Appendix L – Noise Analysis

As part of the Environmental Assessment, noise contours were developed which help visualize sound generated by aircraft operations. These contours are presented in this section and will be a factor in determining appropriate land use measures and the breadth of influence PUW has on nearby property. The noise contours will also help identify and quantify the potential environmental impacts associated with existing and future operations on the current runway layout and the realigned runway.

This section presents the noise contours in five scenarios and documents the data used to generate the contours. Also included is a discussion on the effects airport noise has on a population and how metrics are used to help quantify airport noise.

Section 1 – Airport Noise

1. Introduction

Of all the adverse effects related to airport activity, noise is arguably the most noticeable. To understand airport noise and its effects on people, it is important to understand the science of sound. Sound is a type of energy which travels in the form of a wave. Sound waves create minute pressure differences in the air which are recognized by the human ear or microphones. Sound waves can be measured using decibels (dB) to measure the amplitude or strength of the wave and Hertz (Hz) which measures the frequency or pitch of the wave.

The strength, or loudness, of a sound wave is measured using decibels on a logarithmic scale. The range of audibility of a human ear is 0 dB (threshold of hearing) to 120 dB (threshold of pain). The use of a logarithmic scale often confuses people because it does not directly correspond to the perception of relative loudness. A common misconception is that if two noise events occur at the same time, the result will be twice as loud. In reality, the event will double the sound energy, but only result in a 3 dB increase in magnitude. For a sound event to actually be twice as loud as another, it must be 10 dB higher.

Scientific studies have shown that people do not interpret sound the same way a microphone does. For example, humans are biased and sensitive to tones within a certain frequency range. The A-weighted decibel scale was developed to correlate sound tones with the sensitivity of the human ear. The A-weighted decibel is a "frequency dependent" rating scale which emphasizes the sound components within the frequency range where most speech occurs. This scale is illustrated in **Figure L-1**, Approximate Decibel Level of Common Sound Sources, which lists typical sound levels of common indoor and outdoor sound sources.

When sound becomes annoying to people, it is generally referred to as noise. A common definition of noise is unwanted sound. One person may find higher levels of noise bearable while others do not. Studies have also shown that a person will react differently to the same noise depending on that person's activity at the time the noise is recognized, e.g., when that person is sleeping.

2. Day-Night Noise Level (DNL)

While the A-weighted decibel scale measures human perception of loudness, it does not account for the degree of annoyance based on the duration of a noise event or the differences in sensitivity associated with a person's activity during a noise event.

Noise generated by the operation of aircraft to, from, and around an airport is generally measured in terms of cumulative noise levels of all aircraft operations. Cumulative noise level metrics provide a single measure of the average sound levels in decibels for any point near an airport when exposed over the course of a day. A variety of cumulative noise level metrics have been formulated to provide a single measure of continuous or multiple noise events over an extended period of time. The standard metric used to measure noise from aircraft is the Day-Night Noise Level, or DNL. The DNL metric recognizes that frequent medium intensity noise events are more bothersome than less frequent high intensity noises events.

The DNL penalizes any activity which takes place in the nighttime (10:00 PM – 7:00 AM) by increasing the decibel level by 10 dB. Since the decibel scale uses a base-10 logarithm, each nighttime operation is equivalent to 10 daytime operations. The rationale for this adjustment is based on the reduced ambient noise at these times, and thus the increase in sensitivity to the human ear. This increase in sensitivity creates a perceived notion that aircraft are louder and more disruptive at night. A summary of effects that noise has on people was developed by the Federal Interagency Committee on Noise in 1992. This is presented in **Figure L-2**, Summary of Noise Effects, which gives a better understanding of what type of noise exposure is expected at each decibel level.

