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An Analysis of USAF Aircraft Noise and Hedonic Property Values

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AN ANALYSIS OF USAF AIRCRAFT NOISE
AND HEDONIC PROPERTY VALUES

THESIS

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AFIT/GEM/ENV/06M-07

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APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

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THESIS

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Abstract

The primary purpose of the research was to evaluate whether there was a significant difference in housing values of those affected by the noise of USAF aircraft. The secondary purpose was to evaluate whether there was a significant difference in housing values located near USAF bases with and without aircraft noise and to evaluate whether type of aircraft changed the results created by the aircraft noise. This research effort found that homes located within the 65 dB DNL contour of US Air Force installations showed a significant negative impact due to the presence of aircraft noise when studied with the hedonic pricing method of non-market valuation.

The results of this research show that current methods of noise mitigation may not be adequately alleviating the disturbance that USAF aircraft noise causes local residences. This research effort was the first to evaluate a large number of USAF installations with the hedonic method. Previous studies concentrated on two individual bases. Because this study focused on all of the installations in Air Combat Command, it is able to draw conclusions for a larger set of installations. Future research needs to be accomplished in additional major commands to determine whether this is an AF-wide issue or command-specific.

Acknowledgements

I would like to express my sincere appreciation to my faculty advisor, Maj Sonia Leach, for her guidance and support throughout the course of this thesis effort. The insight and experience was certainly appreciated. I would also like to thank Mr. Bob Lester from the Air Force Center for Environmental Excellence for providing AICUZ noise contour maps from each of the installations for this research. The extra time and effort spent to supply this valuable information was greatly appreciated.

Melissa R. Johnson

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AN ANALYSIS OF USAF AIRCRAFT NOISE AND HEDONIC PROPERTY VALUES

I. Introduction

Overview

The mission of the United States Air Force (USAF) is “To Defend the United States and Protect its Interests Through Air & Space Power” (US Air Force Posture Statement 2). To obtain air and space power, the USAF must have a large force of aircraft which naturally produce noise. Although this noise is created for honorable purposes, it can be a great disturbance to residents of communities local to Air Force installations. According to the U.S. Army Corps of Engineers “the urbanization of adjacent land uses and the constraints that exist inside the fence line have created an increasingly complex and dynamic problem for the military community.” (20) Although the choice existed for builders to not build next to existing airfields, it is still the duty of the USAF to mitigate noise disturbance when possible. When the disturbance is great enough, politics have become involved and missions have been deterred.

Living near an airfield offers both advantages and disadvantages. On the positive side, it offers the convenience of a short commute for military members and civilian workers employed at the installation. It also offers the ability for commercial gain by members of the community providing services to the installation. Other advantages include proximity to medical care for retired service members and a general positive nature that might occur if the community is amicable towards having the military located in their area.

The disadvantages of living near an airfield include the most obvious, aircraft noise. Whether the housing was built prior to or after the installation located near it, there will generally be an adverse reaction to the noise that is produced there. While the AF cannot stop its mission or completely satisfy every person in the area, the AF attempts to minimize the impact by mitigating noise through various methods.

The level of noise can never be completely abated but there are ways in which the USAF can mitigate the noise to levels that are satisfactory so that the mission can be continued. Noise may be mitigated through planting trees, constructing berms, smart land-use management, etc. Although these methods for mitigation have been in place for many years, formally since the 1976 Federal Aviation Administration (FAA) Noise Abatement Policy, a way to measure the success of the USAF Noise Management Program has not been formally adopted. One option for measuring success is with a hedonic pricing method of non-market valuation of housing values. This research seeks to determine the effect that USAF aircraft and noise management have had on communities local to Air Force installations through a study of housing values. The effects will be compared across installations with different types of missions and across time.

The method used by the USAF to assess the impacts of transportation noise, including aircraft noise, on humans is a modification of the 1978 Schultz curve (based on an exposure-response relationship). The curves are used for predicting the percentage highly annoyed versus a measure of the noise. These relationships are used in environmental analyses, such as Environmental Impact Statements, to assess health, welfare, and other potential impacts from noise exposure and for land-use management and planning recommendations (Finegold, Shogren, and White 29).

The USAF has studied many facets of noise exposure including annoyance from aircraft overflights and military training routes, as well as from impulsive noise such as sonic booms, blasts, artillery, and helicopters. They have conducted epidemiologic study of the effects of aircraft noise on human and animal health and animal grazing patterns. Lastly, they have developed an assessment system for predicting possible sonic boom impacts on structure so that supersonic operations may be planned to minimize potential damage and are improving their air base noise model, NOISEMAP. No studies have been completed to assess the effects of the noise exposure on the financial impacts of a less desirable atmosphere caused by living near a base.

Civilian airports must deal with the same issues and do so by completing studies on the disamenity of the housing located within certain distances from the airport or within certain noise contours. They use these values to determine the qualitative feasibility of constructing an additional runway and the amount of money they will be willing to spend to mitigate the noise in that area. In some instances, airports have even offered compensation payments to nearby residents to offset the adverse effects of the aircraft noise that they are subjected to (Thomas and Lever 102).

The USAF spends money to mitigate the aircraft noise it creates but has not attempted to determine how much it spends on it or what it should be spending. The US

Army has compiled data on the amount it spends due to noise mitigation annually. Table 1 shows a summary of this information. Although the document cited provided a comprehensive look at the amount the US Army spends on mitigation, it did not attempt to determine whether the amount spent is worthwhile.

Table 1 Compilation of US Army Noise Compliance Costs (FY 05)

Category	Cost ($K)
Damage Claims	3,924
Complaint Handling	5,670
Range Closures	8,550
Land Acquisition and	8,000
NEPA and INMP Assessments	20,578
Reduced Training Capability	555,800
Total Noise Compliance Cost	602,522

Source: US Army Center for Health Promotion and Preventive Medicine, Directorate Environmental Health Engineering, Army Operational Noise, 15 July 2005.

Research Focus

Because the USAF has not attempted to determine whether its mitigation efforts are successful, it also does not know if the amount spent on mitigation is appropriate. The purpose of this research is to demonstrate the hedonic pricing method of non-market valuation of housing values as a method to determine if noise mitigation efforts have been successful. This study will focus on assessing installations in the Air Combat Command (ACC) and additional installations that do not have flying as a primary mission. Furthermore, this study will investigate whether trends at high or low impact installations can be attributed to specific noise sources.

The research questions of interest in this study are as follows:

1. What is the effect of USAF aircraft noise on housing values in a local community?

2. What is the effect of the USAF on housing values in a local community?

3. How does this effect compare across different installations/types of missions?

II. Literature Review

Explanation of Noise

Noise is commonly defined as any sound that is undesired or interferes with one's hearing of other sound. Sound pressure is the amplitude or measure of the difference between atmospheric pressure (with no sound present) and the total pressure (with sound present) (EPA 3). The unit of sound pressure is the decibel (dB); therefore, a sound pressure level is given as a certain number of decibels. Because the range of sound intensities is so great, decibels are measured using a logarithmic scale which is conveniently compressed to encompass all the sounds that need to be measured. Sound pressure level values for some typical sounds are shown in Table 2.

Table 2 Sound Pressure Level Values for Typical Sounds

Overall Sound Pressure Level (dB)	Example
0	Threshold of hearing
10	
20	Studio for sound pictures
30	Soft whisper (5 ft)
40	Quiet office; Audiometric testing booth
50	Average residence; Large office
60	Conversational speech (3 ft)
70	Freight train (100 ft)
80	Very noisy restaurant
90	Subway; Printing press plant
100	Looms in textile mill; Electric furnace area
110	Woodworking; Casting shakeout area
120	Hydraulic press; 50-HP siren (100 ft)
140	Threshold of pain; Jet plane
180	Rocket-launching pad

Source: <u>Fundamentals of Industrial Hygiene</u> (Itasca, Illinois: National Safety Council, 1996) 203.

The human ear has an extremely wide range of response to sound amplitude. Sharply painful sound is 10 million times greater in sound pressure than the least audible sound. In decibels, this 10 million to 1 ratio is simplified logarithmically to 140 dB. One's ability to hear a sound depends greatly on the frequency composition of the sound. Frequency is the rate at which a sound source vibrates and is measured in Hertz (cycles per second) (EPA 3). People hear sounds most readily when the predominant sound energy occurs at frequencies between 1000 and 6000 Hertz. Sounds at frequencies above 10,000 Hertz (such as high-pitched hissing) are much more difficult to hear, as are sounds at frequencies below about 100 Hz (such as a low rumble). To measure sound on a scale that approximates the way it is heard by people, more weight must be given to the frequencies that people hear more easily. An A-weighted sound level is one of the scales used by the EPA as it is accurate for most purposes, convenient to use and used throughout the world (EPA 3). In the A-weighting scale, the sound pressure levels for the lower frequency bands and high frequency bands are reduced by certain amounts before they are being combined together to give one single sound pressure level value (Environmental Protection Department). Figure 1 and Figure 2 are provided to show a comparison of the different weighting scales and typical A-weighted sound levels of common sounds, respectively.

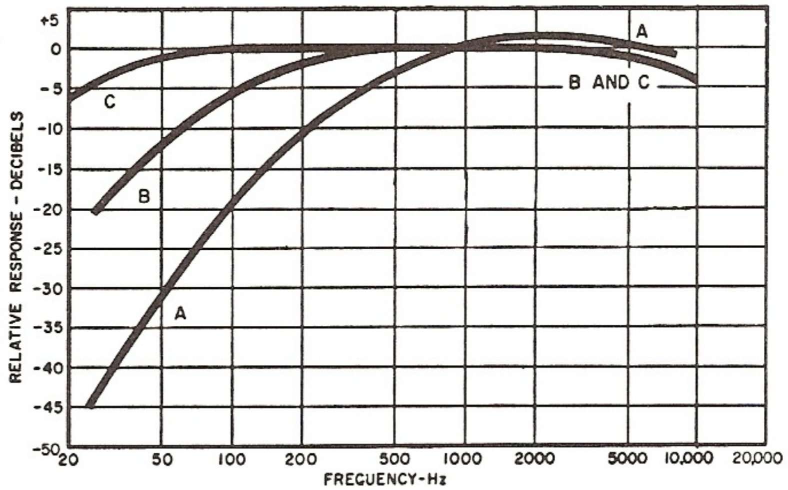


Figure 1 Frequency-response attenuation characteristics for the A-, B-, and C-weighting networks, Fundamentals of Industrial Hygiene (Itasca, Illinois: National Safety Council, 1996) 205.

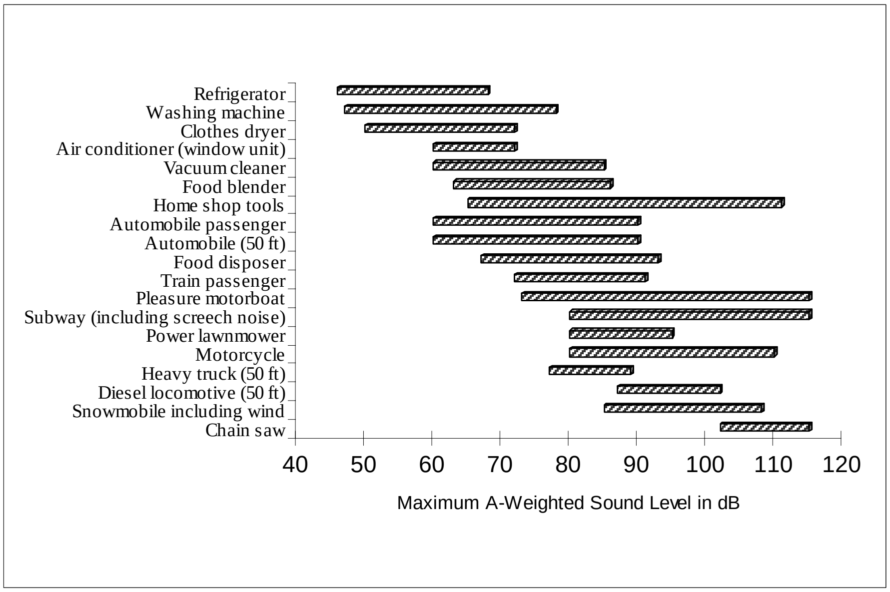


Figure 2 Typical A-weighted sound level ranges of common sounds, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. (Washington D.C.: EPA, 1974) 5.

The day-night sound level (DNL or L_{dn}) is the A-weighted equivalent sound level for a 24-hour period with an additional 10 dB weighting imposed on the equivalent sound levels occurring during nighttime hours (10 pm to 7 am) because it is assumed that increased noise is more disturbing during the night. Hence, an environment that has a measured daytime equivalent sound level of 60 dB and a measured nighttime equivalent sound level of 50 dB, can be said to have a weighted nighttime sound level of 60 dB (50 + 10) and an DNL of 60 dB. A-weighted sound exposure levels are typically used to describe noise from a moving source such as an airplane, train, or truck.

Outdoor DNL’s have a range of over 50 dB depending on the location (e.g. wilderness vs. urban). According to the EPA, over half of the people in the United States live in an urban area with DNL’s ranging 55-60 dB (EPA 9). Federal agencies generally conduct noise assessments at day-night average sound levels of greater than 65 dB. Annoyance and sleep disturbance are the most important health effects of environmental noise exposures if DNL is below 70 dB (Miedema and Vos 3432). No definitive evidence exists that there are non-auditory health effects from aircraft noise, especially at this level (FICON ES-2). Annoyance is measured as the general adverse reaction of people living in noisy environments that cause speech interference, sleep disturbance and an inability to communicate effectively because of noise (FICON ES-2). While there are health effects of noise exposure above 70 dB, generally, people do not live in the area of a flight line that contains that level of noise so it is not necessary for this research to concentrate on it.

Transportation Noise Research

To properly study the effect that aircraft noise has on its surroundings and its research areas from a historical perspective, it is necessary to begin with the study of noise and annoyance. Annoyance is defined as the general adverse reaction of people living in noisy environments that cause speech interference, sleep disturbance and an inability to communicate effectively because of noise.

Since the 1960s, noise has been identified as an environmental pollutant and the Environmental Protection Agency (EPA) has implemented numerous pieces of legislation in attempt to control the emission of noise that they deem unhealthy for humans. One such piece is the Noise Control Act of 1972 which empowered the EPA to: determine the limits of noise required to protect public health and welfare; set noise emission standards for major sources of noise in the environment, including transportation equipment and facilities, construction equipment, and electrical machinery; and recommend regulations for controlling aircraft noise and sonic booms. Shortly prior to that act, the United States Department of Housing and Urban Development (HUD) issued a noise abatement and control policy that encouraged control at the sources of noise and prohibited HUD’s support to new construction on sites that had unacceptable noise exposures. Because of the issuance of these policies, it was necessary to develop a method to measure noise and to predict a community’s subjective response to it. Many social surveys were conducted to attempt to do that, but they were individually conducted for separate projects that usually only dealt with one type of noise source. Landmark research was completed by

Schultz in 1978 when he synthesized a number of these social surveys by developing a common noise rating, the day-night average sound level.

