52.8	68.0
14,000	51.7	66.9
15,000	50.3	65.5

Notes: NC = Compressor Stage Rotations Per Minute (a measure of jet engine power setting), dBA = A-Weighted Sound Pressure Level, L_{max} = Maximum Received Noise Level

The two power settings/speeds were selected based on likely transit scenarios. During transit to the MOA from MCCUL, aircraft would be maintaining altitude (15,000 ft.) at no more than 89 percent power. Therefore, determining maximum received noise levels from these aircraft should consider the 342 knots column of Table J-17.

During transit from the MOA to YETII, aircraft would likely be descending to reach YETII at 10,000 ft., at which point they would slow to 250 knots. Aircraft descend by reducing power; therefore, the lower power setting (250 knots, as indicated in Table J-17) should be used to calculate likely received noise levels from these aircraft, but the 342 knots column is also provided for maximum received noise levels.

Based on the data provided in Table J-17, the Navy estimated maximum noise levels likely to be received at several locations along Growler transit routes, provided in Table J-18. In the table, all values are approximate. "NA" indicates the aircraft would not likely be audible at that location, due to a distance from aircraft greater than 15.6 NM (Table J-15). For values presented as "< 35 dBA," the location could be within the theoretical audibility range of the Growler, but was below the minimum value that MRNMap can calculate (35 dBA).

Table J-18: Maximum Noise Levels at Selected Locations for EA-18G Growler Transit to/from Olympic MOA and W-237A

Location	***Elevation (ft. MSL)***	***Transit to Olympic MOA (MCCUL to NUW 233065)***		***Transit from Olympic MOA (to YETII)***	
		250 knots	***342 knots***	***250 knots***	***342 knots***
Mount Olympus	9,570	NA	NA	75 dBA	91 dBA
Hurricane Ridge	5,242	< 35 dBA	< 35 dBA	68 dBA	84 dBA
Glacier Meadows	4,180	NA	NA	60 dBA	75 dBA
Sol Duc Falls	2,047	< 35 dBA	< 35 dBA	56 dBA	71 dBA
Hoh Rain Forest Visitor Center	583	< 35 dBA	< 35 dBA	52 dBA	67 dBA
Lake Crescent	580	51 dBA	66 dBA	< 35 dBA	< 35 dBA
Port Angeles	350	50 dBA	65 dBA	< 35 dBA	< 35 dBA

Note: NA = Not audible

This table indicates that if a person were standing on the peak of Mount Olympus, Growler aircraft transiting to the Olympic MOA would not be audible (NA), because aircraft on the route from MCCUL to the MOA would be beyond the audible range of Mount Olympus (Table J-15). Aircraft departing the MOA to YETII would be descending with a reduced power setting and likely be at least 3,500 ft. above the elevation of Mount Olympus. Assuming the aircraft was routed directly over Mount Olympus, the resulting maximum noise level would be approximately 75 dBA. If the aircraft were at a lower altitude or a higher power setting, the maximum noise level would be greater, up to 91 dBA. The maximum noise level would be lower if the aircraft were higher or not directly over the mountain peak.

Looking at another location, a person at Lake Crescent, which is beneath the transit route, could experience a maximum noise level of approximately 66 dBA from a Growler transiting from MCCUL to the Olympic MOA. When Growler aircraft depart the MOA to YETII, the maximum noise level would be less than 35 dBA for aircraft departing from the northern half of the MOA. Aircraft departing from the central or southern part of the Olympic MOA would not be audible at Lake Crescent.

As described above, for all locations the most likely maximum levels for aircraft transiting to the Olympic MOA would be found under the “342 knots” column, and under the “250 knots” column for aircraft departing the MOA.

J.7 ACOUSTIC MONITORING REPORT

As discussed previously in this appendix, modeling is the appropriate methodology for predicting potential impacts from aircraft operating in SUA. However, the Navy included results from an acoustic monitoring study conducted by the NPS within the Olympic National Park in 2010 (National Park Service, 2016), as it is the most relevant study of its type in this area.