Figure L-1: Approximate Decibel Level of Common Sound Sources

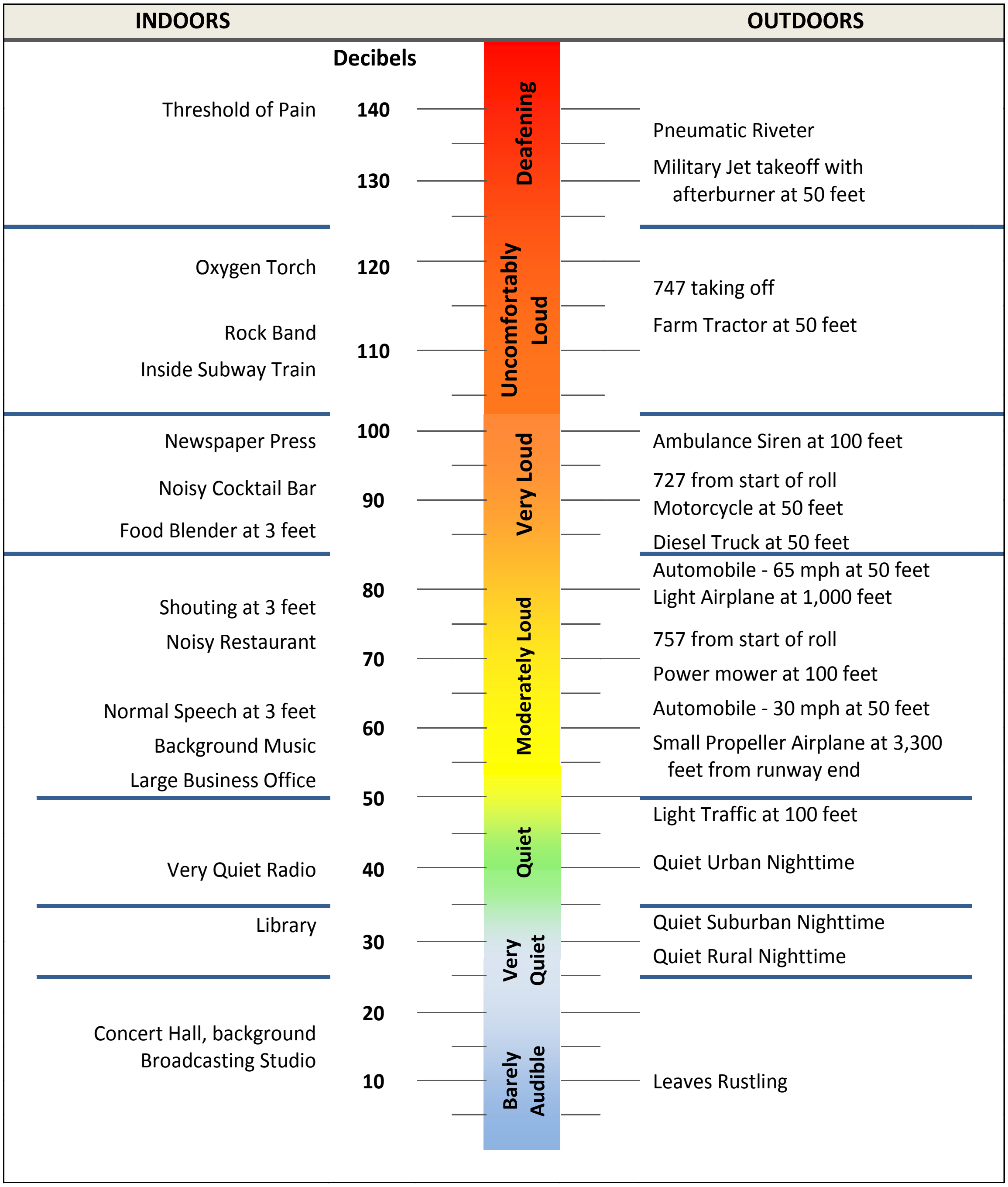

Figure L-2: Summary of Noise Effects

	Effects[1]			
Day-Night Average Sound Level (Decibels)	**Hearing Loss Qualitative Description)**	**Annoyance[2] Percentage of Population Highly Annoyed)[3]**	**Average Community Reaction[4]**	**General Community Attitude Toward Area**
≥75	May begin to occur	37%	Very severe	Noise is likely to be the most important of all adverse aspects of the community environment.
70	Will not likely occur	22%	Severe	Noise is one of the most important adverse aspects of the community environment.
65	Will not occur	12%	Significant	Noise is one of the important adverse aspects of the community environment.
60	Will not occur	7%	Moderate to Slight	Noise may be considered an adverse aspect of the community environment.
≥55	Will not occur	3%		Noise considered no more important than various other environmental factors.

[1] All data is drawn from National Academy of Science 1977 report Guidelines for Preparing Environmental Impact Statements on Noise, Report of Working Group 69 on Evaluation of Environmental Impact of Noise.

[2] A summary measure of the general adverse reaction of people to living in noisy environments that cause speech interference; sleep disturbance; desire for tranquil environment; and the inability to use the telephone, radio or television satisfactorily.

[3] The percentage of people reporting annoyance to lesser extents are higher in each case. An unknown small percentage of people will report being "highly annoyed" even in the quietest surroundings. One reason is the difficulty all people have in integrating annoyance over a very long time. USAF Update with 400 points (Finegold et al. 1992)

[4] Attitudes or other non-acoustic factors can modify this. Noise at low levels can still be an important problem, particularly when it intrudes into a quiet environment.

NOTE:
Research implicates noise as a factor producing stress-related health effects such as heart disease, high blood pressure and stroke, ulcers and other digestive disorders. The relationships between noise and these effects, however, have not as yet been conclusively demonstrated. (Thompson 1981; Thompson et al. 1989; CHABA 1981; CHABA 1982; Hattis et al. 1980; and U.S. EPA 1981)

Source: Federal Interagency Committee on Noise (1992)

Section 2 – PUW Noise Analysis

1. Noise Contour Development

Noise contours for Pullman – Moscow Regional Airport were generated for five operating scenarios. Aviation activity for each scenario matches the Aviation Activity Forecast submitted and approved by the FAA and included in this EA. The five scenarios are:

- Baseline (2013) – this includes existing operations (29,547 annual) on the existing runway configuration. Baseline (2013) contours are illustrated in **Figure L-3**.
- Opening Day (2018) – this scenario utilizes operations projected (32,680 annual) on opening day of the realigned runway. Opening Day (2018) contours are shown in **Figure L-4**.
- Opening Day +5 Years (2023) – this scenario illustrates noise on the realigned runway configuration, with 2023 projected operations (35,980 operations). **Figure L-5** details Opening Day +5 Years (2023) contours.
- No Action (2018) – these contours illustrate 2018 operations (32,630) on the existing runway. This scenario projects 50 less commercial operations then if the runway is realigned. **Figure L-6** shows the No Action (2018) contours.
- No Action +5 Years (2023) –this scenario shows 2023 operations (34,880) on the existing runway. This scenario accepts there will be 550 less commercial operations then if the runway is realigned. **Figure L-7** illustrates the No Action +5 Years (2023) contours.

The noise contours represent noise exposure over a 24-hour period based on average annual day conditions at PUW. The weighted DNL metric is used to statistically predict the amount of annoyance that cumulative noise exposure would have on a typical population.

