



Air Installations Compatible Use Zones Study for MCAS Beaufort, 2013

Prepared by:
United States Department of the Navy
Naval Facilities Engineering Command Atlantic
Norfolk, Virginia



**AIR INSTALLATIONS COMPATIBLE USE ZONES STUDY
FOR
MARINE CORPS AIR STATION BEAUFORT**

SEPTEMBER 2013



Prepared by

UNITED STATES DEPARTMENT OF THE NAVY
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MCAS Beaufort

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ACRONYMS AND ABBREVIATIONS

- # -

2d MAW Second Marine Air Wing

- A -

AOD Airport Overlay District
 AICUZ Air Installations Compatible
 Use Zones
 ANSI American National Standards
 Institute
 APZ Accident Potential Zone
 ARTCC Air Route Traffic Control
 Center
 ATC Air Traffic Control
 AW All Weather

- B -

BASH bird/animal strike hazards
 BCOLT Beaufort County Open Land
 Trust
 BCRCL Beaufort County Rural and
 Critical Lands

- C -

CFA controlled firing area
 CFR Code of Federal Regulations
 CLC Combat Logistics Company
 CNEL Community Noise Exposure
 Level
 CP&LO Community Plans and Liaison
 Officer
 CY Calendar Year

- D -

dB decibels
 dBA A-weighted decibels
 DNL day-night average sound level
 DOD U.S. Department of Defense
 DON U.S. Department of the Navy

- E -

EA Environmental Assessment
 EIS Environmental Impact
 Statement
 EMI electromagnetic interference
 EPA U.S. Environmental Protection
 Agency
 EW/C Early Warning/Control

- F -

FAA Federal Aviation
 Administration
 FAR Federal Aviation Regulations
 FBO Forward Base Operations
 FCLP field carrier landing practice
 FHA Federal Housing Administration
 FICON Federal Interagency Committee
 on Noise
 FICUN Federal Interagency Committee
 on Urban Noise
 FRS Fleet Replacement Squadron

- G -

GCA ground control approach

MCAS Beaufort

- H -

H&HS	Headquarters and Headquarters Squadron
hp	horsepower
HQMC	Headquarters United States Marine Corps
HUD	Housing and Urban Development

- I -

IFR	instrument flight rules
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- J -

JLUS	Joint Land Use Study
JSF	Joint Strike Fighter

- L -

LCOG	Lowcountry Council of Governments
LHD	Landing Helicopter Deck

- M -

MACS	Marine Air Control Squadron
MAG	Marine Air Group
MALS	Marine Aviation Logistics Squadron
Marine Corps	U.S. Marine Corps
MAW	Marine Air Wing
MCAS	Marine Corps Air Station
MCO	Marine Corps Order
MCRD	Marine Corps Recruit Depot
MLS	Multiple Listing Service
MOA	military operating area
MPC	Metropolitan Planning Commission
mph	miles per hour
MSA	Metropolitan Statistical Area
MSL	mean sea level
MTR	military training route
MWSS	Marine Wing Support Squadron

- N -

NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Command
NEPA	National Environmental Policy Act
NHB	Naval Hospital Beaufort
NM	nautical miles

- O -

OCI	Office of Civic Investment
OMB	Office of Management and Budget
OPNAVINST	Chief of Naval Operations Instruction

- P -

PMTC-Det	Pacific Medical Test Center - Detachment
PTC	Pilot Training Center

- R -

ROD	Record of Decision
-----	--------------------

- S -

SPD	Special Planning District
STOVL	Short Take-Off and Vertical Landing
SUA	Special Use Airspace

- T -

TBR	Townsend Bombing Range
TDR	Transfer of Development Rights
TTR	Tactical Training Range

- U -

UDO	Unified Development Ordinance
U.S.C.	United States Code
USCB	U.S. Census Bureau
USMC	U.S. Marine Corps

- V -

VA	U.S. Department of Veterans Affairs
VFR	visual flight rules
VL	vertical landing
VMFA	Marine Fighter Attack Squadron

- W -

W-Areas	warning areas
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EXECUTIVE SUMMARY

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ES.2 MCAS Beaufort

ES.3 Aircraft Operations

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ES.6 Land Use Compatibility Analysis

ES.7 Land Use Tools and Recommendations

ES.8 Appendices

This Air Installations Compatible Use Zones (AICUZ) Study has been prepared in accordance with federal regulations and U.S. Department of the Navy (DON) and Headquarters United States Marine Corps (HQMC) instructions.

Analysis and findings presented in this AICUZ Study focus on the noise impact areas generated from aircraft operations and the aircraft safety zones surrounding the airfield's runways. The DON, HQMC, and Marine Corps Air Station (MCAS) Beaufort strive for compatible development within the noise and safety zones.

The 2003 AICUZ is used as the baseline conditions for comparison purposes in this 2013 AICUZ Study and the 2010 U.S. Marine Corps (USMC) East Coast F-35B Basing Final Environmental Impact Statement (EIS) (herein referred to as the *USMC F-35B East Coast Final EIS*) is used as the projected year, Calendar Year (CY) 2023, for this 2013 AICUZ Study. The 2013 AICUZ map defines the minimum recommended acceptable area within which land use controls are needed to protect the health, safety, and welfare of those living or working near MCAS Beaufort and to preserve the flying mission.

MCAS Beaufort is committed to working with the surrounding communities to ensure a mutually safe environment in which to live and work, while continuing to meet the mission of the installation.

ES.1 PURPOSE OF AN AICUZ STUDY

The purpose of this AICUZ Study is to achieve land use compatibility between MCAS Beaufort and the neighboring communities. In the early 1970s, the U.S. Department of Defense (DOD) established the AICUZ Program to balance the

need for aircraft operations and community concerns over aircraft noise and accident potential. Today, the AICUZ Program is considered a vital tool used by all branches of the military to communicate with surrounding individuals, communities, counties, and municipalities to educate, inform, and present areas of incompatible land use surrounding military airfields.

This AICUZ Study provides background information on MCAS Beaufort, presents noise contours and zones associated with projected aircraft operations, establishes aircraft Accident Potential Zones (APZs) and locates areas of incompatible land uses within these zones, and recommends action to encourage compatible land use.

ES.2 MCAS BEAUFORT

MCAS Beaufort is located in South Carolina's Coastal Region (the Lowcountry), within the City of Beaufort in Beaufort County. The installation is comprised of 6,949 acres at the main site, 971 acres at Laurel Bay Family Housing, located in Beaufort County, and 5,183 acres at the Townsend Bombing Range (TBR) in McIntosh County, Georgia. The airfield at MCAS Beaufort is Merritt Field, named in honor of Major General Lewie Griffith Merritt.

MCAS Beaufort's mission is to provide support as an operational base for Marine Aircraft Group (MAG)-31 and its associated squadrons, and Marine Corps support units. MAG-31 conducts anti-air-warfare and offensive air support operations from advanced bases, expeditionary airfields, or aircraft carriers, and conducts such other air operations as directed.