Schultz's research compiled more than eighteen social surveys that had been completed about noise annoyance caused by transportation sources, such as aircraft or street traffic, to find a common scale that could be used to define what constitutes a "suitable living environment." Previous studies had surveyed people to identify where they stood in a range of not at all annoyed to highly annoyed. Schultz proposed that because it is necessary for regulatory purposes to focus analysis on the noise itself, it is useful to use only those that are "highly annoyed" by the noise source. Those that are not at all annoyed or slightly annoyed might be reacting to other noise sources (or none at all). Schultz then compiled the results of eighteen surveys from nine different countries and translated them to a similar scale, the day-night average A-weighted sound level. From these results, Schultz plotted the percent that were highly annoyed against the L_{dn}. Schultz concluded that all the studies seemed to agree and had a similar curve (Schultz 379). The curve is logarithmic in nature, like the loudness function. The importance to be gained from this is that when a noise is increased by 10 dB, from 60 to 70 dB, for example, the percentage of people that are highly annoyed will rise at a faster rate than if it were a linear relationship.

Schultz's research was reanalyzed many times. Miedema and Vos (1998) completed the most recent research. They stated that annoyance and sleep disturbance are the two most important human health effects of environmental noise when DNL is below 70 dB. Since sleep disturbance cannot be reliably quantified with respect to noise exposure, Miedema and Vos focused on annoyance. The study used preexisting data to establish functions to summarize the relationship between annoyance and the incident noise at the most exposed façade in steady state situations.

Other studies have been done but they were limited in that they did not use a large enough number of studies or did not place importance on insuring the variables were the same. Schultz did the only study that was influential, in the opinion of Miedema and Vos. Schultz discussed 24 noise annoyance surveys from various countries that involved aircraft, road traffic, and railway noise. Schultz established a common noise measure and annoyance measure: DNL and percentage of respondents considered to be highly annoyed. For each of the investigations Schultz plotted a curve with the percentage highly annoyed as a function of DNL. Schultz then synthesized the curves into a single curve as the “best currently available estimate of public annoyance due to transportation noise of all kinds.”

Critics of the Schultz study include Kryter who argued that ground traffic and air traffic should be considered separately. Fidell validated the Schultz study with more datasets although some of Fidell’s data appeared to support the Kryter conclusion. Fields reviewed and found many faults in the Schultz and Fidell studies (Miedema and Vos 3434).

The Miedema and Vos synthesis was based on the studies by Schultz and Fidell and avoided the errors and inaccuracies Fields noted in his review. Based on criteria attempting to standardize the synthesis, 22 of the 35 datasets used by Schultz and Fidell were examined. Two sets of curves were developed; one for each dataset separately and one for each type of transportation. The curves for the types of transportation were determined by least squares regression and with a multilevel approach that took into account the fact that the cases were selected in two stages.

It was determined that the percentages highly annoyed as compared to DNL functions are different for aircraft, road traffic, and railway noise (Miedema and Vos 3443). The rates of increase from highest to lowest are aircraft, road traffic, and railway noise. The percentage highly annoyed was zero below 40-45 dB and is dependent on the transportation mode above 45 dB. These curves apply to steady state situations but can be used to establish noise limits and to compare plans with respect to the noise impact on the community (Miedema and Vos 3443).

A study by Finegold, Harris and von Gierke reanalyzed Schulz's curve and presented technical justifications for two exposure-response relationships for predicting the percentage expected to be highly annoyed as a result of transportation noise and for predicting sleep disturbance in response to transportation noise (Finegold, Harris and von Gierke 25). They were adopted in 1992 by the Federal Interagency Committee on Noise (FICON), which has since been renamed as the Federal Interagency Committee on Aviation Noise (FICAN). Finegold, Harris and von Gierke reanalyzed two sets of previously published data and also added new data to the original 1978 Schulz curve to predict annoyance. The Schulz curve was updated because of new technologically improved community annoyance studies being available. Finegold, Harris and von Gierke used the Fidell update of Schulz's data (1991) to form a new USAF logistic fit curve. The logistic fit used as the prediction curve of choice for the percentage highly annoyed as a result of the transportation noise is:

$$\%HA = \frac{100}{1 + \exp(11.13 - 0.14L_{dn})}$$

Finegold, Harris and von Gierke decided that the 10 dB nighttime penalty is good enough for nighttime disturbance but if there are a large number of nighttime noise events, then supplemental information may be required. This curve is currently being used by federal agencies in Environmental Impact Studies (Finegold, Harris, and von Gierke 29).

Another interesting piece of research that deals with the social aspects of transportation noise was completed at the Georgia Institute of Technology in 1992. It examined the effect of personal and situational variables on noise annoyance with respect to en route noise. It determined through social surveys that noise annoyance is not strongly affected by demographic variables such as age, sex, income, etc. but is positively associated with each of the five attitudinal variables examined, such as fear of danger from the noise source and the belief that the authorities can control the noise.

In addition to the research that has been conducted concerning the social aspects of transportation noise, there is a multitude of research that deals with the physiological aspects of human and animals due to the noise. Studies done by Thayer School of Engineering in Hanover, NH in 2004 centered on applying active noise reduction (ANR) to hearing protection and communication systems. A study by the Norwegian Institute of Health in 2004 improved the amount of knowledge about human perception of noise in outdoor recreational areas by developing applicable noise indicators in areas for recreational purposes. A significant relationship was found between number of aircraft noise events judged as ‘not acceptable’ and the total annoyance response. Finally, the Institute of Environmental and Human Health in 2003 reviewed the effects of aircraft noise on wildlife and humans and determined that more research needs to be done because of current laws and legislations and because of the inconclusive results of previous studies.

USAF Noise Research

Although the research documented above is extremely valuable in its context, the purpose of this research is to study the effects of military aircraft noise as an environmental disamenity and its effect on the local community. Research has been done that singles out military aircraft in a variety of ways. One analysis evaluated differences between civil and military aviation in the United States over the years with respect to environmental concerns specified by noise and emissions impacts (Waitz, Lukachko, and Lee 330). The military aviation situation is unique because the military has to balance environmental concerns with national security needs. In the opinion of Waitz, Lukachko, and Lee, more work needs to be completed by the DoD to establish metrics for assessing national security impacts of fulfillment of environmental requirements. On a small scale, the US Army Center for Health Promotion and Preventive Medicine has attempted to do that in its ETMP for Training and Testing Range Noise Control. This paper summarizes what compliance has cost the Army annually. Some of these costs also had a more qualitative loss associated with them such as range closures which resulted in less training opportunities.

Historically, bases and training ranges were large and remote and faced minimal interaction with local populations. Growth and encroachment in the last few decades have increased pressure on bases to mitigate environmental effects. The 1969 National Environmental Policy Act (NEPA) “requires federal agencies to assess the health, socioeconomic, ecological, cultural, and aesthetic impacts of major actions through the development of an environmental impact statement (EIS).” This has played an important role in bed down decisions for weapons systems. Although the military attempts to mitigate these impacts, there are still complaints. For example Waitz, Lukachko, and Lee report that property owners in Virginia Beach and Chesapeake, Virginia, have alleged that over flights of navy F/A-18C/D aircraft have adversely impacted the value of their property (330). Additionally, the same property owners said that the actions of the US Navy have resulted in a taking without compensation which is a violation of the Fifth Amendment of the U.S. Constitution.

Noise impacts communities around military installations more than commercial airports because more people reside within the higher 65 dB DNL contours at military installations. An example presented by Waitz, Lukachko, and Lee is that at NAS Oceana and NALF Fentress in Virginia there are 87,000 people that reside within the 65 dB contour. In contrast, the estimated cumulative number of people that reside within the 65 dB contours around all of the commercial airports in the United States is only 500,000 (Waitz, Lukachko, and Lee 332). The difference in the exposure is due in part to the fact that military aircraft are much noisier than commercial aircraft. Many military aircraft missions mandate engines of high thrust to weight ratios for maneuverability and low frontal area to minimize drag. Because of this, the propulsion system and engines used are different from commercial aircraft. These engines create more noise because of the higher exit velocities. In addition, technology evolution is slower in military aviation than in other forms of transportation because of the high capital costs and expectation of very long service lives (Waitz, Lukachko, and Lee 333).

Within the USAF, Air Combat Command (ACC) has implemented a few techniques that Air Force Center for Environmental Excellence (AFCEE) suggests that the Air Force should do as well. These recommendations encompass community planning as mandated by the 1976 FAA Aviation Noise Abatement Policy. AFCEE has decided that using a common planning language that is consistent with land use planning outside the Department of Defense (DoD) will help to lessen confusion. AFCEE also wants to work to provide guidance on the role of AF Community Planners in supporting the development and implementation of Range Plans. AFCEE wants to provide guidance enabling or mandating that AF planners be the focal point working with local communities and that they should work with AFCEE Regional Offices to assure their message is consistent with the regional and national message communicated by the Regional Offices to a broader audience (AFCEE 1).

ACC has also established a Wing Infrastructure Development Outlook (WINDO) Concept that formalizes planning between the wing commander and ACC commander, establishes a link between base General Plan and facility funding programs, and captures the vision for infrastructure improvements. They are attempting to establish a Base Planning Board similar to other Mission Support Group boards. They also realigned ACC Planning Branch to facilitate these concepts (Fitzgerald 1).

Other types of noise studies have been completed that are working to improve the environment of military personnel working with the aircraft similar to those mentioned in the civilian community. Active Noise Cancellation (ANC) systems have been studied for C-130 aircraft to minimize mission disturbance due to flight crews and ground maintenance personnel suffering degraded voice communication, impaired performance, increased fatigue, and hearing loss. This system works by tuning an engine propeller to provide a canceling acoustic wave to reduce the noise generated from another engine propeller on the same aircraft.

Active noise control has been developed for head sets and to cancel noise in air ducts and passenger cabins. They are produced in a similar way to the ANC system for C-130's. A study has been done to convert this technology to propeller aircraft.

Hedonic Method Research

Within the literature on aircraft noise, there are many studies that have analyzed the effects that aircraft noise has had on humans and animals. However, as the purpose of this research is to study the effects of military aircraft on the local community, a different type of analysis is necessary. A common approach that has been used to study this type of environmental service to society is the hedonic non-market valuation method. The premise of this method is to "explain the value of a commodity as a bundle of valuable characteristics" (Hanley, Shogren, and White 411).

Commonly, the median value of housing property surrounding an airport is used to estimate how much the aircraft noise of a local airport creates an effect. A multiple regression is performed where the median value of property is the dependent variable and characteristics of the property such as the age of the home, mean income level of the neighborhood, and whether or not it is affected by the commodity (i.e. the aircraft noise) are the independent variables.

Many studies have been completed using the hedonic non-market valuation method. Although large improvements have been made in technology to lower the amount of noise generated by aircraft, poor land-use planning and a failure to prevent urban encroachment have negated the benefits of improved technology, according to Thomas and Lever. Over the next 20 to 30 years, airport growth will continue while technology may not move as fast. They feel that it is the responsibility of the aviation industry to "meet increasing demand for air travel, while at the same time constraining or even reducing the number of people exposed to 'unacceptable levels' of nuisance from aircraft noise." One way to control aircraft noise is through buy out, compensation and sound insulation. Through studies on property values, airports know that their operations produce a negative effect. Airports acquire adjacent land and develop airport-related businesses or leave it uninhabited. Compensation payments are sometimes made to nearby residents. Location-specific and socio-economic factors influence the compensation. Airports also use sound-proofing of buildings near the airport to mitigate the noise. This can be an expensive undertaking and is not completely effective because it does not help reduce sound outdoors (Thomas and Lever 102).

A hedonic study was completed on the Winnipeg International Airport to test a model built from separating the noise effect by representing noise conditions at each location as a vector of characteristics against a more typical Noise Exposure Forecast (NEF) model. Levesque states that the NEF is a cumulative measurement which does not take into account individual effects of loudness and number of events. Because of that, Levesque believes it is impossible to use the results to examine the benefits of alternative noise management strategies. In this study, they change Transport Canada's NEF program to use the Effective Perceived Noise Level (EPNL) at each location instead of interpolating noise contour values. These vectors of values relate the loudness of individual events and the number of events.

The Winnipeg International Airport study tests five models and determines that the fifth one is superior. One regression is done resulting in a coefficient on noise variability that suggests that houses sell at a premium in areas affected by the same number of events, the same average EPNL level, but with a larger variation in the individual noise levels. The results of this study show that the number of flights is less important than the loudness and variability of the loudness of single events. Also, it showed that variability in the level of noise is better than a constant background level (Levesque 209).

A meta-analysis of airport noise and hedonic property values completed at The Pennsylvania State University by Nelson was accomplished by compiling and analyzing twenty hedonic property value studies. They state that because of differences in statistical methods, samples, time periods, etc. empirical studies have not produced a singular value for the effect of airport noise on property values. A meta-regression analysis was performed with the data to examine the variability in weighted-mean noise discounts that might be due to country, year, sample size, model specification, etc. The analysis found that country and model specifications have some effect on the measured noise discount, but the other variables were not routinely significant.

This study was completed to valuate noise effects due to future airport expansions and conversion of the U.S. commercial fleet which will require technology investments by airlines since noise is the number one environmental concern at major airports. Different dummy variables were introduced to control for differences in the studies including methods of controlling for accessibility factors and use of a linear form function.

The results of the study determined that the noise discount was about 0.50 to 0.60% per dB as consistent with a previous study by the author. The noise discount for Canadian airports was larger at about 0.80 to 0.90% per dB (Nelson 21). Limitations of the study include only being able to generalize to areas with noise less than 75 dB (consistent with the findings of the Federal Aviation Administration (FAA)) and comparability only to new hedonic study methods that consider spatial autocorrelation of housing prices (Nelson 22).

One way that hedonic studies can be used is in contemplation of construction of additional runways. Seattle-Tacoma International Airport (SEA) was contemplating a third runway and contracted a study to determine the effects of the additional aircraft noise on the local community. They determined that the runway affected the value of close-by properties in two ways: the airport operations depress property values below the level that real estate markets would produce if the airport did not exist and they cause variation in value among properties by their proximity to the flight paths of arriving and departing aircraft. They used the values to estimate what would happen to real estate values between 1993 and 2000 and between 2000 and 2020 because of 11.7% and 16.5% growth in each time segment, respectively (Helmuth, et al., 9-4).