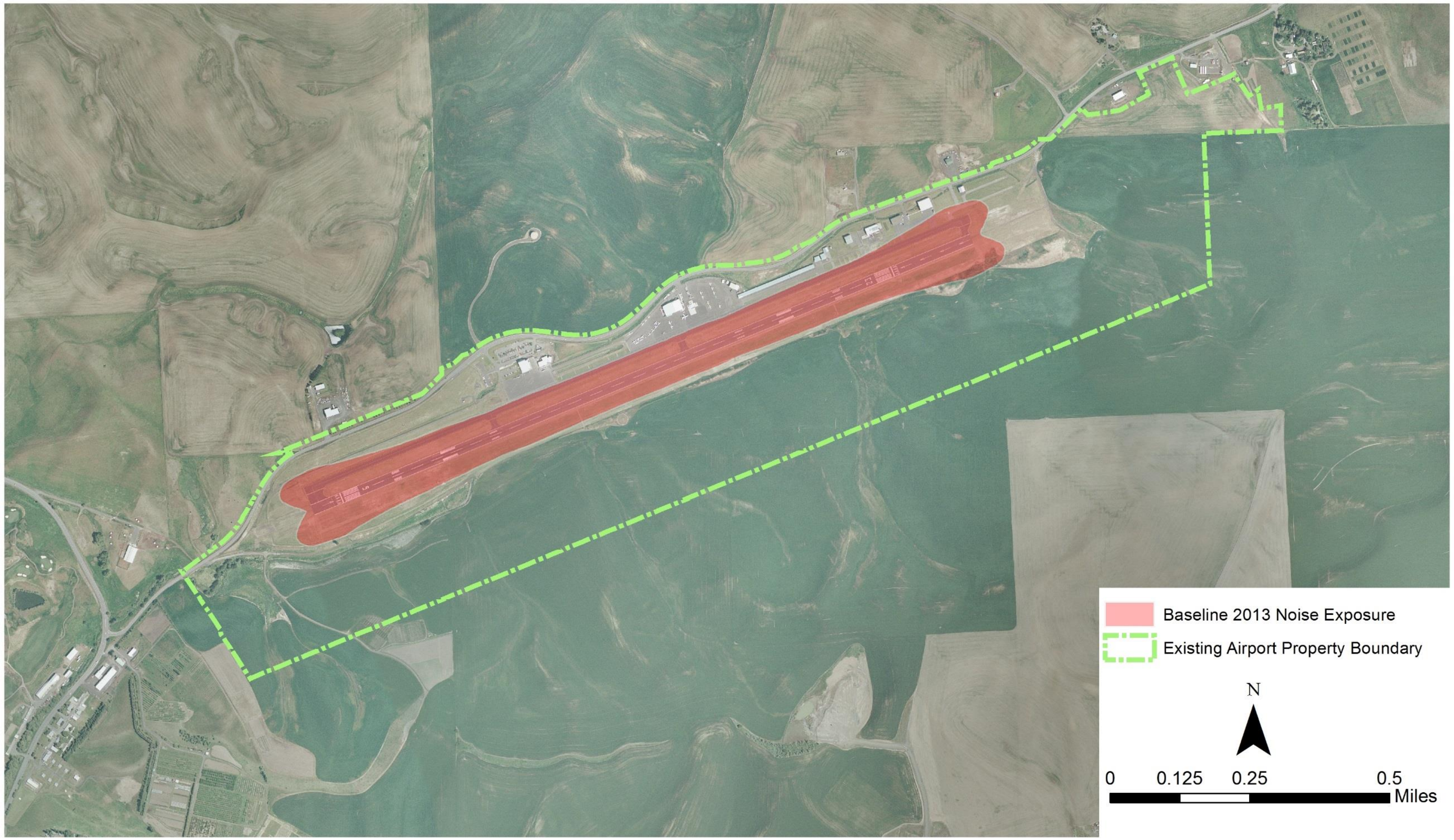

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Figure L-3:
Baseline 2013 Noise Exposure

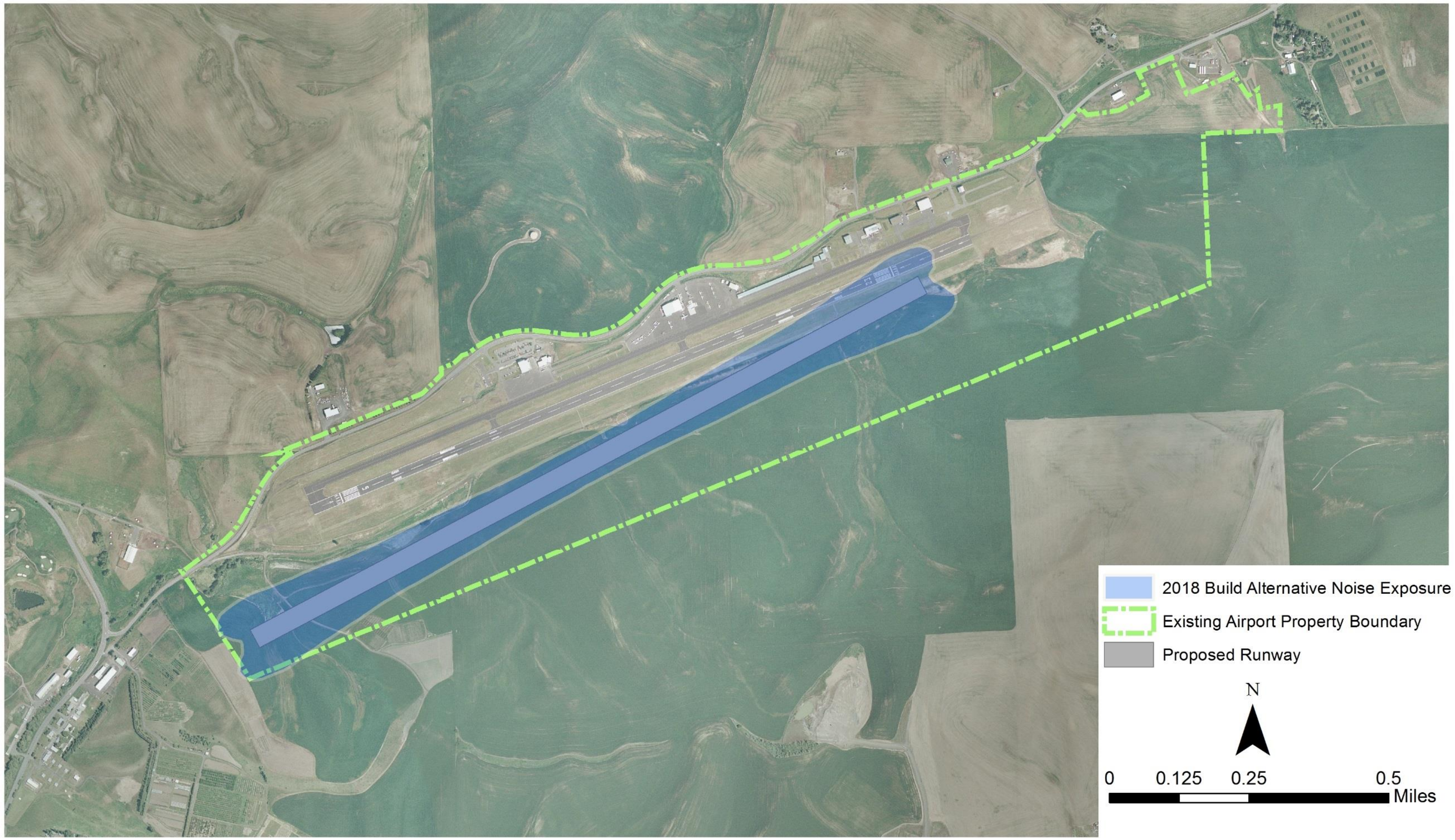

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Figure L-4:
2018 Build Alterantive Noise Exposure