ES.3 AIRCRAFT OPERATIONS

Aircraft that currently utilize MCAS Beaufort include the Marine Corps F-18 A/C/D (F/A-18) Hornet and the UC-12M. As presented in the *USMC F-35B East Coast Final EIS*, the F-35B Joint Strike Fighter (JSF) will be the primary aircraft on station by CY 2025, and there will be no change to the existing UC-12B aircraft on

station. In addition to the permanently stationed aircraft, there is a variety of transient aircraft that also utilize MCAS Beaufort.

Aircraft operations are integral to this AICUZ Study because they are the primary source of noise associated with the installation. The level of noise exposure is related to a number of variables including the aircraft type, engine power setting, altitudes flown, direction of the aircraft, duration of maintenance run-ups, flight tracks, temperature, relative humidity, frequency, and time of operations.

Operations conducted at MCAS Beaufort for the F-35B were derived from data provided and approved by the Marine Corps and are based on best available estimates of the training syllabus for this new aircraft. Typical flight operations to be conducted by aviators at MCAS Beaufort for the F-35B include conventional departures and landings, and short-take-off and vertical landings (STOVL) including slow approach, rolling vertical landings, and vertical landings. Operators will also conduct pattern operations including touch-and-gos, ground control approach (GCA), and field carrier landing practice (FCLP).

ES.4 AIRCRAFT NOISE

The main source of noise at an air installation is from ground engine maintenance “run-up” operations and flight operations. The *USMC F-35B East Coast Final EIS* incorporated both sources of noise to develop installation-specific noise contours for MCAS Beaufort based on the CY 2025 projected operations. The noise contours developed for the *USMC F-35B East Coast Final EIS* are used in this AICUZ Study as the 2013 AICUZ noise contours which project aircraft operations through CY 2023. The noise exposure from aircraft at MCAS Beaufort, as with other installations, is measured using the day-night average sound level (DNL) noise metric. The DNL is depicted visually as a noise contour that connects points of equal value. The noise contours were developed using the DOD approved noise model, NOISEMAP, and incorporated data collected from MCAS Beaufort and the Marine Corps.

The AICUZ Program generally divides noise exposure into three categories, known as noise zones, and provides land use control recommendations. These noise

zones provide the basis for identifying incompatible land use around an airfield. Noise contours and noise zones have been identified for MCAS Beaufort, and parcel-specific land use analysis has been conducted and presented in this AICUZ Study.

ES.5 AIRFIELD SAFETY

While the likelihood of an aircraft mishap occurring is remote, the Marine Corps identifies areas of accident potential to assist in land use planning. The Marine Corps has identified APZs around its runways. The Marine Corps recommends certain land uses that concentrate large numbers of people (e.g., apartments, churches and schools) be constructed outside APZs. The components of standard APZs, as applicable for MCAS Beaufort, are the Clear Zone, APZ I, and APZ II. An accident is more likely to occur in the Clear Zone than in APZ I or APZ II, and is more likely to occur in APZ I than APZ II.

APZs are developed, in part, on the number of annual operations conducted on a runway per flight track. AICUZ guidance (OPNAVINST 11010.36C/Marine Corps Order [MCO] 11010.16), provides a threshold at which APZs are required. APZs were presented for MCAS Beaufort as part of the *USMC F-35B East Coast Final EIS* and are presented in this AICUZ Study as the 2013 APZs.

ES.6 LAND USE COMPATIBILITY ANALYSIS

A composite noise contour and APZ map is developed and overlaid on an aerial photograph to graphically depict the 2013 AICUZ footprint for MCAS Beaufort. The Marine Corps has developed land use compatibility recommendations within noise zones and APZs. While some land uses are considered incompatible, certain land uses are considered compatible within APZs and high-noise zones. This AICUZ Study incorporates city and county land use and zoning regulations and documents as the basis for identifying existing and land use and zoning. Land use compatibility concerns for the area surrounding MCAS Beaufort are identified in this AICUZ Study and recommendations for compatible land use are provided.

ES.7 LAND USE TOOLS AND RECOMMENDATIONS

The federal government, state/regional governments, local governments, private citizens, business, and real estate developers, along with the Marine Corps, all play an important role in the implementation of the AICUZ Study. There are numerous laws, regulations, programs, and initiatives in place at these various levels of government that can assist in AICUZ implementation and overall land use compatibility management. It is critical that the major stakeholders involved with AICUZ issues be aware of these programs and the potential beneficial impact that they can have on MCAS Beaufort's program and to the community. The AICUZ footprint should be incorporated into Beaufort County's land use and zoning process to best guide compatible development around the installation.

ES.8 APPENDICES

The following appendices are provided as reference to the end of this AICUZ Study.

- Appendix A: Discussion of Noise and its Effect on the Environment
- Appendix B: Land Use Compatibility Recommendations
- Appendix C: MCAS Beaufort Online Noise Report Form
- Appendix D: AICUZ Disclosure Statement Form

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- 1.1 AICUZ Program
- 1.2 Purpose, Scope, and Authority
- 1.3 Responsibility for Compatible Land Use
- 1.4 Previous AICUZ Efforts and Related Studies
- 1.5 Changes that Require an AICUZ Update

INTRODUCTION

Many areas throughout the United States have experienced population growth and increased development in proximity to a military installation, as is the case with Marine Corps Air Station (MCAS) Beaufort. This growth typically takes the form of new residential development and expanded commercial development. New homes are constructed near an installation to allow both military and civilian personnel who work at a base to live near their employer. Similarly, businesses are established in proximity to these homes and the military installation to support the installation and its personnel and to service new residential growth. Development located near an installation may be incompatible with aircraft and other military operations that occur at the base and, over time or if not managed appropriately, can result in nearby residents, businesses, and/or military operations being adversely impacted.

The U.S. Marine Corps (USMC, or Marine Corps) actively supports programs to minimize incompatible development and noise impacts, including the requirement that each MCAS implement and maintain an Air Installations Compatible Use Zones (AICUZ) Program. The AICUZ Program was instituted by the U.S. Department of Defense (DOD) in response to incompatible development around military airfields across the country and to help governmental entities and communities anticipate, identify, and promote compatible land use and development near military installations. While also protecting the operational capabilities of the military, the goal of this Program is to protect the health, safety, and welfare of the public. This goal is accomplished by achieving compatible land use patterns and activities around an air installation.

The AICUZ Program recommends that noise contours, Accident Potential Zones (APZs), height obstruction criteria, and associated land use recommendations be incorporated into local community planning programs in order to minimize

impacts to the mission and the residents in the surrounding community. Mutual cooperation between military airfield planners and community-based counterparts serves to increase public awareness of the importance of air installations and the need to address mission requirements and associated noise and risk factors. As the communities that surround airfields grow and develop, the U.S. Department of the Navy (DON) and the Marine Corps have the responsibility to communicate and collaborate with the local government on land use planning, zoning, and similar matters that could affect the installations' operations or missions.