Finally, two studies were completed that used hedonic non-market valuation to examine the effect of aircraft noise at Langley Air Force Base, Virginia and Davis-Monthan Air Force Base, Arizona. The study at Langley was completed first and recommended Davis-Monthan as a follow-on study. The Langley study evaluated the effect of aircraft noise in four areas: noise analyses, geo-database construction, cartographic analyses, and statistical analyses. Aircraft noise exposure was characterized by contours of DNL from Air Installation Compatibility Use Zone (AICUZ) documents in 1975 and 1990. The real estate data was collected from the Hampton City Tax Assessor's Property Review Database and edited based on certain requirements. Properties were used that were in areas in Hampton inside and outside the 65 dB DNL noise contours. The number of sorties at Langley was analyzed resulting in the conclusion that the number of F-15 sorties has been reasonably stable since 1975.

Three samples were studied. The first two samples were random containing 10% of all real estate transactions between 1975 and 1993 in areas of Hampton outside of the 1990 60 dB DNL aircraft noise contour. The two samples were regressed separately and the second set was used to validate the model. Next, the model was refined by applying it to the two combined samples. The resulting validated and refined model was used to study the third sample of sales within the 1990 65 dB DNL noise contours.

Real estate sales were mapped with respect to the noise contour and two features were made apparent: stable patterns of improved real estate prices have persisted in Hampton since at least 1975 and there is no obvious pattern to real estate prices and noise exposure by aircraft operations at Langley.

The cartographic and statistical analyses failed to reveal any evidence of an adverse effect of aircraft noise exposure on property values within the 1990 65 dB DNL noise contour of Langley. The study is limited in its ability to generalize because the real estate data is unique in several respects to Hampton and the large samples produced statistical reliability for small differences between samples.

The study suggested analyzing Davis-Monthan Air Force Base and replicating this study in a very different real estate market to provide validation. They stated that replicating the findings in this study could be used to produce property value maps to be used as a planning tool for various effects and to quantify historical patterns and the monetary risks of encroachment at other Air Force installations (BBN 40).

Consequently, the same contractor evaluated Davis-Monthan two years after the Langley study. The study was broken into three of the four areas that had been evaluated at Langley: noise analyses, cartographic analyses, and statistical analyses. Aircraft noise exposure was characterized by contours of DNL from Air Installation Compatibility Use Zone (AICUZ) documents in 1992. The real estate data was collected from the Pima County Tax Assessor’s Residential Database and the Arizona State Department of

Revenue’s Sales Affidavit Database and edited based on certain requirements. Properties were used that were in areas in Tucson inside the 65 dB DNL noise contour of Davis-Monthan. Other properties that were used were outside of the 65 dB DNL noise contour of Davis-Monthan and Tucson International Airport (TIA) and comparable to the properties inside Davis-Monthan’s 65 dB DNL noise contour. Lastly, a random sample of properties located within Pima County outside the 65 dB contours of Davis-Monthan and TIA not matched in amenities to the noise exposed homes.

Five- and thirteen-predictor models were developed and tested. The five-predictor model was tested with the random sample of properties located outside the 65 dB DNL noise contours of Davis-Monthan and TIA. The thirteen-predictor model was developed to validate the five-predictor model. The study said that it was impossible to attribute housing values to noise because the majority of the properties in the affected area were homogenous.

These studies vary from typical hedonic studies in that they develop models for predicting housing values, apply them to housing samples both inside and outside of the noise contours and then compare the differences. Although the Davis-Monthan study showed significant differences in housing values inside and outside of the noise contours, they conclude that a causal relationship can not be developed because the difference is not equal among all types of housing.

III. Methodology

Overview

There are many methods available for studying the effect of aircraft noise. One well-validated method is the hedonic pricing method of non-market valuation. This research will use the hedonic method to answer these questions:

1. What is the effect of USAF aircraft noise on housing values in a local community?
2. What is the effect of the USAF on housing values in a local community?
3. How does this effect compare across different installations/types of missions?

Hedonic Pricing Method

The method that will be used to perform this research will be the hedonic pricing method of non-market valuation. The hedonic method derives from the characteristics theory of value proposed by Rosen. The hedonic method is an economic technique that determines the implicit price that consumers are willing to pay for quietude or other amenities. Instead of directly asking people what they are willing to pay or sacrifice for the amenity, this method indirectly infers that value from their behavior in a related market (in this case, housing). It does this through a multiple regression of characteristics of housing (such as the age of the home and mean income level of the zip code) located within the affected area and outside of it. Variables are introduced that code the housing that is affected by the adverse characteristic (i.e. aircraft noise). The implicit value of the quietude, for example, is shown through the choices that consumers make in the housing market. The difference shows up in the regression through comparison of properties with identical characteristics excluding the quietude. A benefit of the method is that all of the variables except median housing value are objectively measured (though perhaps not objectively chosen). This lends to creating an answer to the question that is less subject to accusations of bias.

A few limitations that are associated with the hedonic method are:

- Omitted variable bias: a variable that could significantly affect the dependent variable and is correlated with one of the included variables is omitted and biases the coefficient of the included variable.

- Multi-colinearity: some environmental variables may be highly collinear and require separate equations for each to be estimated otherwise the implicit prices are difficult to determine.

- Choice of functional form for the HP function: economic theory does not specify which non-linear function should be used and the choice will influence the value that implicit prices take.

- Expected versus actual characteristic levels: house sales may be attributed to expected future environmental conditions as well as current conditions.

- Attitudes to risk: biased estimates are likely to occur when the value of changes in risky environmental events (i.e. earthquakes) are considered. This is due to people consistently overvaluing very low probability events and consistently undervaluing high probability events and because people have too little, low quality information to arrive at 'correct' probabilities. (Hanley, Shogren, and White 413-14)

Research Model

The model derived for this research is first-order with both quantitative and qualitative dependent variables. The complete model is as follows:

$$E(y) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_{10} x_{10}$$

The independent variable for the regression is Median Value of Owner-Occupied Housing Units pulled from census tracts surrounding USAF installations and comparable tracts without installations from the 2000 US Census data. The dependent variables that have been chosen for the regression are:

1_%WhRes = % White Residents: quantitative; pulled from US Census data

2_Age = Median Age: quantitative; pulled from US Census data

3_PerCapInc = Per Capita Income: quantitative; pulled from US Census data

4_OccRate = Occupancy Rate: quantitative; pulled from US Census data

5_PopDens = Population Density: quantitative; pulled from US Census data

6_ChildUnd18 = Own children 18 & under: quantitative; pulled from US Census data

7_65+ = Individuals 65 & older: quantitative; pulled from US Census data

8_HHsize = Average Household Size: quantitative; pulled from US Census data

9_YrBuilt = Median Year Structure Built: quantitative; pulled from US Census data

11_USAF = $\begin{cases} 1 \text{ if USAF base present} \\ 0 \text{ if not} \end{cases}$; qualitative; assessed from USAF data

14_Aircraft = $\begin{cases} 1 \text{ if aircraft operations are present} \\ 0 \text{ if not} \end{cases}$; qualitative; assessed from USAF data

Research Detail

The first point that will be examined will be USAF installations with primary aircraft operations against their matched counties census tracts. This will test for the effect of the presence of aircraft. The hypothesis is that the presence of the aircraft will create a lowered median home value as opposed to the median home values with an absence of aircraft. Although the BBN report cited no negative difference between aircraft presence and absence (39), many reports completed for civilian airports have shown a negative difference (e.g. Helmuth, et al. and Nelson). Also, it is probable that this research would find a difference as it will study a much larger sample size including multiple USAF installations instead of just the one studied in the BBN report. This test will use all of the quantitative variables and the dummy variable ‘14_Aircraft.’

The second point that will be examined will be all USAF installations versus their matched counties census tracts. The purpose of this examination is to determine whether the presence of the military in general, regardless of aircraft operations, creates a negative environment in the housing market. The hypothesis is that it will not create a difference because there are many possible counterbalancing attributes of a military installation. On the positive side, it creates jobs and a sense of national pride. On the negative side, it possibly creates pollution and stirs anti-military sentiments. This test will use all of the quantitative variables and the dummy variable ‘11_USAF.’

The third and fourth tests will examine USAF installations in terms of their type of aircraft operations. The third test will be USAF installations with fighter aircraft operations versus their matched counties census tracts. The fourth test will be USAF installations with bomber aircraft operations versus their matched counties census tracts. This will test for the variation in loudness that might occur due to aircraft type. Both tests will use all of the quantitative variables and the dummy variable ‘14_Aircraft.’

The fifth test will examine USAF installations without aircraft operations as a primary mission against their matched counties. This will test for the effect of the USAF when no aircraft are present. This test will use all of the quantitative variables and the dummy variable ’11_USAF.’

The last test will repeat the second test but broken out into individual installations. The individual USAF installation tracts will be tested against their matched counties census tracts. The intent of this test is to examine each installation to see if there are particular ones that have extreme results of median housing values. This test will use all of the quantitative variables but only the dummy variables ‘11_USAF’ or ‘14_Aircraft’ depending on whether or not the installation has aircraft operations.

IV. Data Analysis

Overview

The previous chapters discussed aircraft noise and the methods that have been used to evaluate its effect on various factors including the housing values of local communities through the hedonic pricing method of non-market valuation.

To answer questions 1, 2, and 3 presented in chapter one, multiple linear regressions were performed on tracts of US Census data from the year 2000 in accordance with the hedonic pricing method. These questions are summarized in Table 3.

Table 3 Question Summary

Question	*Description*
Question 1	Does the presence of aircraft at USAF installations have a negligible impact on housing values in the local community?
Question 2	Does the presence of the USAF have a negligible impact on housing values in the local community?
Question 3	Is the impact on housing values in the local community due to the presence of aircraft at USAF installations differ between bomber bases and fighter bases?

Question 1 Analysis

The purpose of the first research question was to determine whether the presence of USAF aircraft has an impact on housing values in the local community and, if it does, the type of impact. This question was analyzed by testing the census tracts around USAF installations that have flying as a primary mission and the census tracts that were matched to them through software used by the US Census office. The dummy variable ‘14_Aircraft’ was used to differentiate between the census tracts that had USAF installations with flying as a primary mission. For the purposes of this research, installations with a flying mission are defined as those that had a current Air Installation Compatible Use Zone (AICUZ) contour map on record at the Air Force Center for Environmental Excellence (AFCEE). The lowest level of census data that could be obtained was for the county level. Therefore, to more accurately assess the impact of the USAF aircraft and installations, the data set was pared down. This was done by using only the census tracts from zip codes that were within a particular radius of the installation. The radius was determined by measuring the furthest point that the 65dB DNL contour extended at each installation. For example, at Barksdale AFB, the 65dB contour extended from the center of the runway 15.15 miles at the furthest point. So, all zip codes within 15.15 miles of Barksdale AFB were included in the study. At installations where there was no flying mission, the average of the measured distances of the installations with flying missions was used to determine the zip codes required for the study.

Table 4 shows the results of the test of Question 1. This test showed that a decrease of $22,234 in the median housing values in a local community could be attributed to the presence of USAF aircraft. This is a decrease of 14% when compared to the average of the median housing values ($158,176). The significance level for '14_Aircraft' was determined to be 0.001, well within the acceptable level of 0.01 needed to reject the null hypothesis (USAF aircraft does not affect median housing values) with 99% confidence.

To test the robustness of the model, the data was regressed again with the natural logarithm of the housing values as the dependent variable. The results showed that the model was robust as the coefficient for the dummy variable ‘14_Aircraft’ (-20%) was close to the decrease calculated in the previous paragraph (14%). Table 4 displays the results for both the linear model and the semi-log model. On the first line, the sample size is shown as “n = 1215.” The next two lines show the R^2 and adjusted R^2 values for the two models. Below that is each independent variable with its coefficient and significance value. Table 4 through Table 8 are all displayed in the same manner.

Table 4 Aircraft Model Results

n = 1215		
R^2	0.748	0.704
R^2 Adj.	0.745	0.701
Variables	10-Predictor Model Coefficients (Sig)	10-Predictor Model Semi-Log Coefficients (Sig)
(Constant)	-284,391.000 (0.339)	-0.462 (0.781)
1_%WhRes	-62,756.900 (0.000)	-0.106 (0.097)
2_Age	-2088.866 (0.000)	0.002 (0.537)
3_PerCapInc	10.679 (0.000)	4.68E-05 (0.000)
4_OccRate	-129,022.000 (0.000)	-0.329 (0.000)
5_PopDens	2.309 (0.000)	1.55E-05 (0.024)
6_ChildUnd18	-1.394 (0.130)	1.16E-05 (0.039)
7_65+	3.321 (0.031)	1.77E-05 (0.000)
8_HHSize	29,643.364 (0.000)	0.201 (0.000)
9_YrBuilt	181.122 (0.231)	0.006 (0.000)
14_Aircraft	-22,234.300 (0.001)	-0.202 (0.000)

Question 2 Analysis

The purpose of the second research question was to determine whether the presence of USAF installations has an impact on housing values in the local community and, if it does, the type of impact. This question was analyzed by testing the census tracts around USAF installations and the census tracts that were matched to them through software used by the US Census office. The dummy variable ‘11_USAF’ was used to differentiate between the zip codes that were near USAF installations and those that were not. Once again, the zip codes that were used to represent the impact of the USAF were those that were within the radius of the furthest point of the 65dB contour at the installation. The test showed that the presence of the USAF decreased home values by $17,626 and was significant to the prediction of median housing values at the 99% level with a significance of 0.005. This is a decrease of 12% when compared to the average of the median housing values ($150,759). Table 5 shows the results of the test of Question 2.

To test the robustness of the model, the data was regressed again with the natural logarithm of the housing values as the dependent variable. The results showed that the model was robust as the coefficient for the dummy variable ‘11_USAF’ (-17%) was close to the decrease calculated in the previous paragraph (12%).

Table 5 USAF Model Results

n = 1372		
R^2	0.746	0.705
R^2 Adj.	0.745	0.703
Variables	10-Predictor Model Coefficients (Sig)	10-Predictor Model Semi-Log Coefficients (Sig)
(Constant)	-102,861.000	0.896
	(0.704)	(0.557)
1_%WhRes	-53,134.800	-0.052
	(0.000)	(0.368)
2_Age	-2,262.666	-.001
	(0.000)	(0.842)
3_PerCapInc	10.659	4.76E-05
	(0.000)	(0.000)
4_OccRate	-116,842.000	-0.296
	(0.000)	(0.000)
5_PopDens	2.475	1.66E-05
	(0.000)	(0.051)
6_ChildUnd18	-1.654	9.36E-06
	(0.052)	(0.008)
7_65+	3.759	2.12E-05
	(0.008)	(0.000)
8_HHSize	30,503.852	0.205
	(0.000)	(0.000)
9_YrBuilt	80.123	0.005
	(0.560)	(0.000)
11_USAF	-17,626.100	-0.174
	(0.005)	(0.000)

Question 3 Analysis

The purpose of the third research question was to determine whether there was a difference in impact on housing values in the local community due to the presence of USAF aircraft between bomber and fighter installations. This question was analyzed by separately testing the census tracts around USAF installations and the census tracts that were matched to them by aircraft categorization. All of the fighter installations and their matched counties were tested together and all of the bomber installations and their matched counties were tested together. The dummy variables '14_Aircraft' was used in tests 3 and 4. The zip codes that were used to represent the impact of the aircraft were those that were within the radius of the furthest point of the 65dB contour at the installation. The test showed that the presence of fighter aircraft decreased median housing values by $26,005 and was significant to the prediction of median housing values at the 99% level with a significance of 0.001. This is a decrease of 15% when compared to the average of the median housing values ($171,902). The results of this test are shown in Table 6. To test the robustness of the model, the data was regressed again with the natural logarithm of the housing values as the dependent variable. The results showed that the model was robust as the coefficient for the dummy variable ‘14_Aircraft’ (-21%) was close to the decrease calculated in the previous paragraph (15%). The test of bomber aircraft was not significant at the 90% level with a significance of 0.646. The results of this test are shown in Table 7.