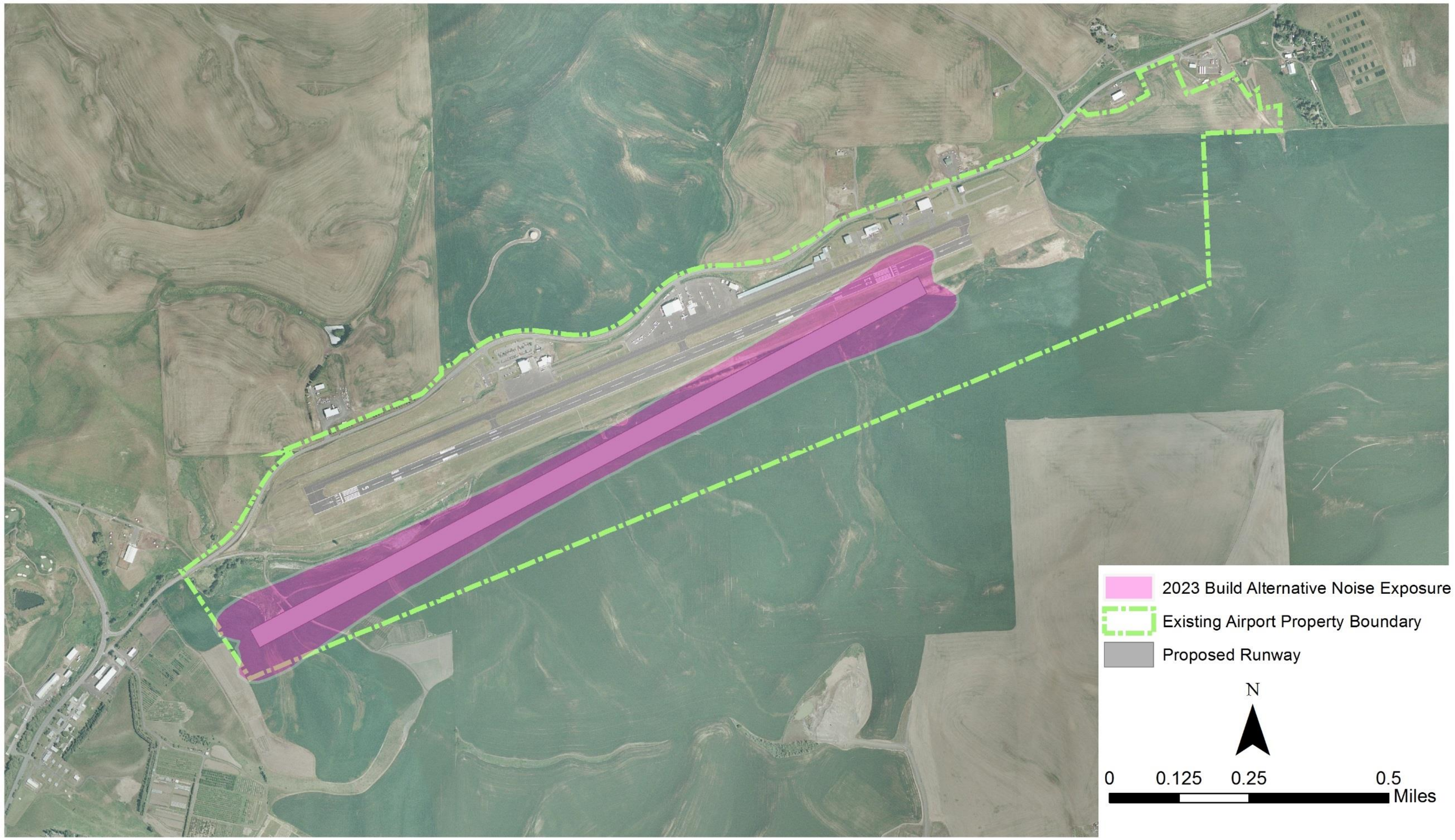

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Figure L-5:
2023 Build Alterantive Noise Exposure