This 2013 AICUZ Study has been prepared for MCAS Beaufort, Beaufort County, South Carolina and is an update of the 2003 AICUZ Study. This AICUZ Study has been prepared in consideration of both past and expected changes in mission, aircraft, and projected operational levels that will occur within the next 10-year planning period, as presented in the October 2010 *USMC East Coast F-35B Basing Final Environmental Impact Statement* (DON 2010).

This AICUZ Study provides background on the AICUZ Program, historical data from the previous AICUZ Study and other related documents, and changes that require an AICUZ Update (Chapter 1). Chapter 2 describes the location and installation features of MCAS Beaufort, including air space and operational areas. Aircraft types, operations, and flight tracks are discussed in Chapter 3. Chapter 4 presents the updated aircraft noise contours, outlining the methodology for determining noise, what changes have occurred, and what the future expectations are for change, as well as what measures have been implemented by the Marine Corps to mitigate any community noise concerns. Aircraft safety issues and the development of APZs are discussed in Chapter 5. Chapter 6 evaluates the compatibility of both current and proposed land uses, as provided by local governments. Chapter 7 provides recommendations for promoting land use compatibility consistent with the goals of the AICUZ Program, and the last section, Chapter 8, is a list of references used in this AICUZ Study.

The goal of the AICUZ Program is to protect military operational capabilities while also protecting the health, welfare, and safety of the public.

This goal is accomplished by achieving compatible land use patterns and activities in the vicinity of a military installation.

1.1 AICUZ PROGRAM

In the early 1970s, the DOD established the AICUZ Program to balance the need for aircraft operations with community concerns over aircraft noise and accident potential. The AICUZ Program was developed in response to growing incompatible urban development around military airfields. The objectives of the AICUZ Program, according to the Chief of Naval Operations Instruction (OPNAVINST) 11010.36C/Marine Corps Order (MCO) 11010.16, are as follows:

- To protect the health, safety, and welfare of civilians and military personnel by encouraging land use that is compatible with aircraft operations;
- To reduce noise impacts caused by aircraft operations while meeting operational, training, and flight safety requirements, both on and in the vicinity of air installations;
- To inform the public and seek cooperative efforts to minimize noise and aircraft accident potential impacts by promoting compatible development; and
- To protect DON and Marine Corps installation investments by safeguarding the installations' operational capabilities.

The Federal Aviation Administration (FAA) and DOD have developed specific instructions and guidance to encourage local communities to restrict development or land uses that could endanger aircraft in the vicinity of an airfield, including: lighting (direct or reflected) that would impair pilot vision; towers, tall structures, and vegetation that penetrate navigable airspace or are constructed near the airfield; development that generate smoke, steam, or dust; uses that attract birds, especially waterfowl; and electromagnetic interference (EMI) sources that may adversely affect aircraft communication, navigation, or other electrical systems. Noise zones and APZs represent and identify areas of concern for the air installation and local planning departments. Since noise zones and APZs often extend beyond the "fence line" of the installation, presenting the most current noise zones and APZs to local planners is essential to fostering mutually beneficial land uses and

Development/Land Uses that could Endanger Aircraft and Pilots

- Lighting that impairs pilot vision
- Towers, tall structures, and vegetation that penetrate airspace
- Development that generates smoke, steam, or dust
- Uses that attract birds
- EMI sources

development. It is a goal of the AICUZ Program to have noise zones and APZs adopted by the local planning department(s) in order to incorporate development criteria in areas around the base.

1.2 PURPOSE, SCOPE, AND AUTHORITY

The purpose of the AICUZ Program is to achieve compatibility between air installations and neighboring communities. OPNAVINST 11010.36C/MCO 11010.16 is the current DON and Marine Corps Instruction document that governs the AICUZ Program. The Marine Corps works with local communities to promote compatible development of lands adjacent to the installation. The scope of the AICUZ Study includes an analysis of:

- Aircraft noise zones for projected year 2023;
- Aircraft APZs for projected year 2023;
- Land use compatibility;
- Historic and current aircraft operations; and
- Possible solutions to existing and potential incompatible land use problems.

The authority for the establishment and implementation of the MCAS Beaufort AICUZ Program is derived from:

- DOD Instruction 4165.57, “Air Installations Compatible Use Zones,” dated May 2, 2011;
- OPNAVINST 11010.36C/MCO 11010.16, “Air Installations Compatible Use Zones Program,” dated October 9, 2008;
- Unified Facilities Criteria 3-260-01, “Airfield and Heliport Planning and Design,” dated November 17, 2008;
- Naval Facilities Engineering Command (NAVFAC) P-80.3, “Facility Planning Factor Criteria for DON and Marine Corps Shore Installations: Airfield Safety Clearances,” dated January 1982; and

OPNAVINST 11010.36C/MCO 11010.16 is the current DON and USMC guidance document that governs the AICUZ Program.

- United States Department of Transportation, FAA Regulations, Code of Federal Regulations (CFR), Title 14, Part 77, “Objects Affecting Navigable Airspace.”

As the surrounding community continues to grow, more people are potentially exposed to noise and accident potential associated with aircraft operations. The AICUZ Study uses an analysis of community development trends, land use tools, and mission requirements at the airfield to recommend strategies for communities to prevent incompatible land development. Implementation of the AICUZ Program requires cooperation between the installation commander, local governments, non-governmental groups, and the community at large.

1.3 RESPONSIBILITY FOR COMPATIBLE LAND USE

Ensuring land use compatibility within the AICUZ is the responsibility of many organizations, including the DOD and Marine Corps, the local air station, local planning and zoning agencies, real estate agencies, residents, and developers. Military installations can advise the local government and agencies on land use near an installation, but it is the local government and agencies that have the authority to preserve land use compatibility outside the fence line. Cooperative action by all parties is essential in preventing land use incompatibility and hazards. Table 1-1 identifies key responsibilities for various community stakeholders with respect to AICUZ and land use compatibility.

Military installations can make recommendations or advise local governments and agencies on land use near an installation, but it is the local government and agencies that have the planning and zoning authority to preserve land use compatibility near the military installation.