Table 6 Fighter Model Results

n = 976		
R^2	0.766	0.729
R^2 Adj.	0.764	0.726
Variables	10-Predictor Model Coefficients (Sig)	10-Predictor Model Semi-Log Coefficients (Sig)
(Constant)	-524,664.000	-0.329
	(0.133)	(0.859)
1_%WhRes	-54,992.600	-0.034
	(0.000)	(0.612)
2_Age	-3,626.516	-.006
	(0.000)	(0.061)
3_PerCapInc	11.202	4.80E-05
	(0.000)	(0.000)
4_OccRate	-167,433.000	-0.483
	(0.000)	(0.000)
5_PopDens	2.222	1.47E-05
	(0.000)	(0.000)
6_ChildUnd18	-1.350	9.58E-06
	(0.181)	(0.073)
7_65+	4.237	2.37E-05
	(0.012)	(0.008)
8_HHSize	31,336.358	0.231
	(0.000)	(0.000)
9_YrBuilt	337.486	0.006
	(0.058)	(0.000)
14_Aircraft	-26,004.700	-0.214
	(0.001)	(0.000)

Table 7 Bomber Model Results

n = 234		
R^2	0.477	0.460
R^2 Adj.	0.453	0.436
Variables	10-Predictor Model Coefficients (Sig)	10-Predictor Model Semi-Log Coefficients (Sig)
(Constant)	-1,822,107.000 (0.000)	-8.102 (0.047)
1_%WhRes	-4,676.583 (0.838)	-0.063 (0.771)
2_Age	3,202.022 (0.000)	.026 (0.000)
3_PerCapInc	2.661 (0.000)	2.66E-05 (0.000)
4_OccRate	15,635.308 (0.383)	0.212 (0.211)
5_PopDens	9.683 (0.025)	6.68E-05 (0.100)
6_ChildUnd18	4.139 (0.043)	2.10E-05 (0.275)
7_65+	-8.171 (0.022)	-4.20E-05 (0.211)
8_HHSize	-6,165.597 (0.540)	-0.061 (0.522)
9_YrBuilt	891.884 (0.000)	0.009 (0.000)
14_Aircraft	-4,202.945 (0.646)	-0.113 (0.191)

Other Significant Research

Lastly, the USAF installations without aircraft operations were analyzed against their matched counties census tracts. The dummy variable '11_USAF' was used to differentiate between the zip codes that were near USAF installations and those that were not. The test was not significant at the 90% level with a significance of 0.176. The results are shown in Table 8.

In addition to analyzing the installations as groups in Questions 1-3, each installation was analyzed separately against its matched zip codes. In each case, the dummy variable '14_Aircraft' or '11_USAF' was used depending on whether the installation had aircraft or not. The disamenity or amenity determined for each installation was compared to the median housing value of the data from the installation and the matched zip codes. The results are shown in Table 9. Each installation varied in significance and coefficients greatly. The coefficients that were significant ranged from -$106,539 at Nellis AFB to $54,170 at Tyndall AFB.

Table 8 USAF Installations w/o Aircraft Model Results

n = 157		
R^2	0.708	0.707
R^2 Adj.	0.688	0.687
Variables	10-Predictor Model Coefficients (Sig)	10-Predictor Model Semi-Log Coefficients (Sig)
(Constant)	38,747.702 (0.920)	9.575 .002
1_%WhRes	-1,924.916 (0.875)	0.100 .305
2_Age	-2,800.602 (0.000)	-.022 (0.000)
3_PerCapInc	7.233 (0.000)	5.55E-05 (0.000)
4_OccRate	-68,173.900 (0.000)	-0.470 (0.000)
5_PopDens	-0.380 (0.905)	-2.60E-06 .918
6_ChildUnd18	-0.315 (0.805)	1.18E-05 .247
7_65+	-1.094 (0.662)	-2.40E-05 .237
8_HHSize	14,315.556 (0.211)	0.164 .073
9_YrBuilt	21.590 (0.915)	0.001 .652
11_USAF	10,474.819 (0.176)	0.108 .080

Table 9 Individual USAF Installations Regression Summary

Base	Model		14_Aircraft		11_USAF	
	n	R^2	B	Sig	B	Sig
Arnold	61	0.716			-3969.808	0.647
Barksdale	52	0.962	-5072.850	0.638		
Cannon	27	0.765	7577.667	0.805		
Davis Monthan	121	0.683	-3787.902	0.835		
Dyess	69	0.571	-39810.100	0.015		
Eglin	51	0.759	28779.034	0.008		
Eielson	37	0.759	28608.913	0.057		
Ellsworth	34	0.736	18342.250	0.684		
Elmendorf	43	0.875	15831.259	0.289		
FE Warren	43	0.648			-620.341	0.987
Hill	33	0.888	2240.997	0.906		
Holloman	29	0.776	-40668.100	0.036		
Lackland	174	0.860	-29732.700	0.032		
Langley	30	0.960	-5756.441	0.716		
Luke	191	0.821	-44477.900	0.105		
Malmstrom	22	0.951			11517.192	0.098
Minot	28	0.786	8255.119	0.625		
Mtn Home	28	0.837	52510.859	0.318		
Nellis	99	0.888	-106539.000	0.047		
Rome	32	0.969			7237.507	0.417
Seymour Johnson	32	0.900	-14672.200	0.262		
Shaw	45	0.904	-17540.500	0.398		
Tyndall	45	0.870	54170.011	0.004		
Whiteman	52	0.612	-56666.000	0.000		

Summary

This chapter outlined the results obtained during this study. The hedonic pricing method of non-market valuation was used to analyze the three research questions. Significant relationships between the independent variables of interest and the dependent variable, median housing values, were shown for all of the questions except bomber installations and installations with no aircraft operations.

V. Conclusion

Overview

The overall purpose of this study was to examine the effect that USAF aircraft noise has on local communities. Additionally, the effect of the presence of the USAF and the difference between installations with fighter and bomber aircraft were assessed. Twenty-three USAF bases, primarily from the Air Combat Command (ACC), and one USAF research laboratory site were used in the research. US Census data from 2000 was compiled including zip code tracts from the counties that house each installation and from two counties that were matched to each installation based on economic similarities. With this data, multiple linear regressions were performed in accordance with the hedonic pricing method of non-market valuation. This chapter presents conclusions, implications for the Air Force, limitations of the study, and recommendations for future research based on the analysis of the data.

Discussion

Research question one, “What is the effect of USAF aircraft noise on housing values in a local community?”, was answered by performing a multiple linear regression in accordance with the hedonic pricing method of non-market valuation on a set of data that included economic data and dummy variables for zip codes that included USAF installations with flying as a primary mission and two matched counties per installation. The coefficient for the dummy variable ‘14_Aircraft’ was used as the measure of effect that the presence of aircraft noise has on housing values.

Research question two, “What is the effect of the USAF on housing values in a local community?”, was answered by performing a multiple linear regression in accordance with the hedonic pricing method of non-market valuation on a set of data that included economic data and dummy variables for zip codes that included USAF installations and two matched counties per installation. The coefficient for the dummy variable ‘11_USAF’ was used as the measure of effect that the presence of the USAF has on housing values.

Research question three, “How does this effect compare across different installations/types of missions?”, was answered by performing multiple linear regressions in accordance with the hedonic pricing method of non-market valuation on two sets of data that included economic data and dummy variables for zip codes that included USAF installations with primary aircraft operations and two matched counties per installation. The sets of data were separated into two tests: one for USAF installations with fighter aircraft operations and one for USAF installations with bomber aircraft operations. The coefficient for the dummy variable ‘14_Aircraft’ was used as the measure of effect that the presence of different type of missions have on housing values.

Implications for the Air Force

This study did not validate the findings of the previous two noise impact studies contracted by ACC at Langley AFB, Virginia and Davis-Monthan AFB, Arizona, in which it was determined that it was impossible to associate a value with the impact of the noise. The fact that the results were not the same could be attributed to the difference in methods. The contract studies were completed by forming models of housing values using attributes of the housing similar to this study but different in that they did not use the presence of aircraft in the regression. They took the two models and ran them with data inside and outside the noise contours and then looked at the difference between the two models. They also used MLS data where this study used census data. The result in this study was for a large group of installations as opposed to the single base results from the two contract studies. When these two bases were examined individually in this study, though, the result was similar to the contract study: changes in housing values could not be strongly attributed to aircraft noise. These results are displayed in Table 9. The important factor about this study is that it is the only one that has been completed that studied a large group of USAF installations. Langley and Davis-Monthan could very well be isolated cases of situations where aircraft noise is not easily modeled as a contribution to changes in housing values.

Because of this result, the implications for the Air Force are that it has been found that the noise being created by USAF aircraft is associated with a negative impact on local community housing values. This means that the Air Force is potentially not doing an adequate job of mitigating the aircraft noise or that the community, local and state governments may not be doing an adequate job of providing buffers surrounding the installations. In other words, there is a need to change the way the Air Force is handling the issue of aircraft noise. For instance, examining a couple of the installations with significant large decreases of housing values (Luke and Lackland) on commercial GIS software shows how the local housing has been built fairly close to the installations and in fact, in some cases, in the flight path of the installation’s runway. This shows that the need to work to plan for undeveloped land near installations and in their flight paths is important and may not be done well currently. Oppositely, two installations with significant increases of housing values (Tyndall and Eglin) have much less residential development in their flight paths. It is important to remember that these installations were regressed with data from counties that match their economic makeup, i.e. the value of these houses is not increased because they are matched against less desirable neighborhoods. The test results from USAF installations without aircraft also add to this conclusion. The presence of these installations is not determined to be significant in the model of the housing values. The presence of fighter bases (the majority of the aircraft bases) is highly significant in the model of the housing values. The difference between these two data sets is the presence of aircraft noise which points to it as the factor that contributes the most to the decrease in housing values.

Installations that have the worst decrease in housing values may not be the most important to worry about first.   Although they decrease housing values significantly, they may only affect a small amount of people. This research would suggest that the installations with the most impact in terms of population affected would be the best to be concerned with in the immediate future.   Because of their large population, the chances that someone will complain about the noise will most likely be greater and the dollar cost of the impact is larger. A few of the installations that should be high on the list of priorities to research further would be Nellis, Lackland, Luke, Dyess, and Hill AFBs. These installations should be analyzed separately in as great detail as possible to ascertain the complete affect of the aircraft noise and to determine, if possible, the reasons for the difference, i.e. flight patterns and schedules or land-use management policies enacted at that installation.

Limitations

The results of this study are limited in the fact that the installations studied were only out of the ACC. They are more able to be generalized than the individual contract studies but they are still only accurate for fighter and bomber installations.

Another limitation is that the census data for the installations was matched at the county level and for this study was pared down to reflect only zip codes affected by the AICUZ noise contours.

Future Research

There are a few opportunities for future research in this area. First, since this study and the previous two contracted USAF studies were primarily concerned with ACC installations, it would be interesting to study other types of installations. Installations in the Air Mobility Command would be a logical next step as they contain another large group of loud aircraft. To add to the study of the effect that the presence of the USAF has on communities, other types of installations such as those in Air Force Space Command and Air Force Special Operations Command could be researched. A third avenue of additional installations to study would be those at overseas locations. These might be a little more difficult as the sources for data collection would be different than those used in the United States. Another avenue to research would be to match the actual zip codes with comparable zip codes census tracts instead of with comparable counties.

An interesting approach to take on following research in this area would be to take the findings in this study and perform case studies on each or many of the individual installations to find out if there are particular mitigation practices at these installations that lend them to having a large or small affect on the community.

Summary

The primary purpose of the research was to evaluate whether there was a significant difference in housing values of houses affected by the noise of USAF aircraft. The secondary purpose was to evaluate whether there was a significant difference in housing values located near USAF bases with and without aircraft noise and to evaluate whether type of aircraft changed the results created by the aircraft noise. The results showed that homes located within the 65 dB DNL contour of US Air Force installations in ACC showed a significant negative impact due to the presence of aircraft noise when studied with the hedonic pricing method of non-market valuation.