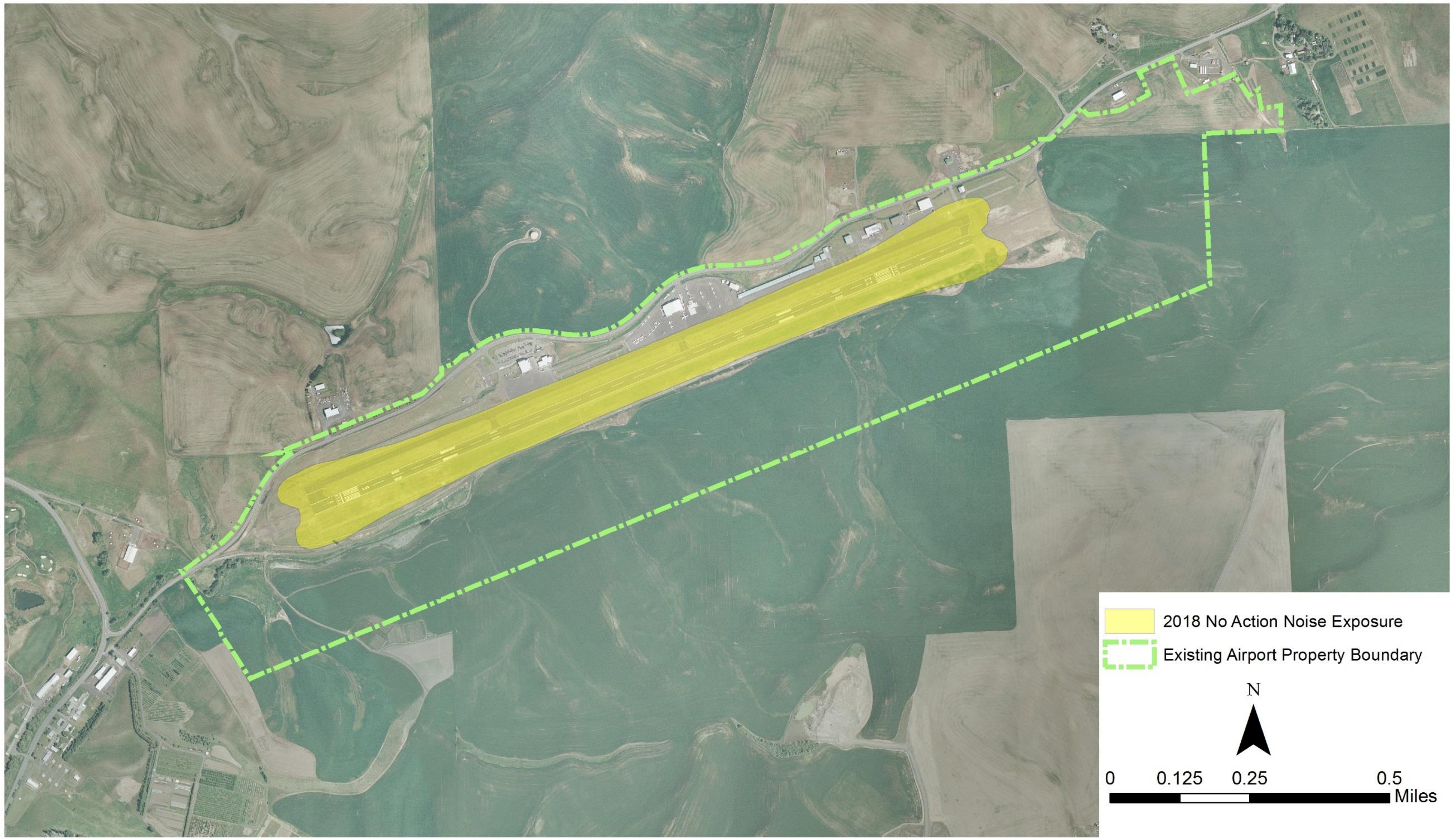

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Figure L-6:
2018 No Action Noise Exposure

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Figure L-7:
2023 No Action Noise Exposure

2. Noise Model Inputs

The Integrated Noise Model (INM) 7.0c was used to generate the DNL noise contours for each scenario. The INM is developed by the FAA and is the standard model for computer analysis of aircraft noise. Detailed operational data is required for input into the INM for the program to generate the contours. This data includes specific aircraft fleet mix and number of operations for each, time of day that aircraft operate, runway use percentages, and the dispersal of flight tracks - the paths aircraft use when approaching or departing a particular runway.

To accurately portray average noise exposure at PUW, aircraft operational data was obtained from multiple sources. These include, but are not limited to: airport management and air traffic control tower staff, the FAA's Enhanced Traffic Management System Counts (ETMSC), apgDat airport data, and previous studies.

3. Aircraft Operations and Fleet Mix

Existing and future operation totals for each contour scenario are based on the totals presented in the aviation demand forecast presented in the Terminal Area Plan. Figures for air carrier, air taxi, cargo, general aviation, and military aircraft match what is presented in this section.

The aircraft fleet mix at PUW was derived from the aviation demand forecast presented in the Terminal Area Plan and looking at previous studies. It is assumed that the aviation fleet mix will remain relatively constant throughout the planning period. The exception is commercial operations. It is projected that commercial operations will increase more in the build scenarios where the runway is realigned. The No Action scenarios see less of an increase in commercial operations in the future.

Table L-1 details operations for Baseline (2013) contours. Operations in 2013 total 29,547, as detailed in the aviation demand forecast presented in the Terminal Area Plan.

Table L-2 shows operations for Opening Day (2018) contours. Operations for the No Action (2018) contours are the same, except for 50 less commercial operations (38 ops by 737800 and 13 ops by A319). Total operations for No Action (2018) contours equal 32,630.

Table L-3 shows feet mix operations for Opening Day +5 Years (2023). Total operations for the No Action +5 Years (2023) scenario are identical, except for 550 less commercial operations (38 ops by 737800, 13 ops by A319, and 2,000 ops by DO328). Total operations for No Action (2023) contours equal 35,430.

4. Aircraft Substitutions

A limitation of the INM is that it contains only a selected sample of aircraft. Since aircraft of similar make produce similar noise levels, the INM provides a substitution list for aircraft not included in the INM. The specific types of aircraft used in each Scenario are detailed under the INM Aircraft Type heading in **Tables L-1** through **L-3**.

An important part of this study was to carefully select the types of aircraft INM offers for modeling purposes for this study. Aircraft types modeled in this study represent the best available information from previous plans and available tower information. The aircraft listed in **Tables L-1** through **L-3** do not include every type of aircraft model that operates at PUW. The INM program only contains a limited number of aircraft in its database. Aircraft not included in the INM are provided with substitute aircraft. This substitute aircraft has a similar noise footprint to the original aircraft and the FAA accepts these substitutions for aircraft not in the database.

A common aircraft that uses PUW for commercial operations is the Q400. This aircraft is not included in the INM and no substitute aircraft is listed. Previous approved federal studies and conversations with FAA staff have indicated the DO328 is an acceptable substitution aircraft for the Q400, and is used in this study.

It is difficult to assume what aircraft types will be operating in the long term. The INM only contains current aircraft and estimating what will be in service in +30 years is only a guess. Rational assumptions were made for the future scenarios fleet mix, per the operation forecasts in this EA.

5. Aircraft Groups

To help simplify data input into the INM, aircraft were placed into 4 groups: Commercial (COM), Business Jet/Turboprop (CORP), General Aviation - Propeller (GA) and Military (MIL). Aircraft in the same group are distributed the same over each flight track (see Flight Tracks information and tables below). The groups should not be confused with air carrier and air taxi. The aircraft used for air carrier and air taxi are primarily in the commercial group. Some exceptions include the CNA 750 and the GV, which provide some air taxi activity butare in the CORP group.

6. Day/Night Split

As discussed above, the DNL metric 'penalizes' aircraft activity that occurs after 10:00 PM and before 7:00 AM by assessing a 10 dB increase for each operation. Therefore it is important to obtain accurate night data and separate these operations from those that occur during the day. Time of day percentage splits for each aircraft type are shown in the tables below. Time of day splits are projected to remain constant in all future scenarios.

7. Runway Splits

Aircraft operations on each runway are also detailed in the tables below. Each aircraft group operates differently at PUW. For instance the COM group favors Runway 6 on 80% of operations and Runway 24 on 20%. The GA group splits operations at 50% on each runway. Runway splits are projected to remain the same in all future scenarios.