Table 1-1 Responsibility for Compatible Land Uses

Marine Corps	<ul style="list-style-type: none">• Work with local governments and private citizens.• Monitor operations and noise inquiries.• Examine local land uses and growth trends.• Conduct noise and APZ studies.• Release an AICUZ Study.• Update AICUZ studies, as required.• Make land use recommendations.• Examine air mission for operational changes that could reduce impacts.
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Table 1-1 Responsibility for Compatible Land Uses

Local Government	<ul style="list-style-type: none"> • Incorporate AICUZ guidelines into a comprehensive development plan and zoning ordinance. • Regulate height and obstruction concerns through an airport ordinance. • Require fair disclosure in real estate for all buyers, renters, lessees, and developers.
Private Citizens	<ul style="list-style-type: none"> • Seek information and self-education on the established zones and what impacts they may cause to an individual. • Identify AICUZ considerations in all property transactions. • Understand AICUZ effects before buying, renting, leasing, or developing property.
Real Estate Professionals	<ul style="list-style-type: none"> • Ensure potential buyers and lessees receive and understand AICUZ information on affected properties. • When working with builders/developers, ensure an understanding and evaluation of the AICUZ Program.
Builders/Developers	<ul style="list-style-type: none"> • Develop properties in a manner that appropriately protects the health, safety, and welfare of the civilian population by constructing facilities which are compatible with aircraft operations (e.g., sound attenuation features, densities, and compatible businesses).

1.4 PREVIOUS AICUZ EFFORTS AND RELATED STUDIES

The original, complete AICUZ for MCAS Beaufort was approved by Headquarters United States Marine Corps (HQMC) and published in 1976. Since the original publication date, the AICUZ Study has been revised based on additional noise studies and surveys, AICUZ updates, installation planning documents, and environmental assessments between 1984 and 2010. These studies were developed to account for changes in aircraft that were being used at the installation, changes in operational parameters such as revised flight tracks, and changes derived from

revisions to the Marine Corps AICUZ Instruction. The following list highlights significant documents that present noise contours for MCAS Beaufort. A timeline with a brief summary and the relevance of each document is provided.

Previous AICUZ Efforts and Related Studies

1976	AICUZ Study for MCAS Beaufort
1984	Addendum to the 1976 AICUZ Study
1994	AICUZ Study Update
2003	AICUZ Study Update
2010	USMC East Coast F-35B Basing FEIS

1976 – AICUZ Study for Marine Corps Air Station Beaufort

This original AICUZ Study was prepared in response to DODINST 4165.57 and was approved for implementation by HQMC in 1976. This Study established the AICUZ footprint for the airfield and provided strategies for compatible land use.

1984 – Addendum to the 1976 AICUZ Study

This Addendum was prepared to revise the composite AICUZ footprint (i.e., APZs and noise contours) in response to changes in facilities, aircraft operations, and runway utilization. A land use compatibility implementation program and methods for mitigating land use incompatibility within the AICUZ were recommended as part of the 1984 Addendum in response to changes in aircraft type (F-18 arrivals).

1994 – AICUZ Study Update

This Study was conducted as an update to the original AICUZ Study and the 1984 Addendum.

2003 – AICUZ Study Update

This Study served as an update to the 1994 AICUZ Study, and the noise contours and APZs represented the prospective year 2007.

2010 – U.S. Marine Corps East Coast F-35B Basing Final Environmental Impact Statement

The Marine Corps prepared an Environmental Impact Statement (EIS) to assess the potential environmental impacts of basing the F-35B on the East Coast of the United States. The F-35B is considered the “next generation” fighter/attack aircraft and the future of Marine Corps aviation. This aircraft would replace the legacy F/A-18A/C/D (F/A-18) Hornet and AV-8B Harrier aircraft in the Second Marine Air Wing (2d MAW) currently based at both MCAS Beaufort, South Carolina and MCAS Cherry Point, North Carolina. Per the December 2010 Record of Decision (ROD), the DON decided to base three F-35B operational squadrons and the Pilot Training Center (PTC) at MCAS Beaufort. As part of the EIS, a noise study

The USMC East Coast F-35B Basing Final EIS Preferred Alternative includes three F-35B operational squadrons and the Pilot Training Center at MCAS Beaufort.

was conducted which modeled the Preferred Alternative. Projected year 2023 noise contours and APZs were developed as part of the EIS analysis.

The 2003 AICUZ Study is used as the baseline conditions for comparison purposes in this 2013 AICUZ Study, and the 2010 USMC East Coast F-35B Basing Final EIS (herein referred to as the *USMC F-35B East Coast Final EIS*) is used as the projected year, 2023, for this 2013 AICUZ Study.

1.5 CHANGES THAT REQUIRE AN AICUZ UPDATE

AICUZ studies should be updated when an air installation has a change in the type of aircraft at the installation, a significant change in operations (i.e., the number of take-offs and landings or significant increases in nighttime [2200 to 0700 hours] flying activities), or changes in flight paths or procedures.

Since publication of the 2003 AICUZ Study, the DON has determined the basing of the Marine Corps variant of the Joint Strike Fighter (JSF), F-35B, with one location being MCAS Beaufort. In addition, the AICUZ Instruction, OPNAVINST 11010.36C/MCO 11010.16, has been updated since the 2003 AICUZ Study, thus providing guidance and instruction in this AICUZ Study that was not considered in the previous study. In accordance with OPNAVINST 11010.36C/MCO 11010.16, this AICUZ Study has been prepared to reflect flight tracks, APZs, and operations projected for Calendar Year (CY) 2023.

1.5.1 Changes in Aircraft Mix

A significant change in aircraft mix has occurred since the publication of the 2003 AICUZ Study. The 2003 AICUZ Study was developed to present projected CY 2007 operations, which presented the F/A-18 as the primary aircraft at MCAS Beaufort. The USMC anticipates significant changes in aircraft operating at MCAS Beaufort through the CY 2023 timeframe (DON 2010). As a result, this 2013 AICUZ Study assumes that the F-35B will replace the F/A-18 and become the primary aircraft operating from MCAS Beaufort.



1.5.2 Changes in Operations Level

Projected operations in the 2003 AICUZ Study anticipated 62,000 total operations for MCAS Beaufort. The *USMC F-35B East Coast Final EIS* projected 99,881 annual F-35B operations at MCAS Beaufort, with an additional 6,149 annual transient operations, for a total of 106,030.

Table 1-2 provides the annual military operations from the 2003 AICUZ Study and projected aircraft operations for CY 2023 for MCAS Beaufort. Chapter 3 presents a more detailed look into the operational level at the airfield.

Table 1-2 Annual Military Operations at MCAS Beaufort

Calendar Year	Based	Transient	Total
2023*	99,881	6,149	106,030
2012	37,303	739	38,042
2011	26,969	1,028	27,997
2010	32,307	810	33,117
2009	32,310	1,039	33,349
2008	27,084	1,042	28,126
2007	34,158	1,228	35,386
2006	30,678	1,145	31,823
2005	39,619	1,145	40,764
2004	40,818	931	41,749
2003	41,239	1,555	42,794

Source: DON 2010, MCAS Beaufort 2013

Note:

* = Projected operations. The 2023 projection from the *USMC F-35B East Coast Final EIS*.