Appendix A

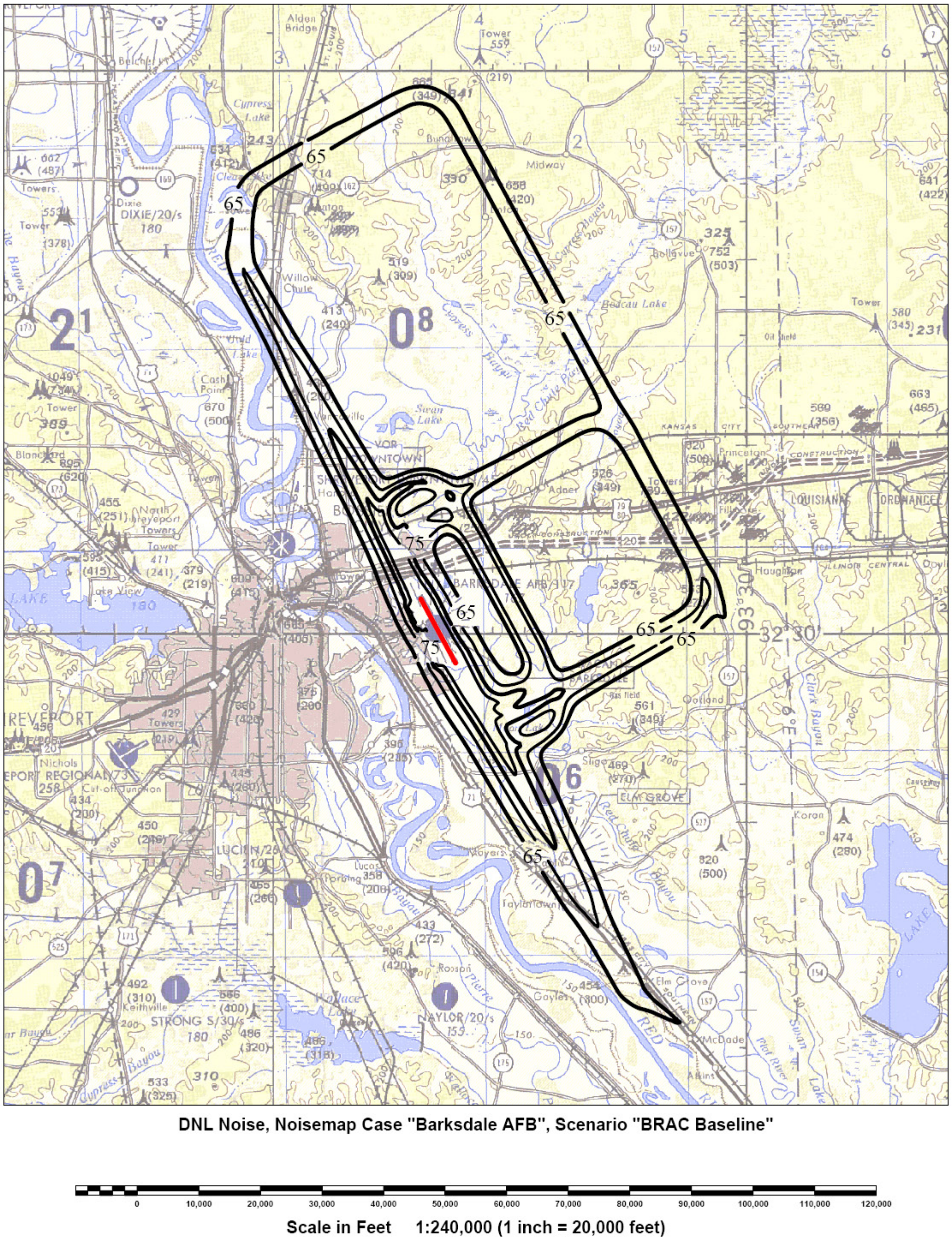


Figure 3 Barksdale AFB AICUZ Contour Map

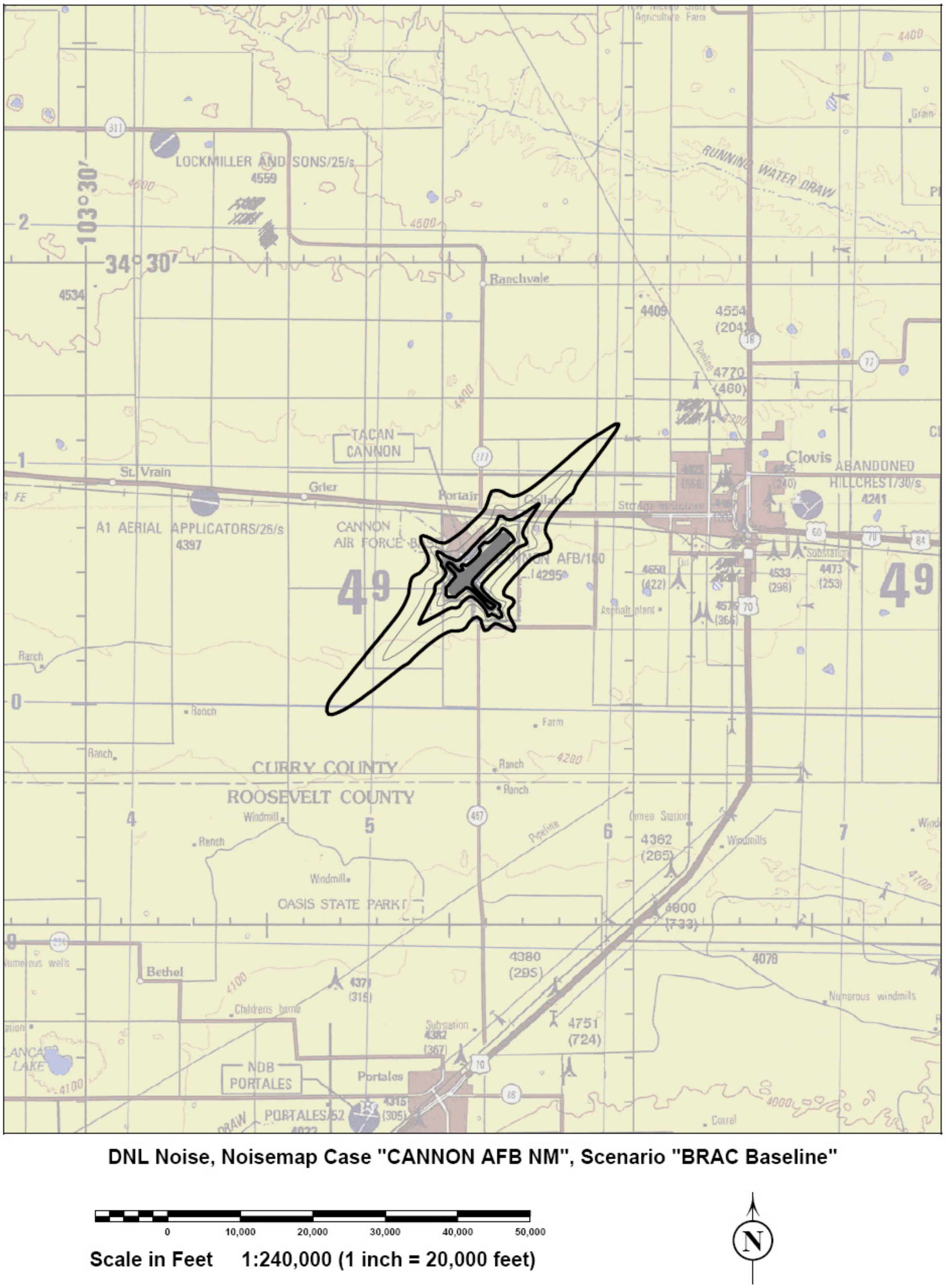

DNL Noise, Noisemap Case "CANNON AFB NM", Scenario "BRAC Baseline"

Figure 4 Cannon AFB AICUZ Contour Map

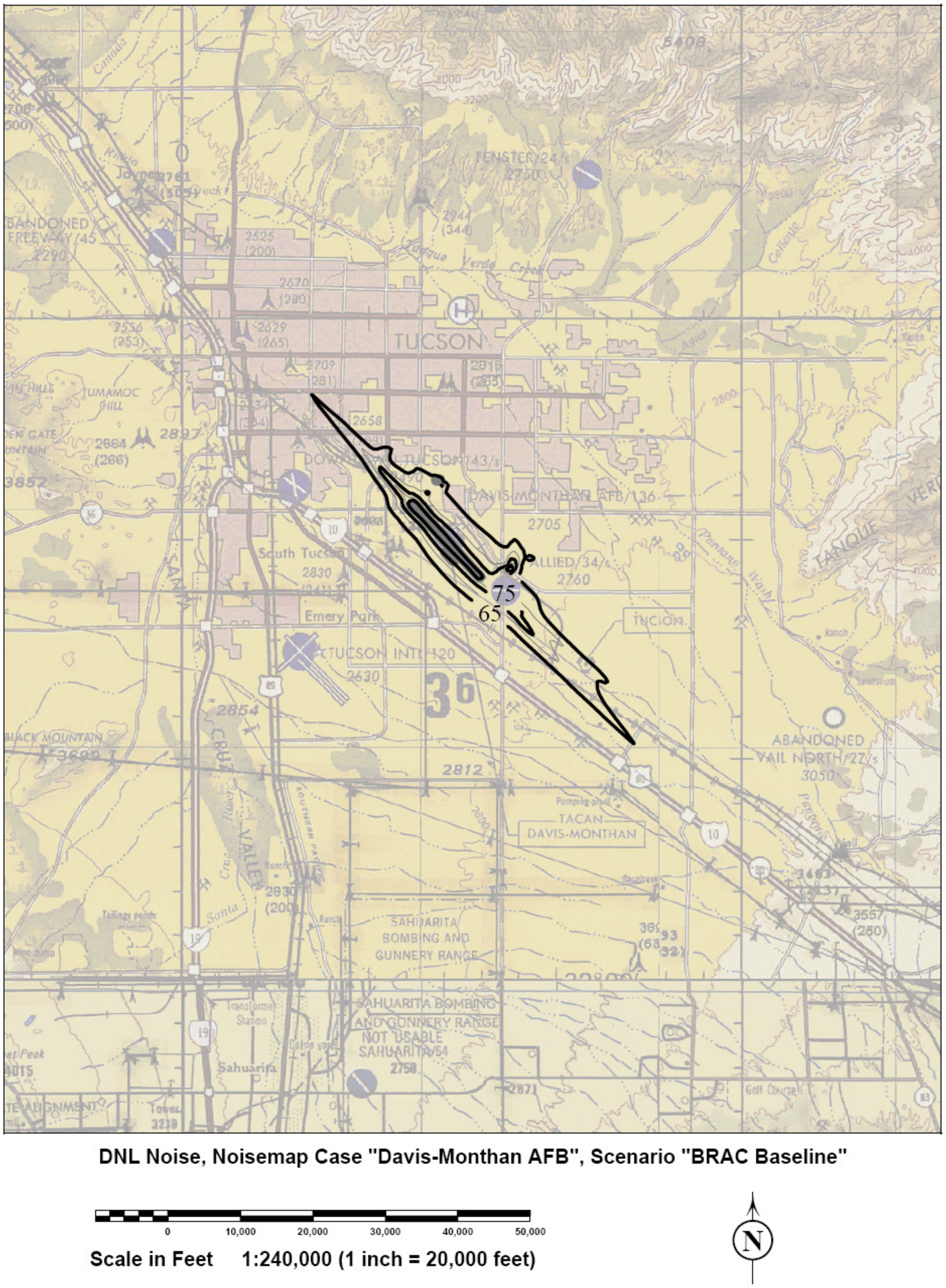
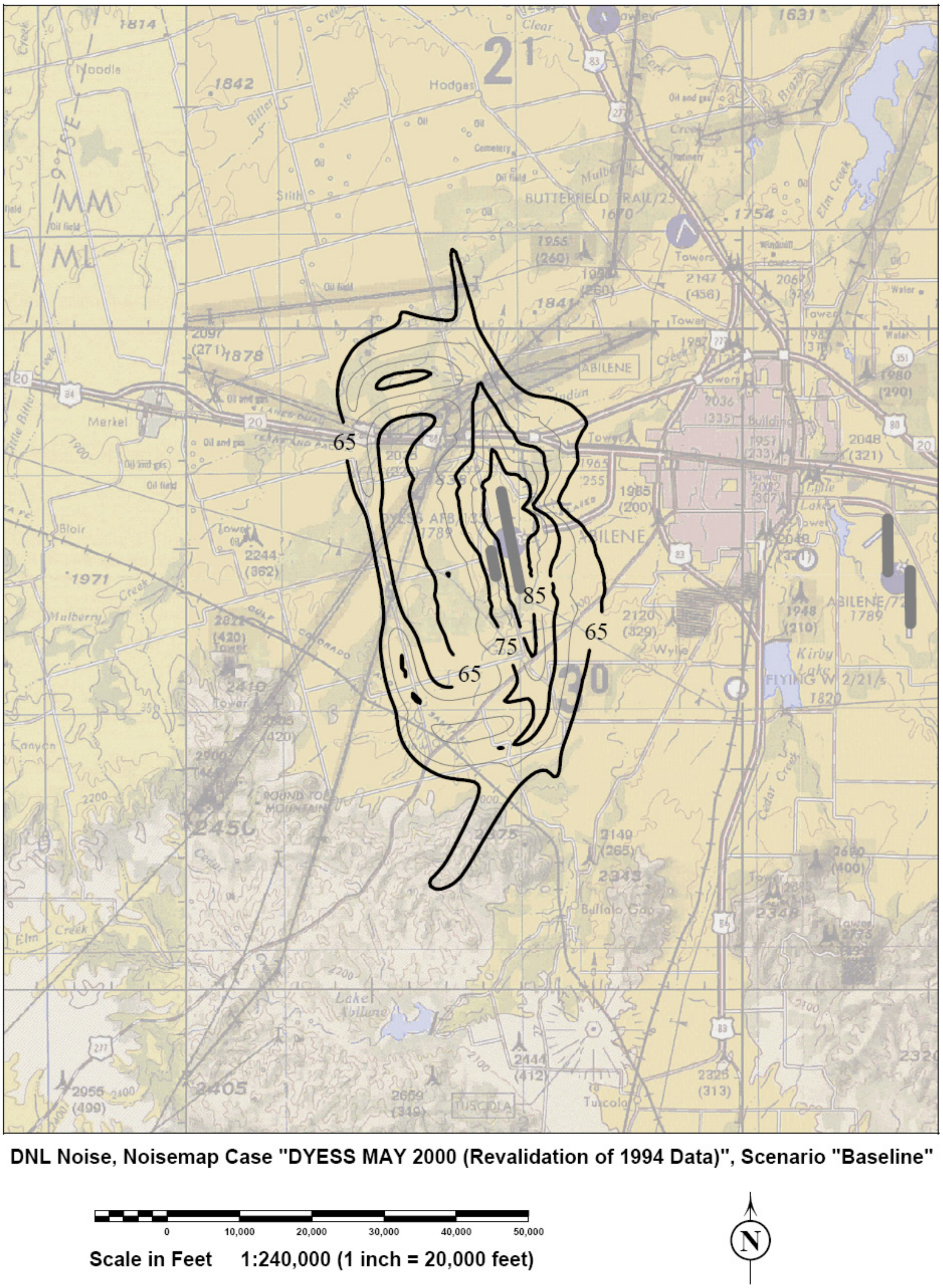