The data for this study were collected in 2010 but are considered relevant to current conditions related to Navy aircraft training, as the level of Navy activity in 2010 is generally consistent with the baseline data presented in Section J.5 (Airspace Training and Testing Activities) of this Airspace Noise Analysis, and the transit routes and operating airspace remain unchanged from 2010.

Of five ground locations where noise sampling took place, three (Hoh River Trail, Third Beach Trail, and Lake Ozette) lie beneath the Olympic MOA. Two locations (Hurricane Ridge and Lake Crescent-Pyramid

Mountain Trail) occur outside the Olympic MOA, but lie near or beneath the route typically taken by Navy aircraft transiting to the Olympic MOA. The purpose of this monitoring effort was to characterize existing sound levels and estimate natural ambient acoustic baselines for these areas, as well as identify audible sound sources.

The natural daytime ambient acoustic baseline for this study was found to be 34.1 dBA for Hoh River Trail, 35.6 dBA for Third Beach Trail, 31.4 dBA for Lake Ozette, 23.1 for Hurricane Ridge, and 32.3 for Lake Crescent-Pyramid Mountain Trail. Each of these is the median, or L_{50} value, meaning that half the time, the soundscape was quieter than the cited value.

Data from the study are summarized below in Tables J-19 and J-20. Table J-19 reports the percent of time that sound levels were above four metrics (35, 45, 52, and 60 dBA) at each of the measurement locations for the winter season. The metric of 52 dBA is the Environmental Protection Agency's speech interference threshold for speaking in a raised voice to an audience at 10 meters; and 60 dBA provides a basis for estimating impacts on normal voice communications at 3 ft. Hikers and visitors viewing scenic vistas in the park would likely be conducting these types of conversations.

Table J-19: Percent Time Above Metrics for Winter Season Beneath the Olympic MOA

Site Name	% Time above sound level: Daytime (7 am to 7 pm)				% Time above sound level: Nighttime (7 pm to 7 am)			
	35 dBA	45 dBA	52 dBA	60 dBA	35 dBA	45 dBA	52 dBA	60 dBA
Hoh River Trail	41.39	2.29	0.21	0.01	29.88	3.86	0.21	0.00
Third Beach Trail	57.43	19.29	5.79	0.18	58.91	19.46	4.83	0.33
Lake Ozette	40.14	16.67	7.85	1.19	44.36	16.15	5.18	1.40
Hurricane Ridge	15.46	2.70	0.76	0.04	14.05	3.31	1.02	0.04
Lake Crescent-Pyramid Mountain Trail	50.46	17.56	4.41	0.12	29.25	12.40	5.50	0.34

Notes: MOA = Military Operations Area, dBA = A-Weighted Sound Pressure Level

Table J-20: Summary of Acoustic Observer Log Data for All Sites for the Winter Season

Site Name	% Time Audible: Daytime (7 am to 7 pm)			
	Fixed-Wing Aircraft and Helicopter Sounds	Other Aircraft Sounds	Other Human Sounds	Natural Sounds
Hoh River Trail	0.5	11.2	4.9	83.4
Third Beach Trail	1.3	3.7	4.2	90.8
Lake Ozette	0.8	6.3	0.4	92.5
Hurricane Ridge	0.4	8.3	0.4	90.9
Lake Crescent-Pyramid Mountain Trail	0.3	7.2	57.8	34.7

As noted in the National Park Service study, none of these metrics should be construed as thresholds of impact. The results indicate that, at the Hoh River Trail site where aircraft sounds were audible 11.7 percent of the time, 52 dBA was exceeded less than 0.3 percent of the time. At the other sites, while the time above 52 dBA was greater, approximately 1–8 percent, fewer of those occurrences appear to be related to aircraft noise. Natural sounds were the predominant sources of sounds measured at all three sites, and were audible between 34 and 93 percent of the time.

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