1.5.3 Changes in Flight Tracks and Procedures

Flight tracks are dependent on aircraft mix, operational level, runway usage, and control measures. Marine Corps flight tracks were specifically developed for F-35B operations based on training syllabi in development for the operations and Fleet Replacement Squadrons (DON 2010). The incorporation of the F-35B aircraft provides only profile changes to the tracks and procedures due to its ability to perform Short Take-Off and Vertical Landing (STOVL) operations. To accommodate these operations, five vertical landing (VL) pads will be constructed at MCAS Beaufort. In addition, requirements call for a landing area that simulates landing on an amphibious assault ship (LHD) and a Forward Base Operations (FBO) landing

area. The F-35B can employ conventional arrivals, and its STOVL capabilities involve slow approach, rolling vertical landings, and vertical landings. Flight tracks associated with these operations will follow established tracks until they have crossed the airfield boundary where they will divert to or terminate at the LHD or FBO for landing instead of on the primary runways. Locations of the landing pads, LHD facility, and FBO area are discussed in Chapter 2, and associated flight tracks are discussed in Chapter 4.

2

2.1 Location & History

2.2 Mission

2.3 Installation Activities

2.4 Operational Areas

2.5 Local Economic Impacts and Population Growth

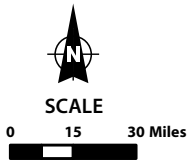
MARINE CORPS AIR STATION BEAUFORT

2.1 LOCATION AND HISTORY

MCAS Beaufort is located in South Carolina's Coastal Region (the Lowcountry), within the City of Beaufort in Beaufort County, approximately 5 miles northwest of downtown. Located 15 miles inland from the Atlantic Ocean, MCAS Beaufort is approximately 40 miles southwest of Charleston, South Carolina, and 30 miles north of Savannah, Georgia (Figure 2-1).

The installation complex is comprised of 6,949 acres at the main site, located in Beaufort County, 971 acres at Laurel Bay Family Housing located in the City of Beaufort, and 5,183 acres at the Townsend Bombing Range (TBR) in McIntosh County Georgia. The majority of installation property (approximately 5,400 acres) is located east of U.S. Highway 21 and west of the Atlantic Intracoastal Waterway and includes the main airfield complex and operational facilities. The boundaries of the installation are within the City of Beaufort on Port Royal Island, Beaufort County, South Carolina.





Legend

- Airport
- Military Base
- Interstate
- Urban Area
- State Boundary
- Waterbody

Figure 2-1
Regional Location Map
MCAS Beaufort
MCAS Beaufort AICUZ
Beaufort County, SC

MCAS Beaufort, commonly called Merritt Field, is named in honor of Major General Lewie Griffith Merritt. The history of the installation dates back to World War II, as noted in Table 2-1.

Table 2-1 History of MCAS Beaufort/Merritt Field

Year	Event
1943	Civil Aeronautics Authority established Naval Air Station (NAS) Beaufort as an auxiliary air station that supported advanced training of anti-submarine patrol squadrons to ensure the security of shipping along the Eastern Seaboard.
1946	Field is deactivated.
1955	The field was reactivated and designated as an auxiliary landing field to MCAS Cherry Point, North Carolina.
1960	The activity was designated as a Marine Corps Air Station (MCAS). Since then, Marine Air Group 31 (MAG 31) has been the primary tenant at the base and currently flies the F/A-18 aircraft.
1975	MCAS Beaufort is named Merritt Field in honor of Major General Lewie Griffith Merritt.

MCAS Beaufort consists of approximately 4,000 military and 700 civilian personnel and home to the Marine Corps' East Coast fixed-wing, fighter-attack aircraft. Six Marine Corps F/A-18 squadrons are currently based at MCAS Beaufort.

Three versions of the F/A-18 Hornet are found aboard MCAS Beaufort: the F/A-18 Hornet A/C (single-seat aircraft) and the F/A-18 D (2-seat aircraft).



Maj Gen Lewie G. Merritt, Solomon Islands 1944

2.2 MISSION



MCAS Beaufort’s mission is to provide support as an operational base for Marine Aircraft Group-31 (MAG-31), its associated squadrons, and Marine Corps support units. MCAS Beaufort “...provides the highest quality aviation facilities, support and services to promote the combat readiness of our Marines and Sailors in defense of our nation.”

The installation is responsible for providing basic facility services, business and support functions, housing and accommodations, and quality of life services, all in support of the installation’s mission. The mission of MCAS Beaufort will remain the same with the arrival of the F-35B aircraft. Both installation and MAG-31 activities are summarized in Section 2.3, Installation Activities.

2.3 INSTALLATION ACTIVITIES

MCAS Beaufort operates much like a small city and provides a variety of services required to operate and maintain a fully functioning installation. MCAS Beaufort supports the commands aboard MCAS Beaufort, Marine Corps Recruit Depot (MCRD) Parris Island, and Laurel Bay Housing Area with a wide range of activities that provide for the supported command operations and the quality of life of their Marines, Sailors, and family members.

Airfield operational support to Merritt Field and the supported operational squadrons is provided by MCAS Beaufort’s S-3 Department, Airfield Operations Division. The Airfield Operations Division supports the aviation operations aboard Merritt Field with Air Traffic Control (ATC), ATC Maintenance, Aircraft Rescue Fire Fighting, Aircraft Recovery, Weather Observation and Forecasting, Fuel, and Visiting Aircraft Line services.

As noted above, MAG-31 is the principal tenant on station; however, there are other major units onboard MCAS Beaufort. A brief description of each is provided below.

2.3.1 Marine Aircraft Group 31 (MAG-31)



The mission of MAG-31 is to conduct anti-air warfare and offensive air support operations from advanced bases, expeditionary airfields, or aircraft carriers, and conduct such other air operations as directed. MAG-31 reports to the 2nd Marine Air Wing (MAW) at MCAS Cherry Point, North Carolina. MAG-31 currently includes the largest concentration of operational Marine Corps F/A-18 aircraft and squadrons in the United States. There are six operational Marine Fighter Attack Squadrons (VMFA) of F/A-18s, with a total of 72 F/A-18 aircraft and two C-12 aircraft. The VMFA and VMFA All Weather (AW) MAG-31 units include:

- VMFA-115 “Silver Eagles;”
- VMFA-122 “Werewolves;”
- VMFA (AW)-224 “Bengals;”
- VMFA-251 “Thunderbolts;”
- VMFA-312 “Checkerboards;” and
- VMFA (AW)-533 “Hawks” (cadre status).

MCAS Beaufort hosts other tenant organizations that are part of MAG-31 and provide support for the F/A-18 squadrons.

Marine Wing Support Squadron-273 (MWSS-273)

MWSS-273 consists of combat engineering, utilities, heavy equipment, motor transportation, communications, and construction sections that can establish and maintain a forward-deployed camp for MAG-31, including an expeditionary airfield capable of landing F/A-18s.

Marine Aviation Logistics Squadron-31 (MALS-31) “Stingers”

MALS-31 provides aviation logistics support, personnel, guidance, planning, and direction to MAG-31 squadrons. This unit maintains aircraft radar and operating systems, with the capability of performing maintenance in tactical trailers that can be deployed around the world.