Figure 5 Davis-Monthan AFB AICUZ Contour Map



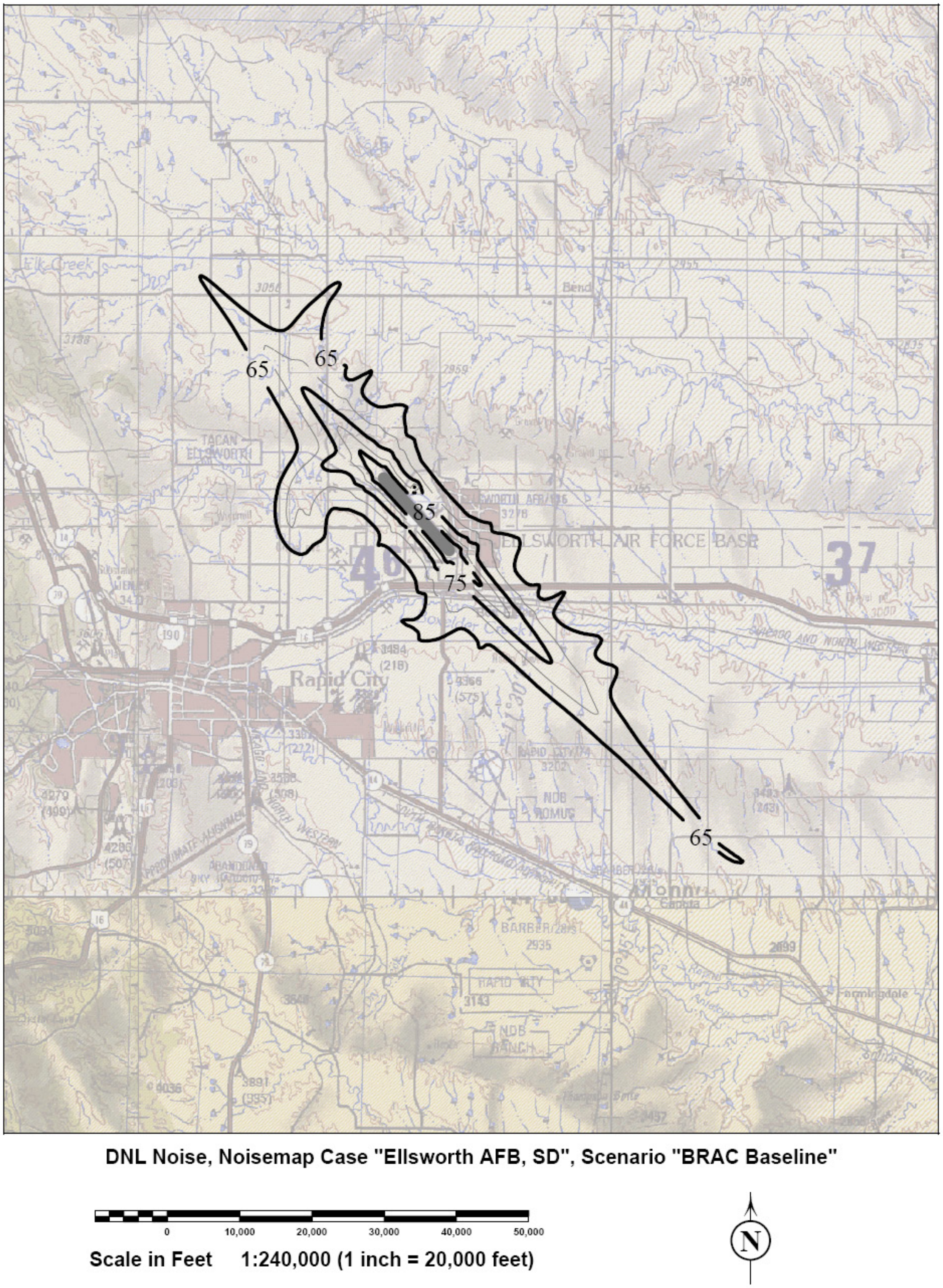
DNL Noise, Noisemap Case "DYESS MAY 2000 (Revalidation of 1994 Data)", Scenario "Baseline"

Scale in Feet 1:240,000 (1 inch = 20,000 feet)

Figure 6 Dyess AFB AICUZ Contour Map

Figure 7 Eglin AFB AICUZ Contour Map

Figure 8 Eielson AFB AICUZ Contour Map

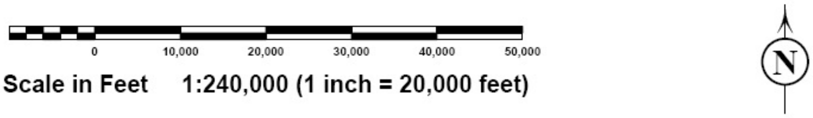


DNL Noise, Noisemap Case "Ellsworth AFB, SD", Scenario "BRAC Baseline"

Scale in Feet 1:240,000 (1 inch = 20,000 feet)

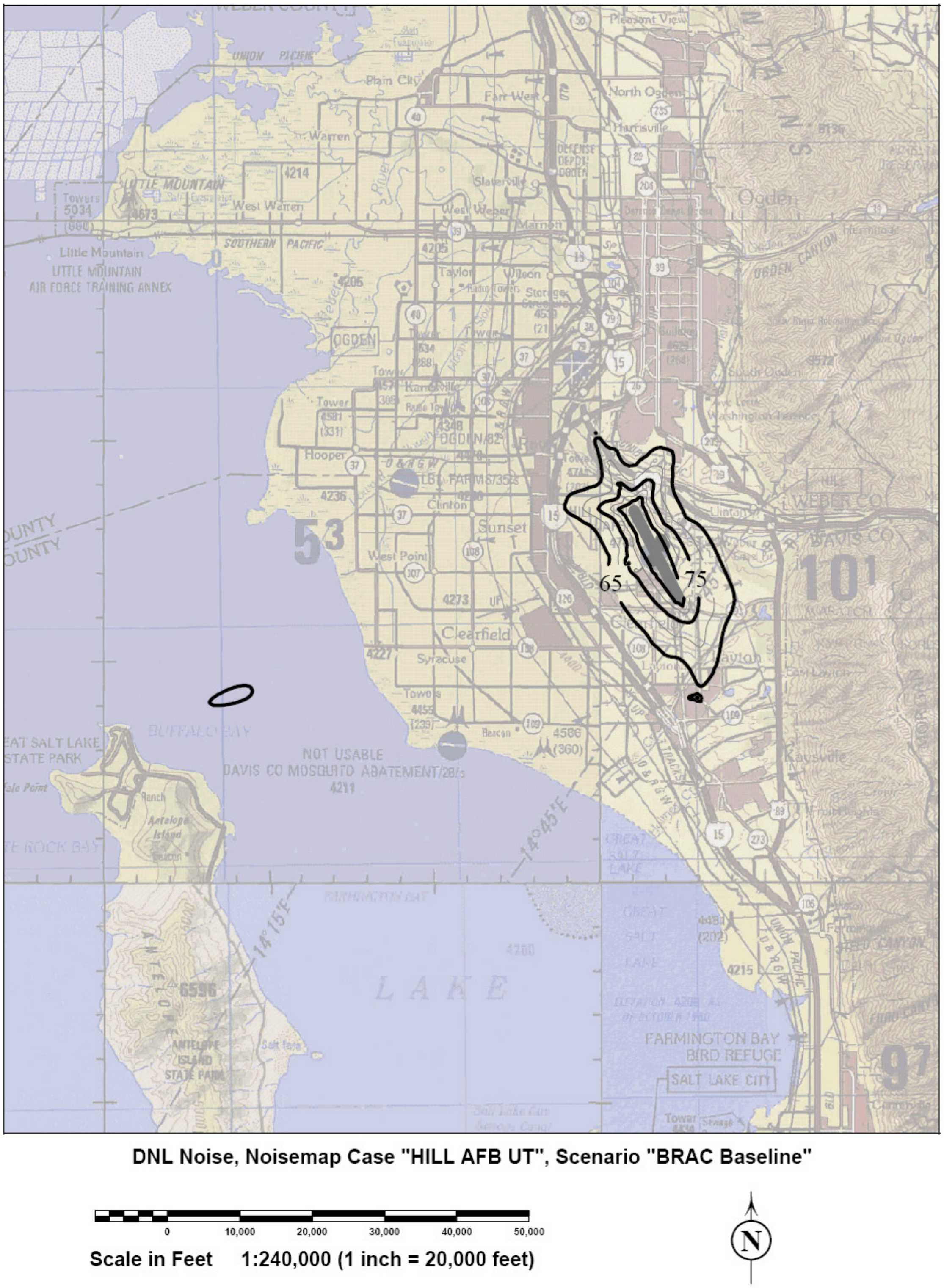
Figure 9 Ellsworth AFB AICUZ Contour Map

DNL Noise, Noisemap Case "ELMENDORF AFB AK", Scenario "BRAC Baseline"



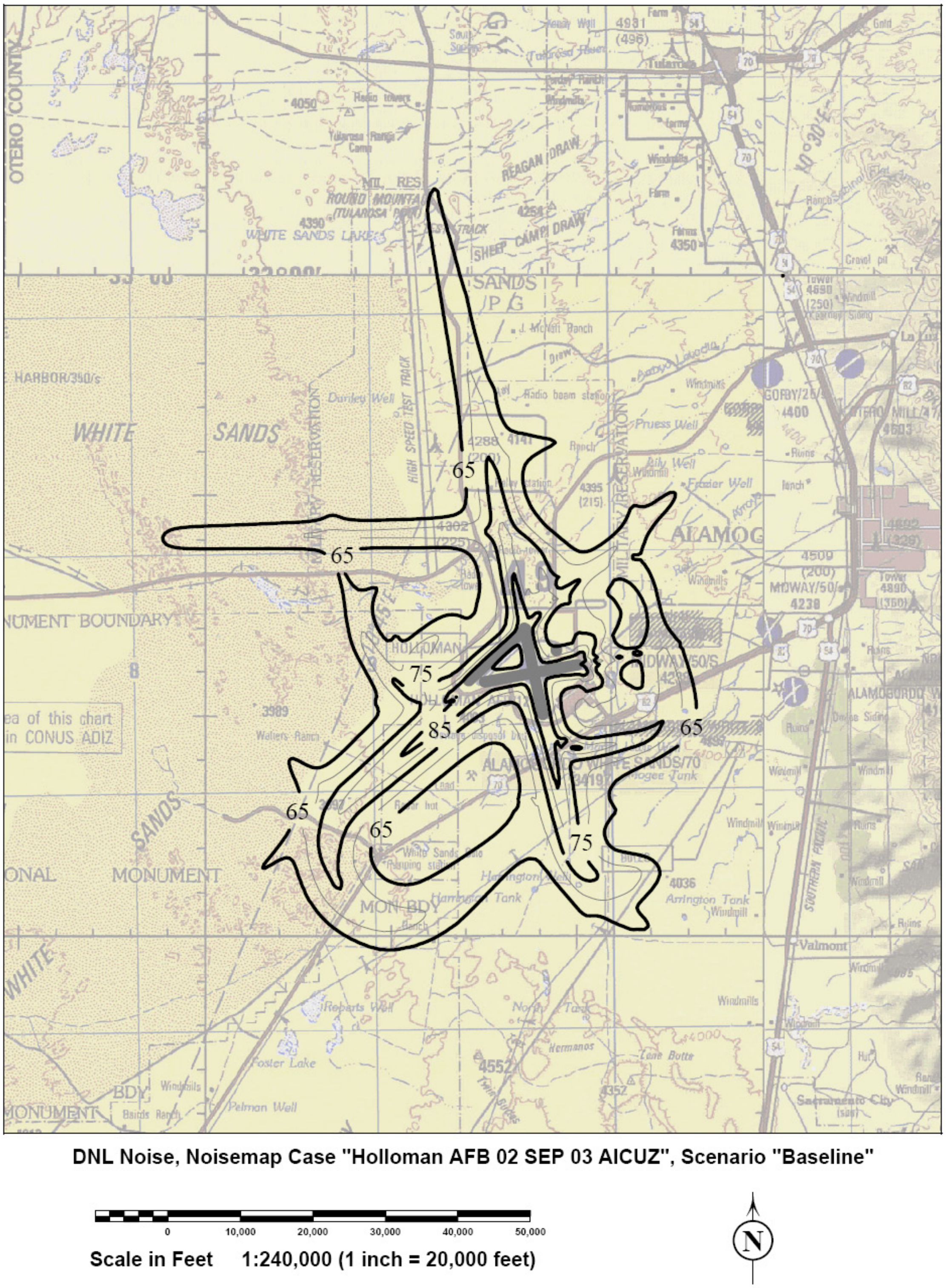
Scale in Feet 1:240,000 (1 inch = 20,000 feet)

Figure 10 Elmendorf AFB AICUZ Contour Map



DNL Noise, Noisemap Case "HILL AFB UT", Scenario "BRAC Baseline"

Figure 11 Hill AFB AICUZ Contour Map



DNL Noise, Noisemap Case "Holloman AFB 02 SEP 03 AICUZ", Scenario "Baseline"