TABLE L-1: Baseline (2013) Contour Input Data								
INM Aircraft Type	Itinerant Operations		Local Operations		Time of Day (% of all operations)		Runway Splits (% of all operations)	
	Annual Operations	Daily Operations	Annual Operations	Daily Operations	Day (7am-10pm)	Night (7am-10pm)	Runway 6	Runway 24
Aircraft Group: COM								
737800	38	0.103	0	N/A	50%	50%	80%	20%
A319-131	13	0.034	0	N/A	50%	50%		
DO328	1,854	5.079	0	N/A	95%	5%		
Aircraft Group: CORP								
CNA525	159	0.436	0	N/A	80%	20%	40%	60%
CNA500	1,206	3.305	0	N/A				
CNA560U	159	0.436	0	N/A				
CNA560XL	205	0.561	0	N/A				
CIT3	91	0.249	0	N/A				
CNA680	364	0.998	0	N/A				
CNA750	1,457	3.991	0	N/A				
GIV	91	0.249	0	N/A				
GV	46	0.125	0	N/A				
Aircraft Group: GA								
BEC58P	618	1.694	630	1.727	95%	5%	50%	50%
DHC6	61	0.167	62	0.170				
GASEPF	1,398	3.831	1,426	3.908				
GASEPV	1,348	3.692	1,375	3.766				
CNA441	213	0.583	217	0.595				
CNA172	3,759	10.300	3,835	10.506				
CNA206	4,003	10.966	4,083	11.185				
CNA20T	304	0.833	382	1.048				
CNA208	71	0.194	0	N/A				
Aircraft Group: MIL								
C130	80	0.22	0	N/A	100%	0%	50%	50%
Annual Totals	13,537		12,100		29,547 Annual Total			

<table>
<tr><th colspan="9">TABLE L-2: Opening Day (2018) Contour Input Data</th></tr>
<tr><th rowspan="2">INM Aircraft Type</th><th colspan="2">Itinerant Operations</th><th colspan="2">Local Operations</th><th colspan="2">Time of Day (% of all operations)</th><th colspan="2">Runway Splits (% of all operations)</th></tr>
<tr><th>Annual Operations</th><th>Daily Operations</th><th>Annual Operations</th><th>Daily Operations</th><th>Day (7am-10pm)</th><th>Night (7am-10pm)</th><th>Runway 6</th><th>Runway 24</th></tr>
<tr><td colspan="9">Aircraft Group: COM</td></tr>
<tr><td>737800</td><td>75</td><td>0.205</td><td>0</td><td>N/A</td><td>50%</td><td>50%</td><td rowspan="3">80%</td><td rowspan="3">20%</td></tr>
<tr><td>A319-131</td><td>25</td><td>0.068</td><td>0</td><td>N/A</td><td>50%</td><td>50%</td></tr>
<tr><td>DO328</td><td>1,900</td><td>5.205</td><td>0</td><td>N/A</td><td>95%</td><td>5%</td></tr>
<tr><td colspan="9">Aircraft Group: CORP</td></tr>
<tr><td>CNA525</td><td>179</td><td>0.490</td><td>0</td><td>N/A</td><td rowspan="9">80%</td><td rowspan="9">20%</td><td rowspan="9">40%</td><td rowspan="9">60%</td></tr>
<tr><td>CNA500</td><td>1,353</td><td>3.707</td><td>0</td><td>N/A</td></tr>
<tr><td>CNA560U</td><td>179</td><td>0.490</td><td>0</td><td>N/A</td></tr>
<tr><td>CNA560XL</td><td>230</td><td>0.629</td><td>0</td><td>N/A</td></tr>
<tr><td>CIT3</td><td>102</td><td>0.280</td><td>0</td><td>N/A</td></tr>
<tr><td>CNA680</td><td>408</td><td>1.119</td><td>0</td><td>N/A</td></tr>
<tr><td>CNA750</td><td>1,634</td><td>4.476</td><td>0</td><td>N/A</td></tr>
<tr><td>GIV</td><td>102</td><td>0.280</td><td>0</td><td>N/A</td></tr>
<tr><td>GV</td><td>51</td><td>0.140</td><td>0</td><td>N/A</td></tr>
<tr><td colspan="9">Aircraft Group: GA</td></tr>
<tr><td>BEC58P</td><td>749</td><td>2.051</td><td>630</td><td>1.727</td><td rowspan="9">95%</td><td rowspan="9">5%</td><td rowspan="9">50%</td><td rowspan="9">50%</td></tr>
<tr><td>DHC6</td><td>74</td><td>0.202</td><td>62</td><td>0.170</td></tr>
<tr><td>GASEPF</td><td>1,694</td><td>4.641</td><td>1,426</td><td>3.908</td></tr>
<tr><td>GASEPV</td><td>1,632</td><td>4.472</td><td>1,375</td><td>3.766</td></tr>
<tr><td>CNA441</td><td>258</td><td>0.706</td><td>217</td><td>0.595</td></tr>
<tr><td>CNA172</td><td>4,554</td><td>12.476</td><td>3,835</td><td>10.506</td></tr>
<tr><td>CNA206</td><td>4,848</td><td>13.283</td><td>4,083</td><td>11.185</td></tr>
<tr><td>CNA20T</td><td>368</td><td>1.009</td><td>382</td><td>1.048</td></tr>
<tr><td>CNA208</td><td>86</td><td>0.235</td><td>0</td><td>N/A</td></tr>
<tr><td colspan="9">Aircraft Group: MIL</td></tr>
<tr><td>C130</td><td>80</td><td>0.22</td><td>0</td><td>N/A</td><td>100%</td><td>0%</td><td>50%</td><td>50%</td></tr>
<tr><td>Annual Totals</td><td colspan="2">16,380</td><td colspan="2">12,100</td><td colspan="4">32,680 Annual Total</td></tr>
<tr><td colspan="9">Note: Data for No Action (2018) contours identical expect 50 less commercial operations (38 ops by 737800 and 13 ops by A319). Total operations for No Action (2018) contours equal 32,630.</td></tr>
</table>