Air Operations

The Air Operations Department provides air traffic controllers, ground electronics personnel, weapons personnel, and fire department personnel for MCAS Beaufort. Commonly called “Air Ops,” this department is responsible for the daily coordination and safety of all aircraft and operations onboard MCAS Beaufort. Air Ops is the overarching term to describe aircraft operations, the coordination of flights, the availability of airspace and airfields, the maintenance of airport facilities and services, and the safety of aviators and the public.

Headquarters and Headquarters Squadron (H&HS)

The H&HS at MCAS Beaufort is charged with supporting and enhancing the combat readiness of the Marine Corps squadrons located at MCAS Beaufort and improving the quality of life for military personnel, their families, and the work force assigned to MCAS Beaufort. H&HS’s approximately 600 Marines provide various support including ATC, weather forecasts, military police, communications, legal services, meals, pay and accounting, aircraft rescue and firefighting support, explosive ordnance disposal, and other essential support for the MCAS Beaufort.

2.3.2 Other Tenants

MCAS Beaufort hosts several other tenant organizations that support the station and the F/A-18 squadrons or perform specialized functions.



Marine Air Control Squadron-2 (MACS-2), Detachment “A”

MACS-2 is an aviation command and control squadron that provides aerial surveillance to detect, identify, and control the interception of hostile aircraft and missiles, and provide ATC services to friendly aircraft. MACS-2 also has Early Warning/Control (EW/C) detachment and is capable of establishing a fully functioning expeditionary group.



Combat Logistics Company-23 (CLC-23)

CLC-23 provides MCAS Beaufort and MAG-31 with support functions including disbursing, military exchange, legal, security, personnel administration, postal services and communications, supply, and dental and medical personnel through the Fleet Assistance Program.

Other MCAS Beaufort tenants include the following:

- Pacific Missile Test Center-Detachment (PMTTC Det);
- Naval Hospital Beaufort (NHB);
- South Carolina Army National Guard;
- Naval Criminal Investigative Service; and
- Naval Surface Warfare Center.

2.3.3 Projected Activities

The Marine Corps prepared an EIS for the East Coast basing of the F-35B. The ROD includes basing three operational squadrons and a PTC which would support two Fleet Replacement Squadrons (FRSs) at MCAS Beaufort. A maximum of 88 F-35B aircraft are projected to be on station by CY 2023. Under the Preferred Alternative, all F/A-18 aircraft at MCAS Beaufort will be replaced by F-35Bs (DON 2010). This AICUZ Study assumes only the F-35B (88 aircraft) and C-12 (2 aircraft) would be stationed at MCAS Beaufort in projected CY 2023. The three operational squadrons will have missions similar to MAG-31, with additional capabilities associated with the F-35B aircraft.

2.4 OPERATIONAL AREAS

Since 1943, MCAS Beaufort has served as a landing field for Naval and Marine aircraft, and today the station is a premier air station along the East Coast of the United States. In addition to the main station airfield, MCAS Beaufort owns the TBR. This range is located in McIntosh County, Georgia, and is operated by the Georgia Air National Guard. Operational areas also include the airspace surrounding the installation and TBR and the designated military training airspace utilized by MCAS Beaufort F/A-18 squadrons and projected F-35B squadrons. For MAG-31 F/A-18 aircrew traveling from MCAS Beaufort to TBR, flight distance is approximately 70 nautical miles (NM), or an approximately 20-minute flight in the F/A-18.

The following sections present general airfield operations and area specifics including location, runway configurations, and the dimensions for MCAS Beaufort's runways. Section 2.4.1, Airspace, describes the designated airspace used by MCAS Beaufort; Section 2.4.2, Training Areas, describes the training areas used by the installation; and Section 2.4.3, Projected Operational Areas, describes the projected operational areas associated with the F-35B aircraft.

DOD fixed-wing runways are separated into two classes, Class A and Class B. Class A runways are primarily used by light aircraft and do not have the potential for intensive use by heavy or high-performance aircraft. Class B runways are all other fixed-wing runways. In addition, runways are classified according to the type of aircraft which operate from the runway. Runways at MCAS Beaufort are categorized as Class B runways.

Merritt Field at MCAS Beaufort

MCAS Beaufort's airfield, known as Merritt Field has two runways, 5/23 and 14/32. The primary runway is 5/23 which supports 75 to 80 percent of flight operations. Runway 14/32 is the secondary (crosswind) runway (Figure 2-2).

All runways at MCAS Beaufort are classified as Class B fixed-wing runways.

Merritt Field consists of two active runways, with runway 5/23 supporting 75 to 80% of flight operations.

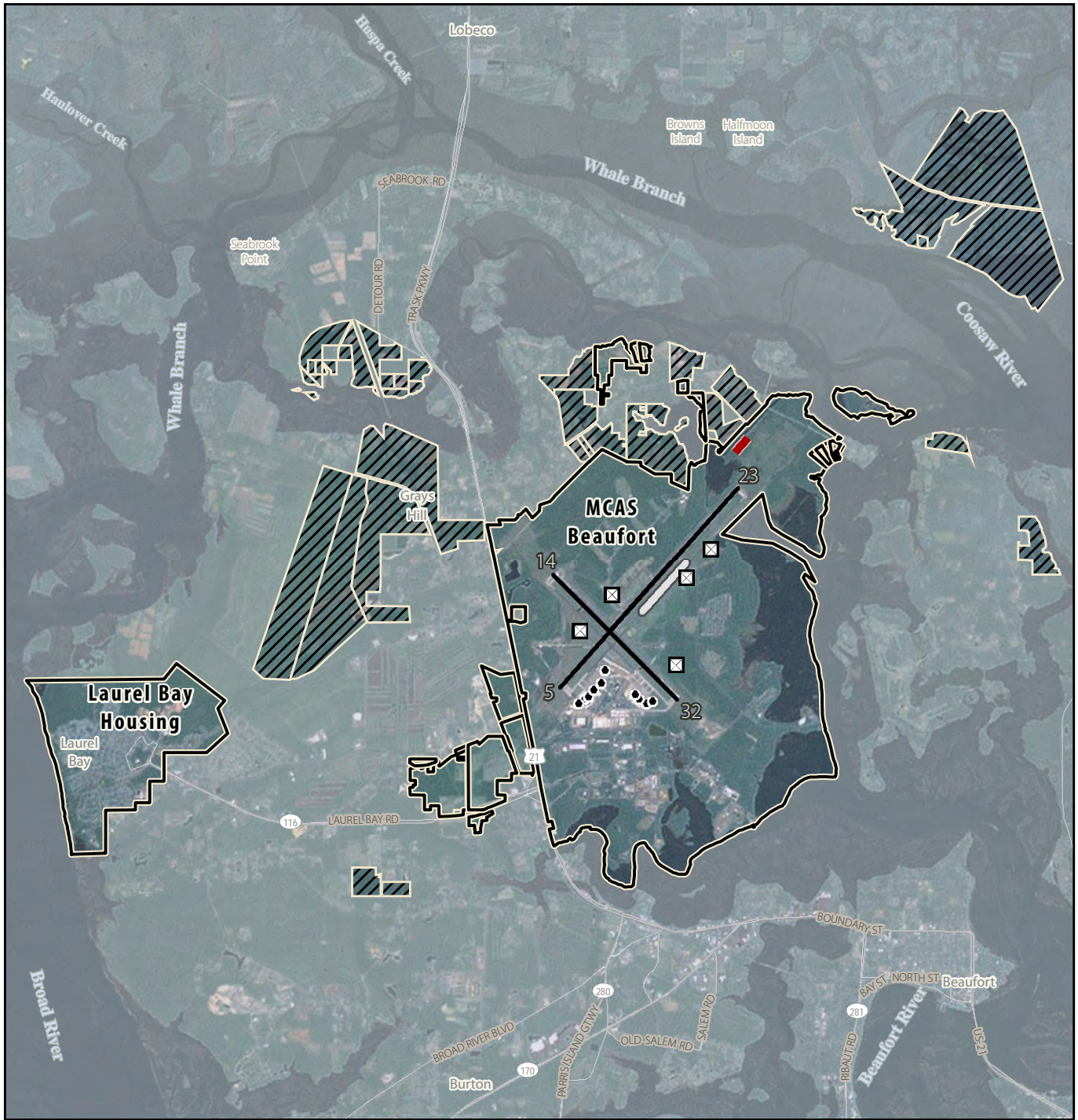
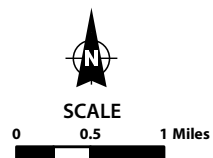