Figure 12 Holloman AFB AICUZ Contour Map

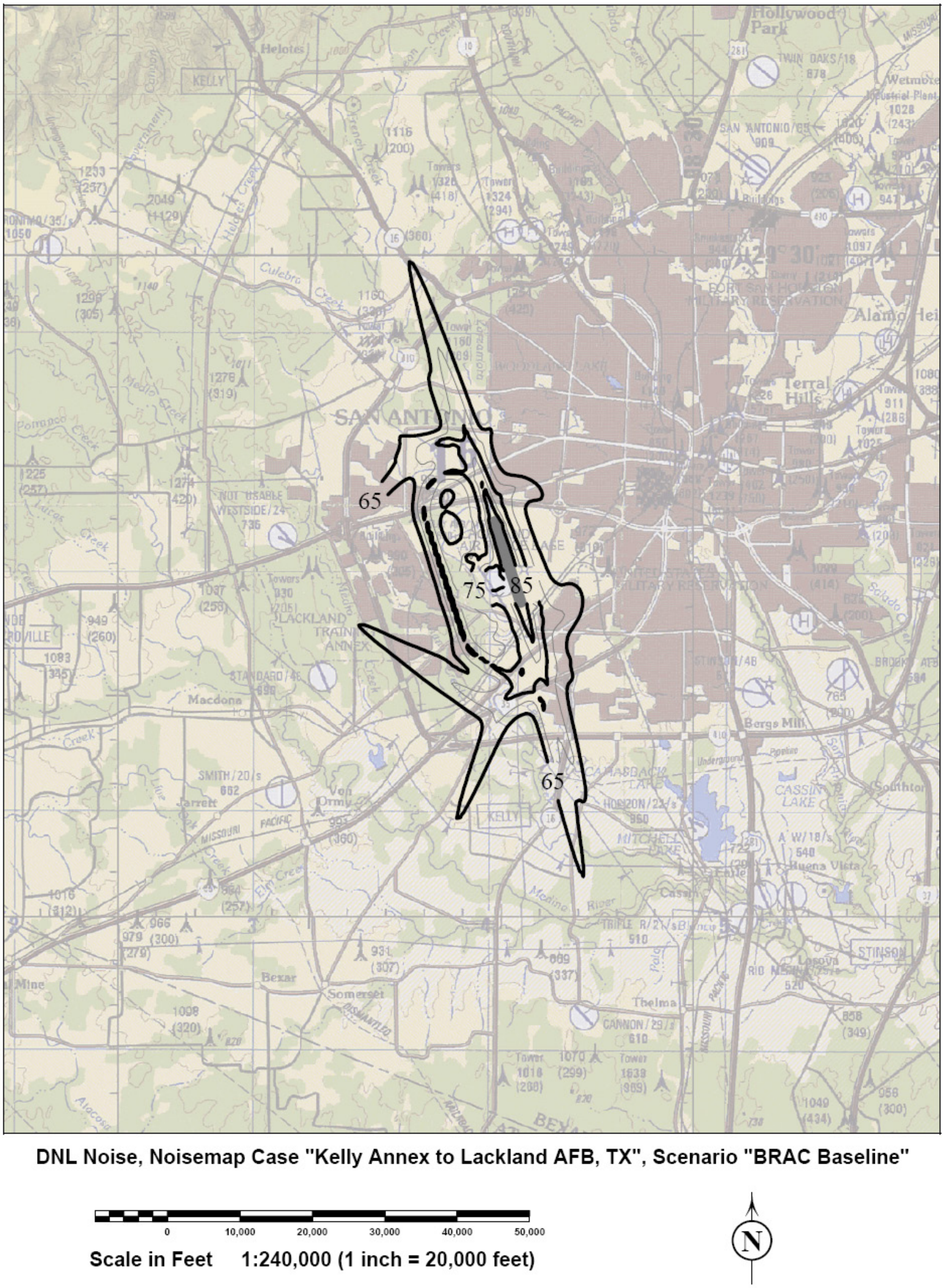


Figure 13 Lackland AFB AICUZ Contour Map

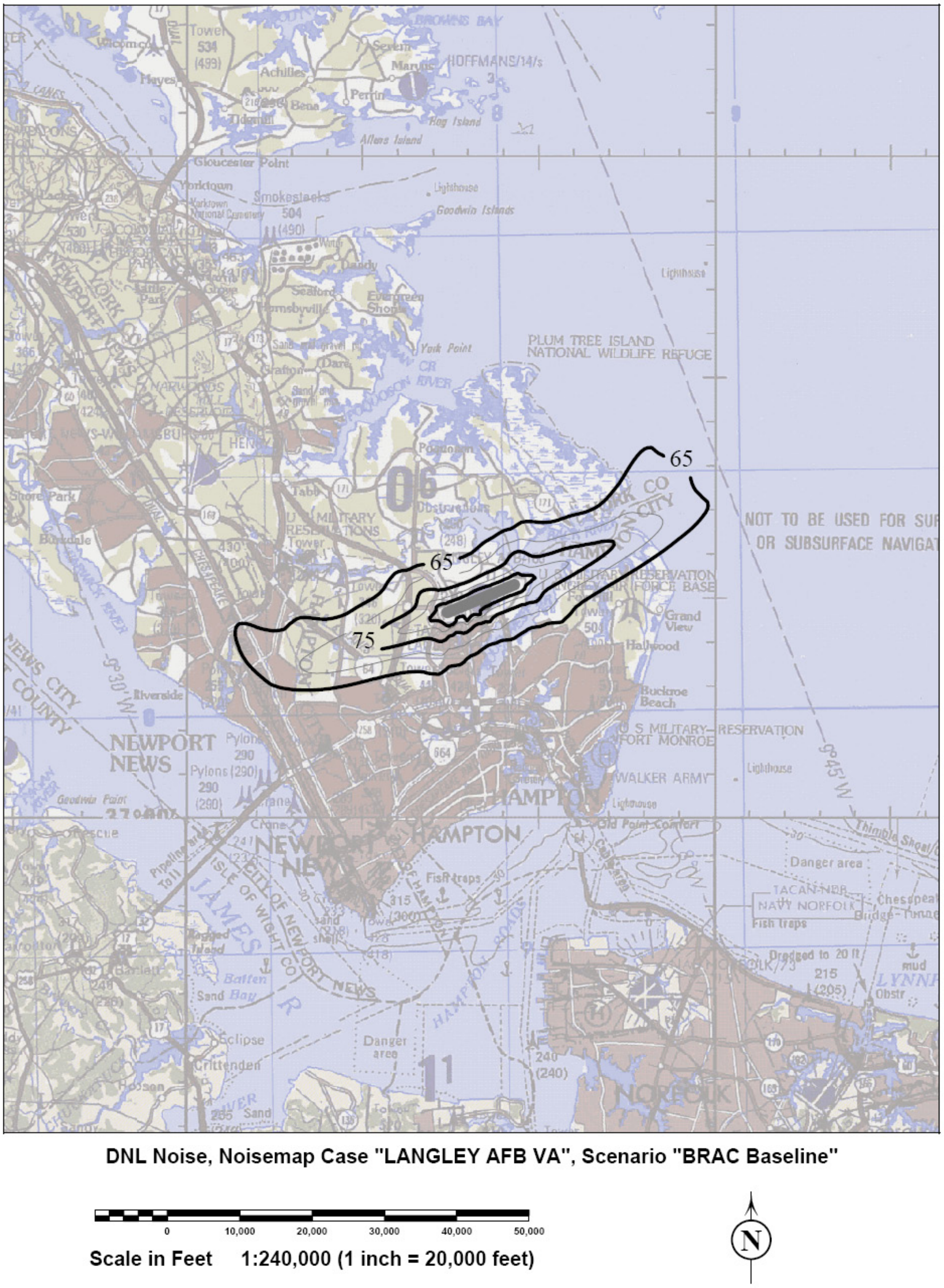


Figure 14 Langley AFB AICUZ Contour Map

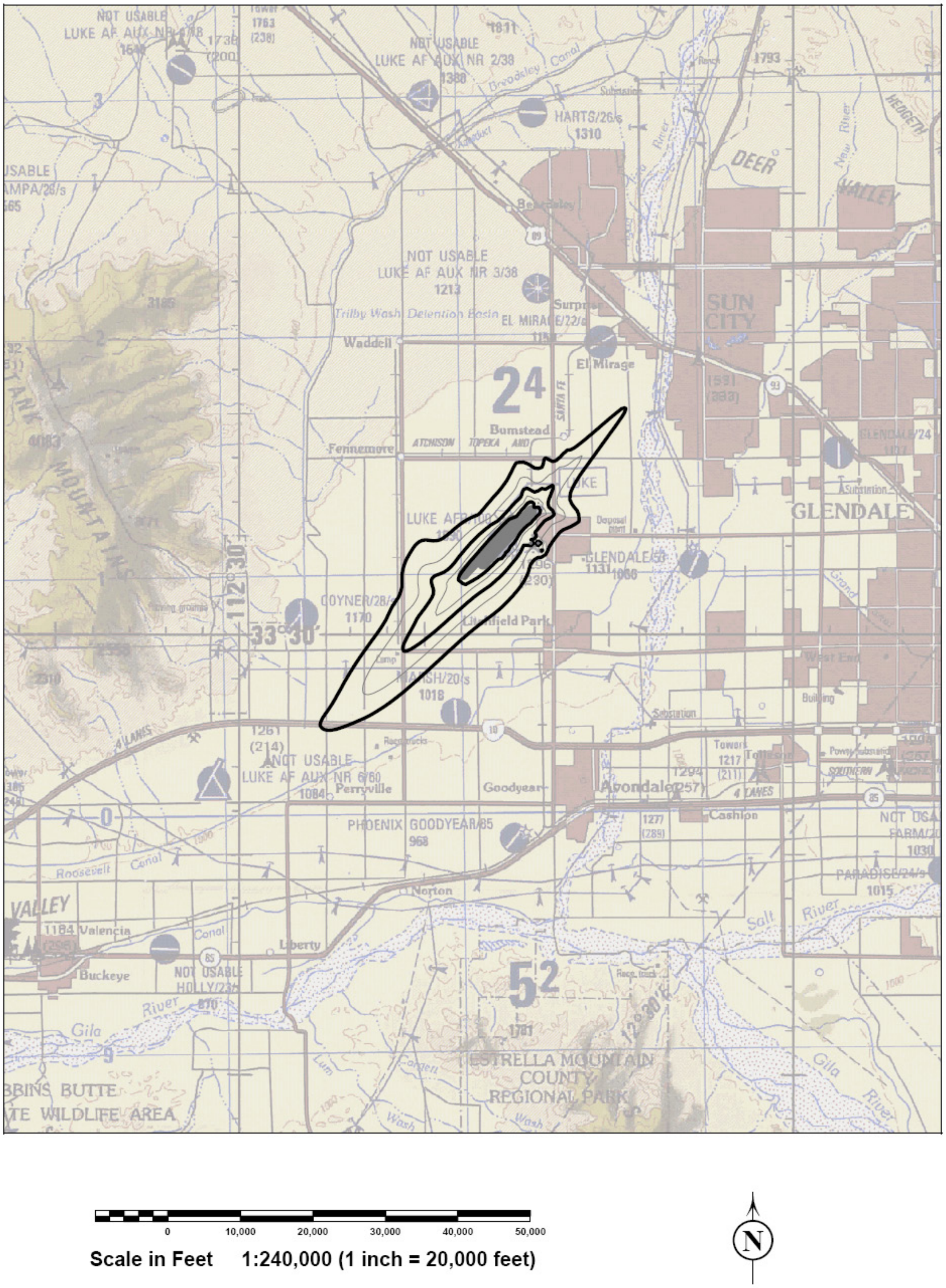
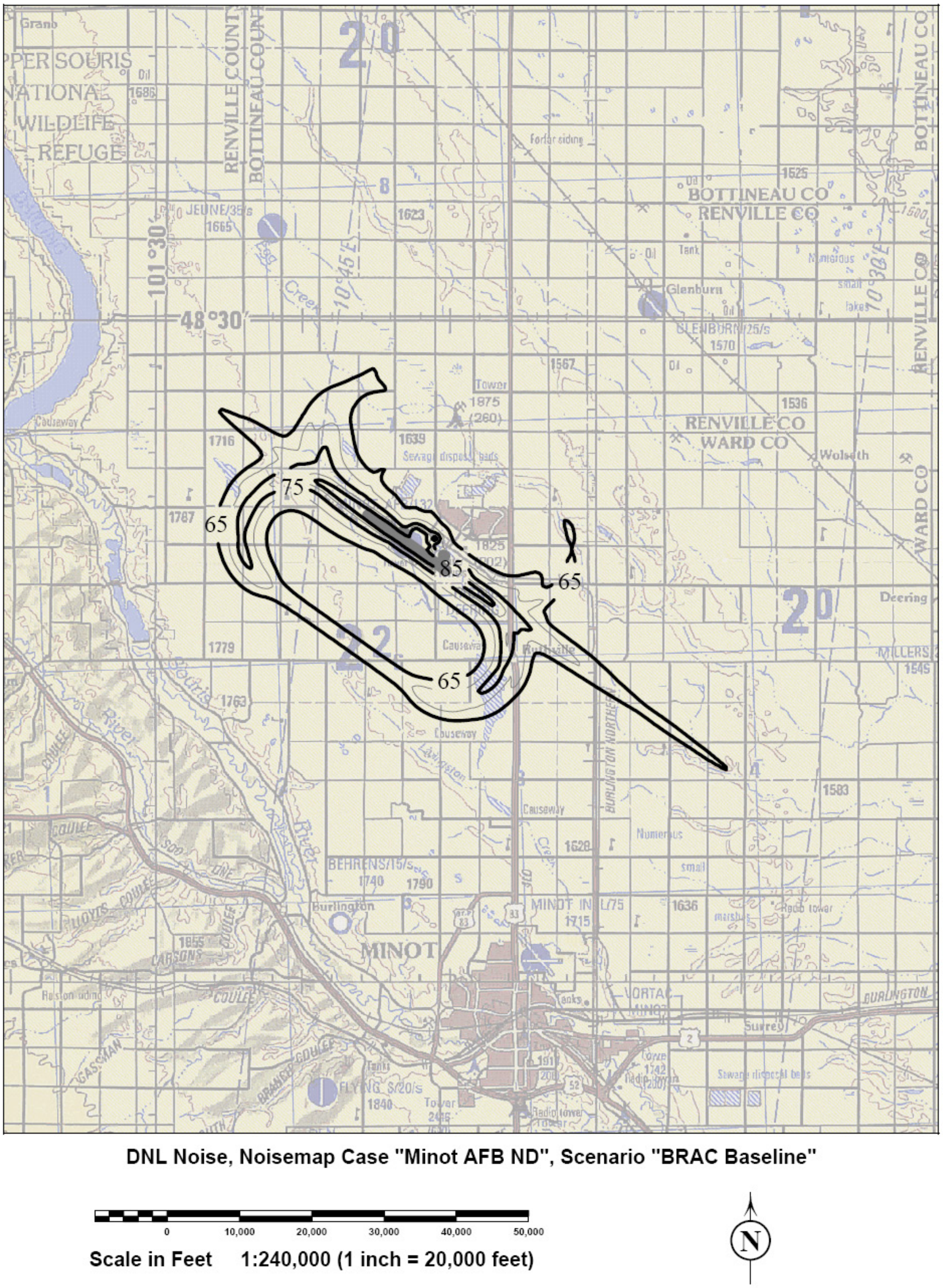
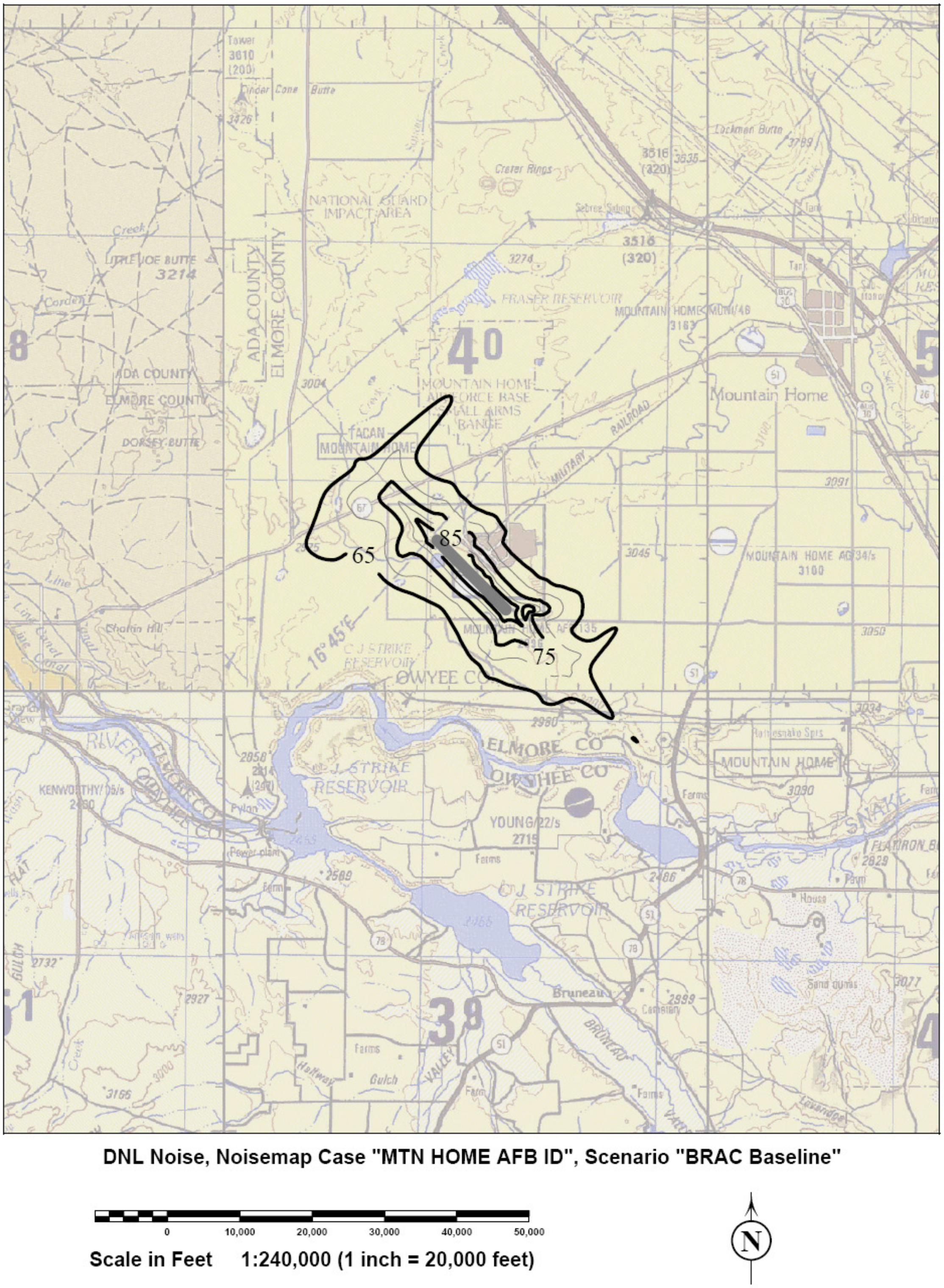