TABLE L-3: Opening Day +5 Years (2023) Contour Input Data								
INM Aircraft Type	Itinerant Operations		Local Operations		Time of Day (% of all operations)		Runway Splits (% of all operations)	
	Annual Operations	Daily Operations	Annual Operations	Daily Operations	Day (7am-10pm)	Night (7am-10pm)	Runway 6	Runway 24
Aircraft Group: COM								
737800	75	0.21	0	N/A	50%	50%	80%	20%
A319-131	25	0.07	0	N/A	50%	50%		
DO328	2,500	6.85	0	N/A	95%	5%		
Aircraft Group: CORP								
CNA525	174	0.48	0	N/A	80%	20%	40%	60%
CNA500	1,321	3.62	0	N/A				
CNA560U	174	0.48	0	N/A				
CNA560XL	224	0.61	0	N/A				
CIT3	100	0.27	0	N/A				
CNA680	399	1.09	0	N/A				
CNA750	1,595	4.37	0	N/A				
GIV	100	0.27	0	N/A				
GV	50	0.14	0	N/A				
Aircraft Group: GA								
BEC58P	896	2.45	635	1.740	95%	5%	50%	50%
DHC6	88	0.24	62	0.171				
GASEPF	2,026	5.55	1,437	3.937				
GASEPV	1,953	5.35	1,385	3.794				
CNA441	308	0.84	219	0.599				
CNA172	5,448	14.93	3,863	10.584				
CNA206	5,800	15.89	4,113	11.269				
CNA20T	441	1.21	385	1.056				
CNA208	103	0.28	0	N/A				
Aircraft Group: MIL								
C130	80	0.22	0	N/A	100%	0%	50%	50%
Annual Totals	19,580		12,100		35,980 Annual Total			
Note: Data for No Action (2023) contours identical expect 550 less commercial operations (38 ops by 737800, 13 ops by A319, and 2,000 ops by DO328). Total operations for No Action (2023) contours equal 35,430.								

8. Flight Tracks

Aircraft arriving and departing PUW normally follow similar flight paths, or tracks. The tracks are not finite but over the course of time an average position of the tracks can be observed. Different aircraft will use different tracks based on various factors. The size of the aircraft may determine how soon after departure (or prior to arrival) that aircraft turn from the heading of the runway. Larger aircraft require more time to climb (and descend) and will usually turn at points further from the runway. The origin or destination of the aircraft also helps determine which way aircraft travel to and from the runway. During IFR conditions, aircraft may be directed by air traffic control on different routes that same aircraft would take during VFR conditions.

Flight track data used in previous studies was retained for this EA and all 5 scenarios. The flight tracks for the existing runway configuration are illustrated in **Figure L-8.** Flight tracks modeled on the future runway alignment are shown in **Figure L-9**. The flight track use data is shown below in **Table L-4**.

Table L-4 Flight Track Distribution					
		Aircraft Group			
Runway	Track Name	COM	CORP	GA	MIL
Arrival Tacks					
Runway 5/6	Arrival - Straight	80%	40%	50%	50%
Runway 23/24	Arrival - Straight	20%	60%	50%	50%
Departure Tracks					
Runway 5/6	Departure - Straight	--	6%	25%	50%
	Departure - Left Turn	80%	34%	25%	--
Runway 23/24	Departure - Straight	--	9%	25%	50%
	Departure - VOR	20%	51%	25%	--

PUW has four published instrument approach procedures (IAPs) for the existing runway alignment:

- RNAV (RNP) Z Runway 06
- RNAV (GPS) Runway 24
- RNAV (GPS) Y Runway 06
- VOR Runway 06

Because of the type of aircraft and number of operations at PUW modeling each IAP has no impact on the noise exposure model for existing or future conditions. Below is a summary of the approach to modeling IAPs for the EA.

Review of the RNAV and VOR IAPs determined that the nearest turn to the runway surface is 2.4 nautical miles from the airport. Because of the distance between the runway end and the nearest turn these IAPs were considered as a straight arrival or departure for the purposes of noise modeling. The IAPs are treated as a straight-in approach in the INM.

The VOR departure procedures for both Runways 06 and 24 have some variability and for that reason were modeled independently and included in the noise analysis.

It is assumed that the IAPs to the future runway alignment will be amended. Specific procedure details of these future IAPs are unknown at this time. For the purposes of modeling noise on the future runway alignment, it is assumed that the existing IAPs will shift to the new runway alignment. The location of the modeled tracks of aircraft utilizing the IAPs, and the underlying land uses are assumed to be similar to the existing scenario, but follow the new runway alignment. The future RNAV IAPs are anticipated to maintain the 2.4 nautical mile straight in final approach.

The existing VOR IAP was replicated for the future runway alignment and because it will continue to vary from the RNAV IAPs it was modeled independently and included in the noise analysis.

The Proposed Action also includes an Instrument Landing System (ILS) approach to Runway 5 and would include a 2 mile final approach on runway centerline. The future ILS approach was included in the straight arrival track.