Figure 2-2
Merritt Field
MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC



- Legend**
- Aircraft Maintenance Location
 - ⊠ Vertical Landing Pad
 - MCAS Beaufort Base Boundary
 - ▨ USMC Land Protected Under Restrictive Easements
 - Runway
 - FBO Location
 - LHD Facility

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

Runways are numbered according to their magnetic heading for aircraft on approach or departure. For example, on Runway 14/32, the numbers 14 and 32 signify that this runway is most closely aligned with a compass heading of 140 and 320 degrees, respectively. Table 2-2 provides detailed information about the length and width of each runway.

Table 2-2 MCAS Beaufort Runways

Runway	Length (feet)	Width (feet)
5/23	12,202	200
14/32	7,999	200

The airfield's elevation is 37 feet above mean sea level (MSL). The airfield and tower are open Monday through Thursday, 7:00 a.m. (0700) to 11:00 p.m. (2300), Friday 7:00 a.m. (0700) to 6:00 p.m. (1800), Sunday 4:00 p.m. (1600) to 6:00 p.m. (1800) and is closed Saturday, and federal holidays. Training or operational necessity can result in extended operating hours or days and/or temporarily suspend operations.



2.4.1 Airspace

Airspace utilized by MCAS Beaufort to conduct air operations is delegated to the Marine Corps from the FAA and uses several classifications of airspace to ensure safe, orderly, and expeditious movement of aircraft operations. The Marine Corps operates a control tower which utilizes Class Delta airspace to control aircraft departing and arriving from MCAS Beaufort. Additionally, the Marine Corps operates a terminal radar approach control facility aboard MCAS Beaufort that utilizes Class E airspace delegated from the FAA’s Jacksonville Enroute Air Route Traffic Control Center (ARTCC) to control aircraft arriving and departing MCAS Beaufort and other aircraft operating within the National Airspace System in delegated airspace from the FAA. Both the control tower and radar approach control facility are capable of servicing all aircraft operating under visual flight rules (VFR) and instrument flight rules (IFR).

MCAS Beaufort is surrounded by Class D airspace; the airspace encompassing the airfield is Class E airspace. Applicable airspace classifications are described below and depicted on Figures 2-3 and 2-4.