Figure 15 Luke AFB AICUZ Contour Map



DNL Noise, Noisemap Case "Minot AFB ND", Scenario "BRAC Baseline"

Figure 16 Minot AFB AICUZ Contour Map



DNL Noise, Noisemap Case "MTN HOME AFB ID", Scenario "BRAC Baseline"

Scale in Feet 1:240,000 (1 inch = 20,000 feet)

Figure 17 Mountain Home AFB AICUZ Contour Map

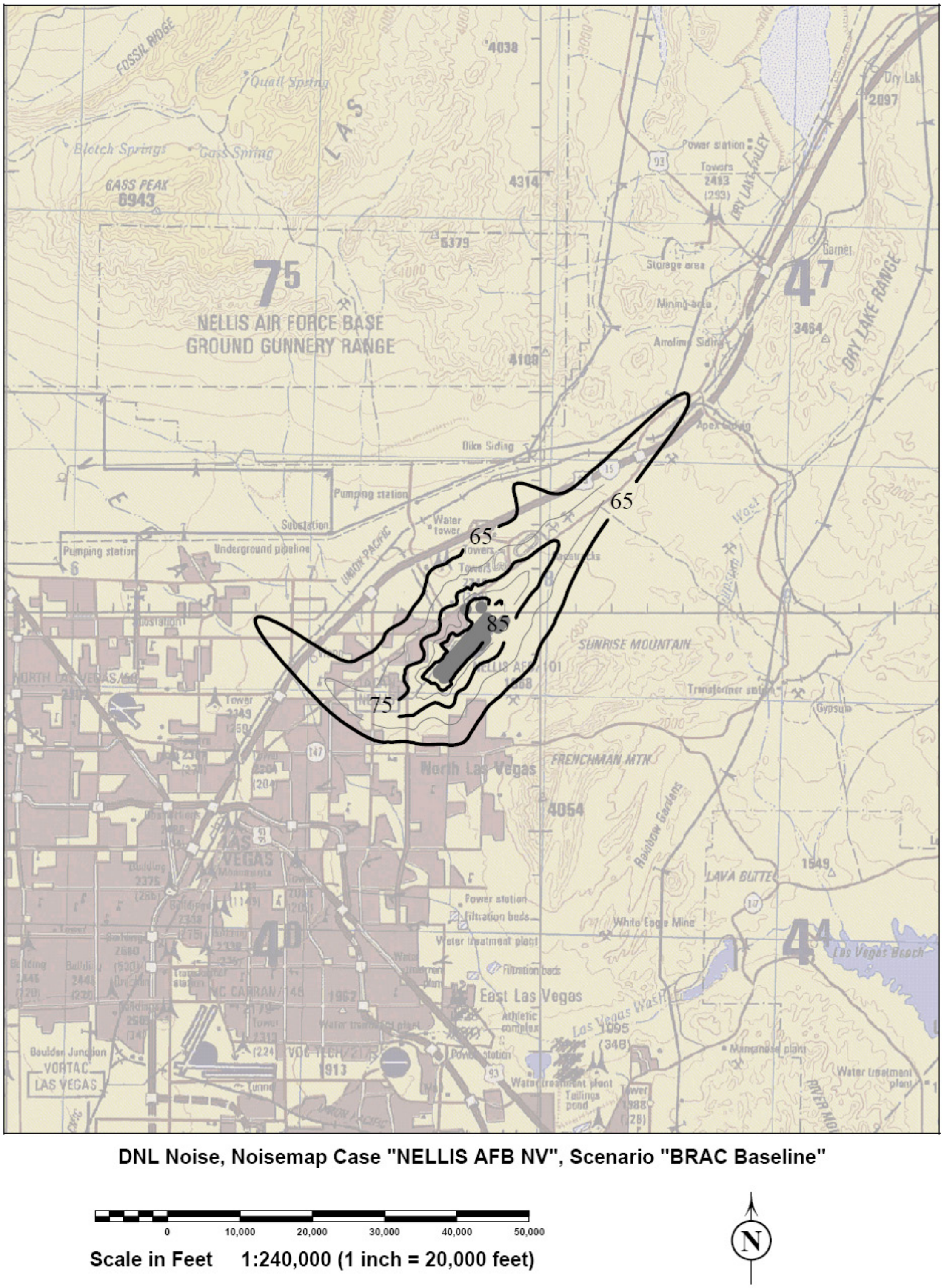


Figure 18 Nellis AFB AICUZ Contour Map

Figure 19 Seymour Johnson AFB AICUZ Contour Map

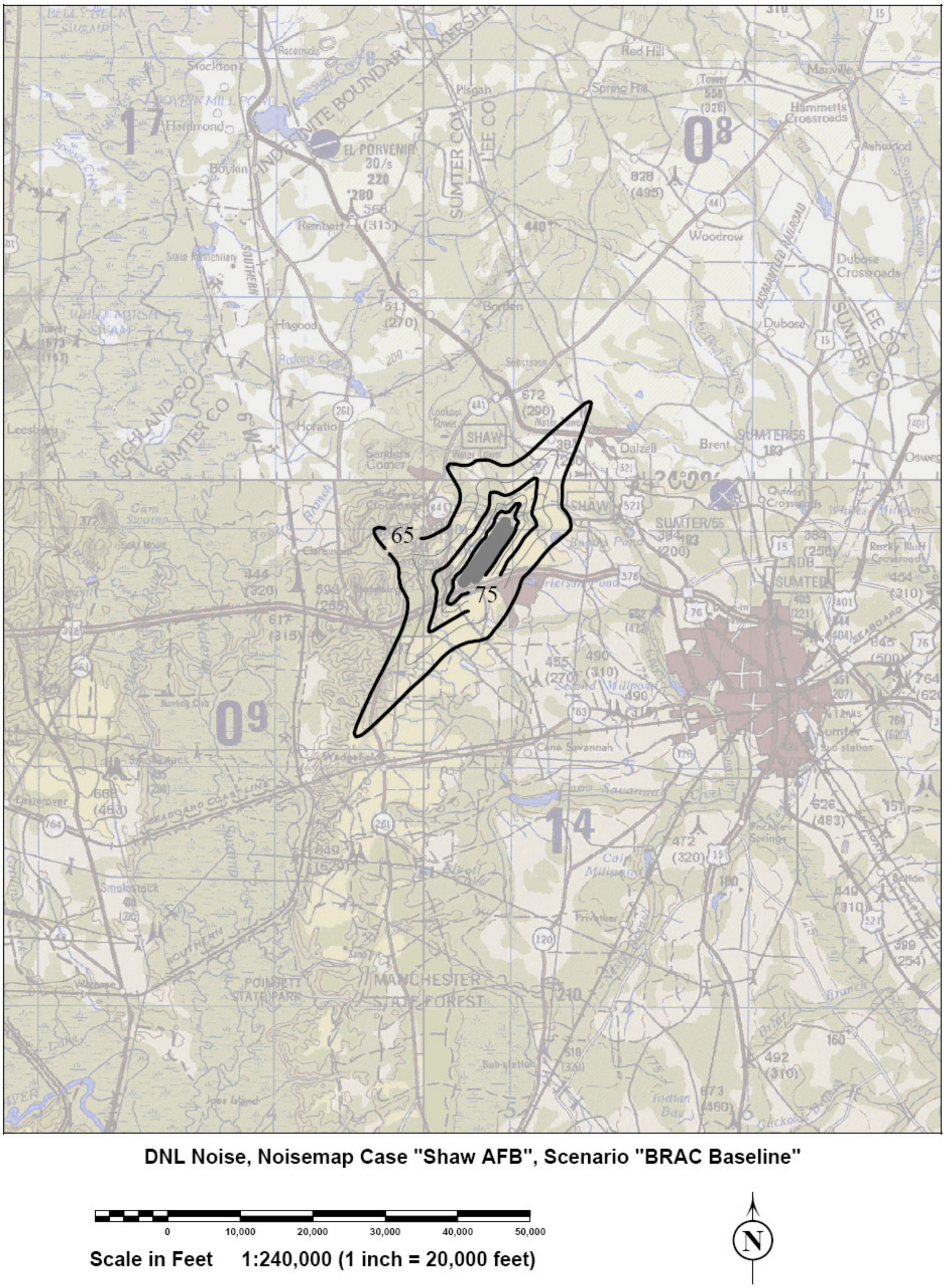


Figure 20 Shaw AFB AICUZ Contour Map

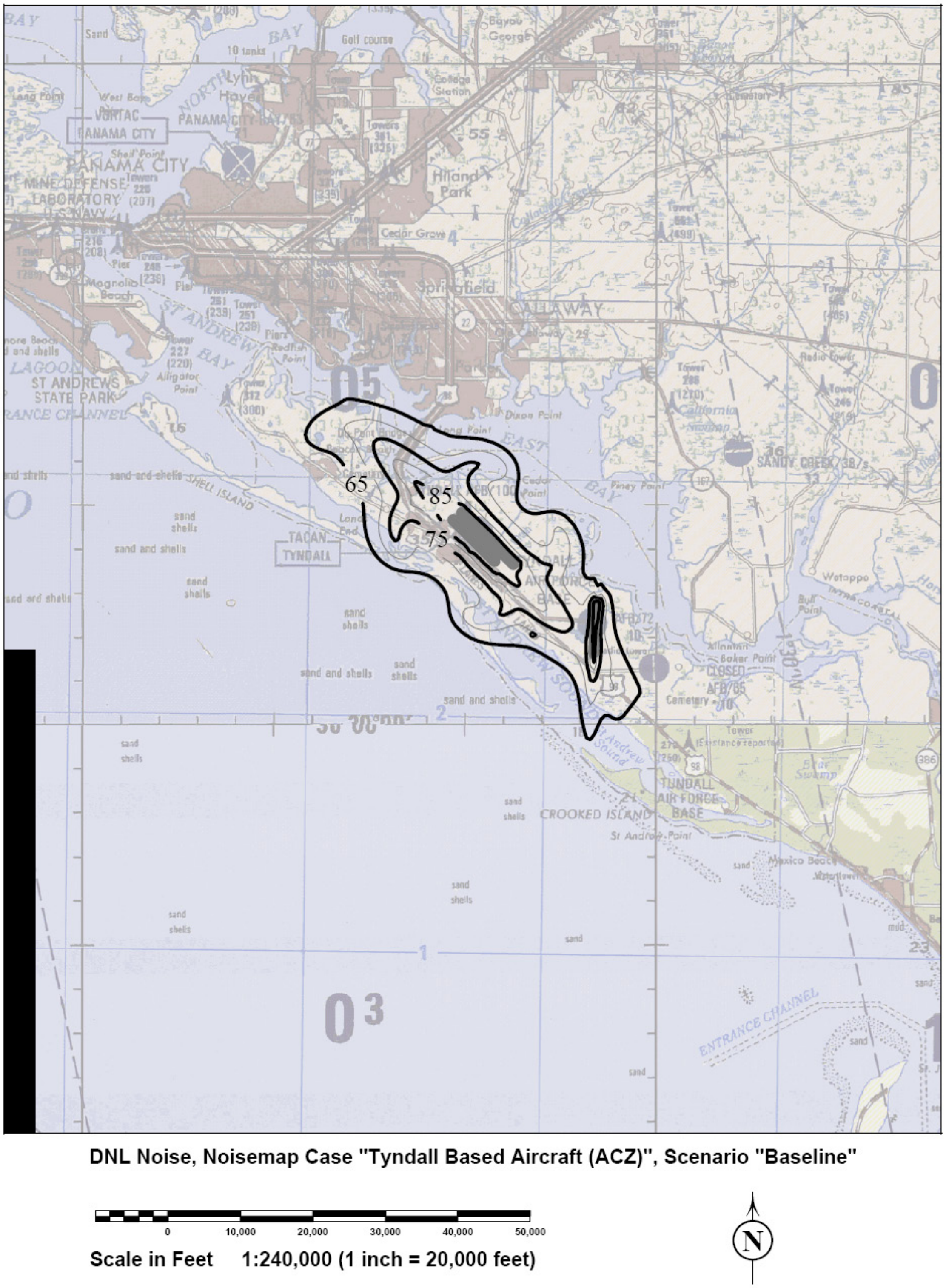


Figure 21 Tyndall AFB AICUZ Contour Map

Figure 22 Whiteman AFB AICUZ Contour Map

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Vita

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Her first assignment was at Travis AFB in January 2002. While there, she worked as a Project Programmer in the Engineering Flight and as Chief of Maintenance Engineering in the Operations Flight. In Aug 2004, she entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, she will be assigned to the 374th Civil Engineer Squadron at Yokota AB, Japan.

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14. ABSTRACT

The primary purpose of the research was to evaluate whether there was a significant difference in housing values of those affected by the noise of USAF aircraft. The secondary purpose was to evaluate whether there was a significant difference in housing values located near USAF bases with and without aircraft noise and to evaluate whether type of aircraft changed the results created by the aircraft noise. This research effort found that homes located within the 65 dB DNL contour of US Air Force installations showed a significant negative impact due to the presence of aircraft noise when studied with the hedonic pricing method of non-market valuation.

The results of this research show that current methods of noise mitigation are not adequately alleviating the disturbance that USAF aircraft noise causes local residences. This research effort was the first to evaluate a large number of USAF installations with the hedonic method. Previous studies concentrated on two individual bases. Because this study focused on all of the installations in ACC, it is able to draw conclusions for a larger set of installations. Future research needs to be accomplished in additional major commands to determine whether this is an AF-wide issue or command-specific.

15. SUBJECT TERMS

Aircraft Noise, Jet Engine Noise, Noise Reduction, Civil Engineering, Economics

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