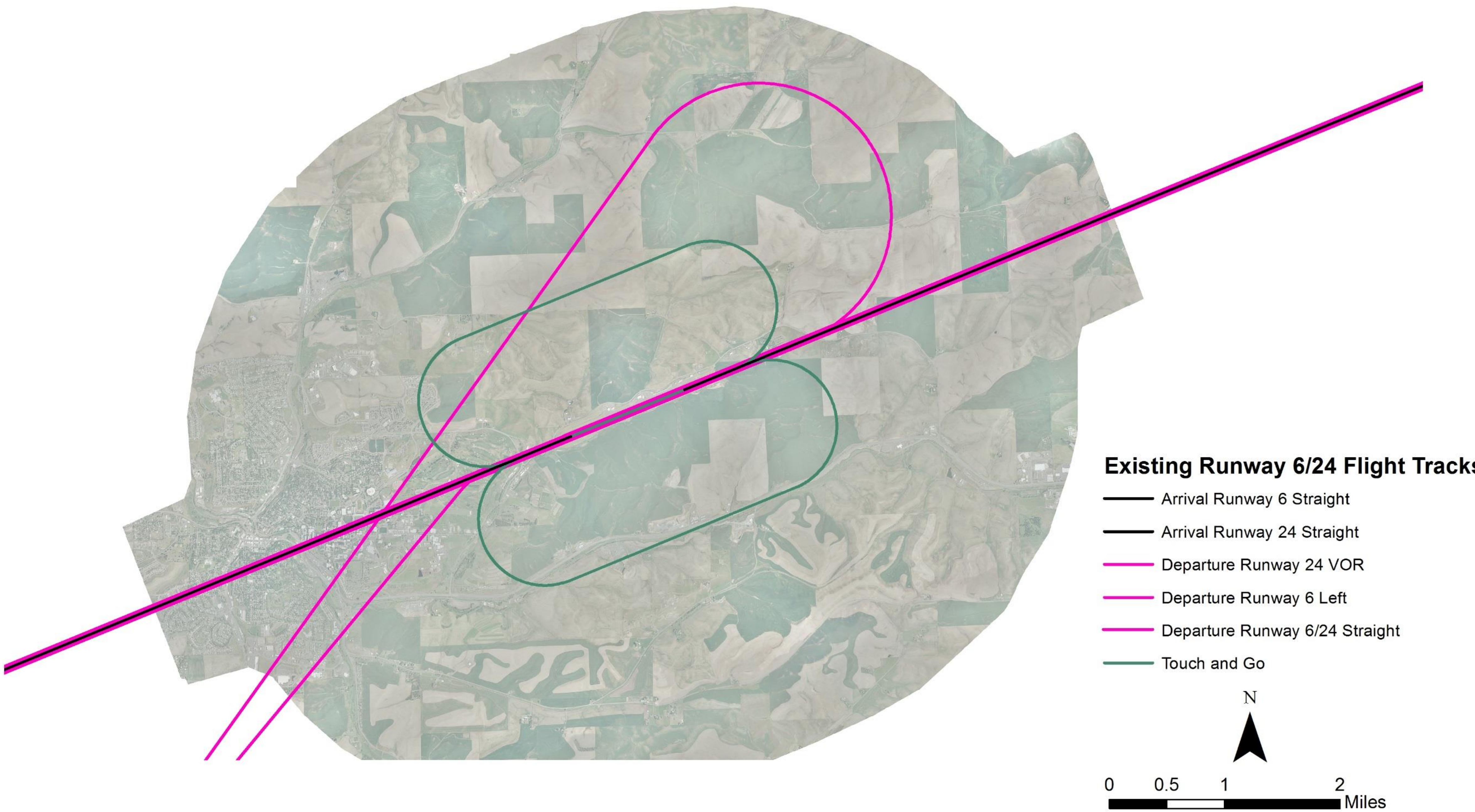

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Figure L-8:
Existing Runway 6/24 Flight Tracks

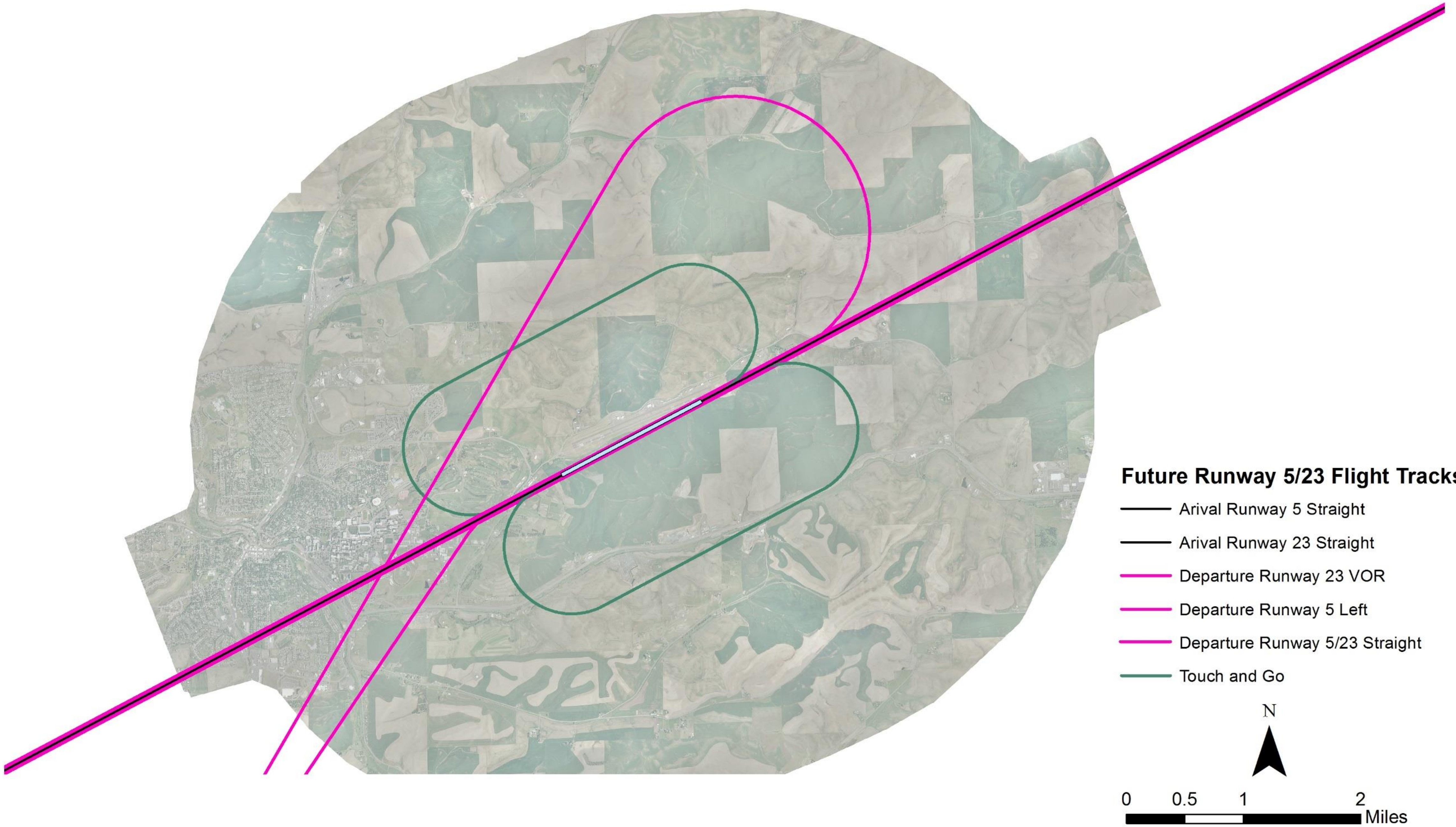

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Figure L-9:
Future Runway 5/23 Flight Tracks