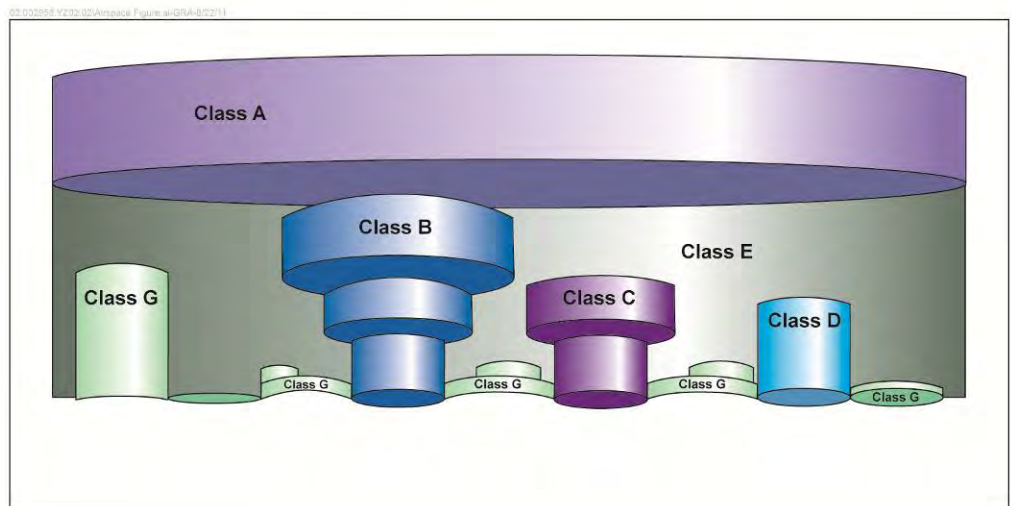
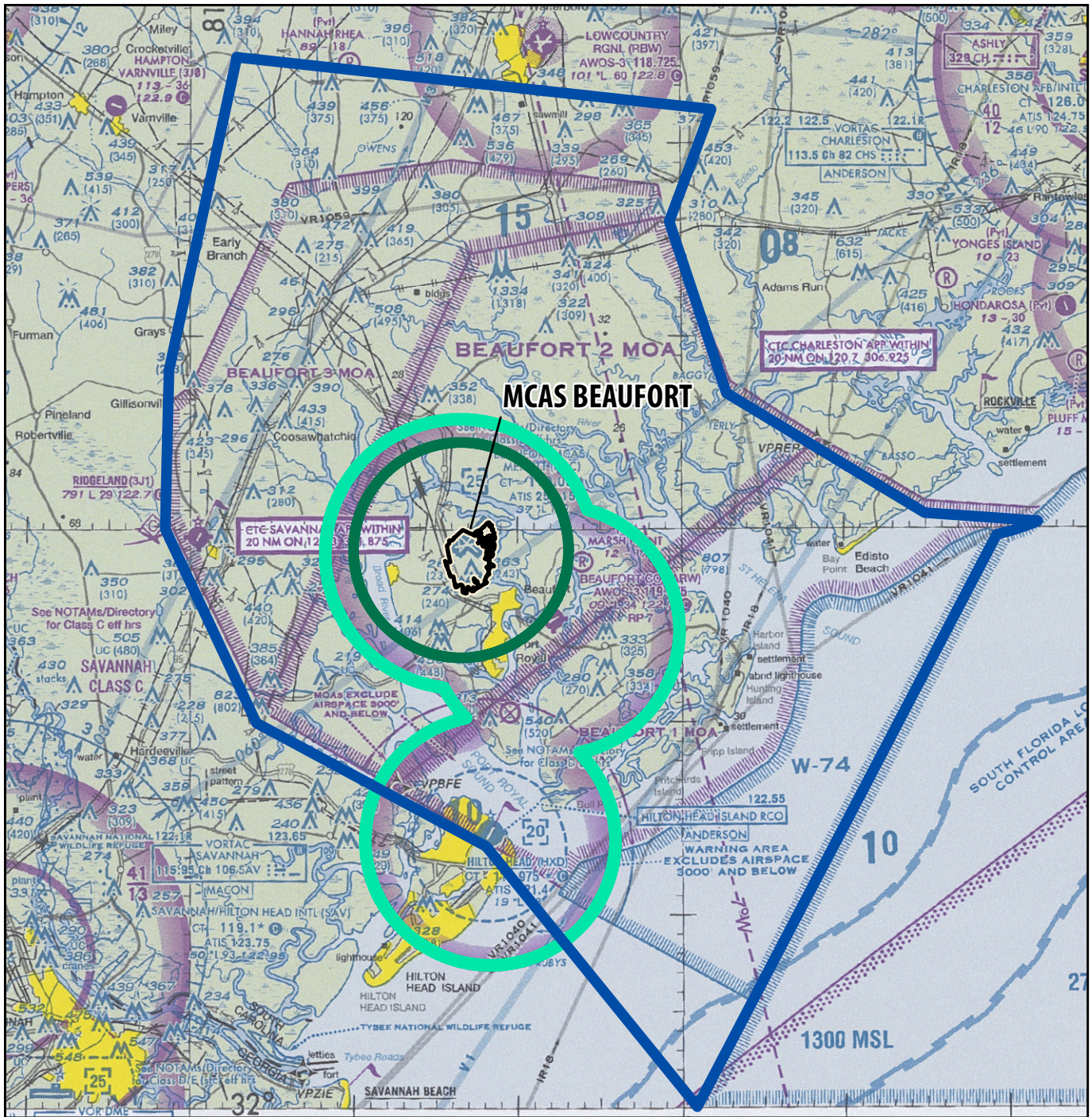


Figure 2-3 General Airspace Classifications



SCALE

0 2.5 5 Miles

Legend





-  MCAS Beaufort
-  Class D 5.6NM (2,500 MSL)
-  Class E Transitional (700 or 1,200 MSL)
-  Class E Approach Control (10,000 MSL)

Figure 2-4
Airspace Classification
 MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, South Carolina

MCAS Beaufort is surrounded by Class D airspace; the airspace encompassing the airfield is Class E airspace.

Class D Airspace

Class D airspace is terminal airspace that consists of specified dimensions calculated by the FAA and within which all aircraft operators are subject to rules and equipment requirements. Generally, a surface is designated as Class D airspace to provide controlled airspace for terminal VFR or IFR operations at airports having a control tower. The MCAS Beaufort Class D Surface Area is assigned a 5.6-nautical-mile (NM) radius from the airport reference point and an altitude from the surface up to, but not including, 2,500 feet above MSL.

Class E Airspace

Class E airspace is the FAA controlled airspace that is not classified as A through D, and extends upward from either the surface or a designated altitude to the overlying or adjacent airspace. Class E airspace can also be utilized as transitional airspace providing aviators airspace that transitions from uncontrolled to controlled airspace. Class E airspace delegated to MCAS Beaufort for approach control services has an upper limit of 10,000 feet above mean sea level. VFR communication is not required within Class E airspace; however, by definition, IFR communication is required.

2.4.2 Training Areas

MCAS Beaufort's operational training areas include controlled and Special Use Airspace (SUA). MCAS Beaufort is a tower controlled field; however, a majority of the flying activities occur outside the tower control within designated SUA training areas.

SUA is the designation of airspace in which certain activities must be confined, or where limitations may be imposed on aircraft operations that are not part of those activities. The SUA dimensions are defined so that military activities can operate and have boundaries that limit access by non-participating aircraft. Certain SUA areas can create limitations on the mixed use of airspace. There are six major types of SUAs: prohibited areas, restricted areas, warning areas (W-Areas), military operating areas (MOAs), alert areas, and controlled firing areas (CFAs). A brief description of SUA classifications are further described below:

- **Prohibited Areas.** Airspace of defined dimensions within which the flight of aircraft is prohibited.
- **Restricted Areas.** Areas where operations are hazardous to non-participating aircraft and contain airspace within which flight of aircraft, while not wholly prohibited, is subject to restrictions.
- **Warning Areas (W-Areas).** Airspace of defined dimensions, extending from approximately 12 NM outward from the coast of the United States, containing activity that may be hazardous to non-participating aircraft. These areas may contain a wide variety of aircraft and non-aircraft activities, such as aerial gunnery, bombing, aircraft carrier operations, surface and subsurface operations, naval gunfire, and missile shoots.
- **Military Operating Areas (MOAs).** Airspace with defined vertical and lateral limits established for the purpose of separating certain military training activities from IFR traffic.
- **Alert Areas.** Areas that may contain a high volume of pilot training or an unusual type of aerial activity. Pilots should exercise caution in alert areas.
- **Controlled Firing Areas (CFAs).** Areas that contain activities, which, if not conducted in a controlled environment, could be hazardous to non-participating aircraft.

Within the vicinity of MCAS Beaufort, aircrew use restricted areas, WAs, and MOAs for operational training (Figure 2-5). Training missions in the vicinity of MCAS Beaufort are conducted within a series of three adjoining MOAs, with MCAS Beaufort located in the center. Beaufort MOA 2 overlays the installation and extends northeast to the town of Jacksonboro and southwest to southern Beaufort County. MOA 2 is bordered on the southeast by MOA 1 and on the northwest by MOA 3. All MOAs include airspace beginning at 100 feet MSL, up to and including 10,000 feet MSL for MOA 1, 7,000 feet MSL for MOA 2, and 2,000 feet MSL for MOA 3. A W-area, W-74, begins adjacent to MOA 1 to the east at a distance of 3 NM from and adjacent to the coastline. Airspace in W-74 begins at surface level, up to and including 10,000 feet MSL.

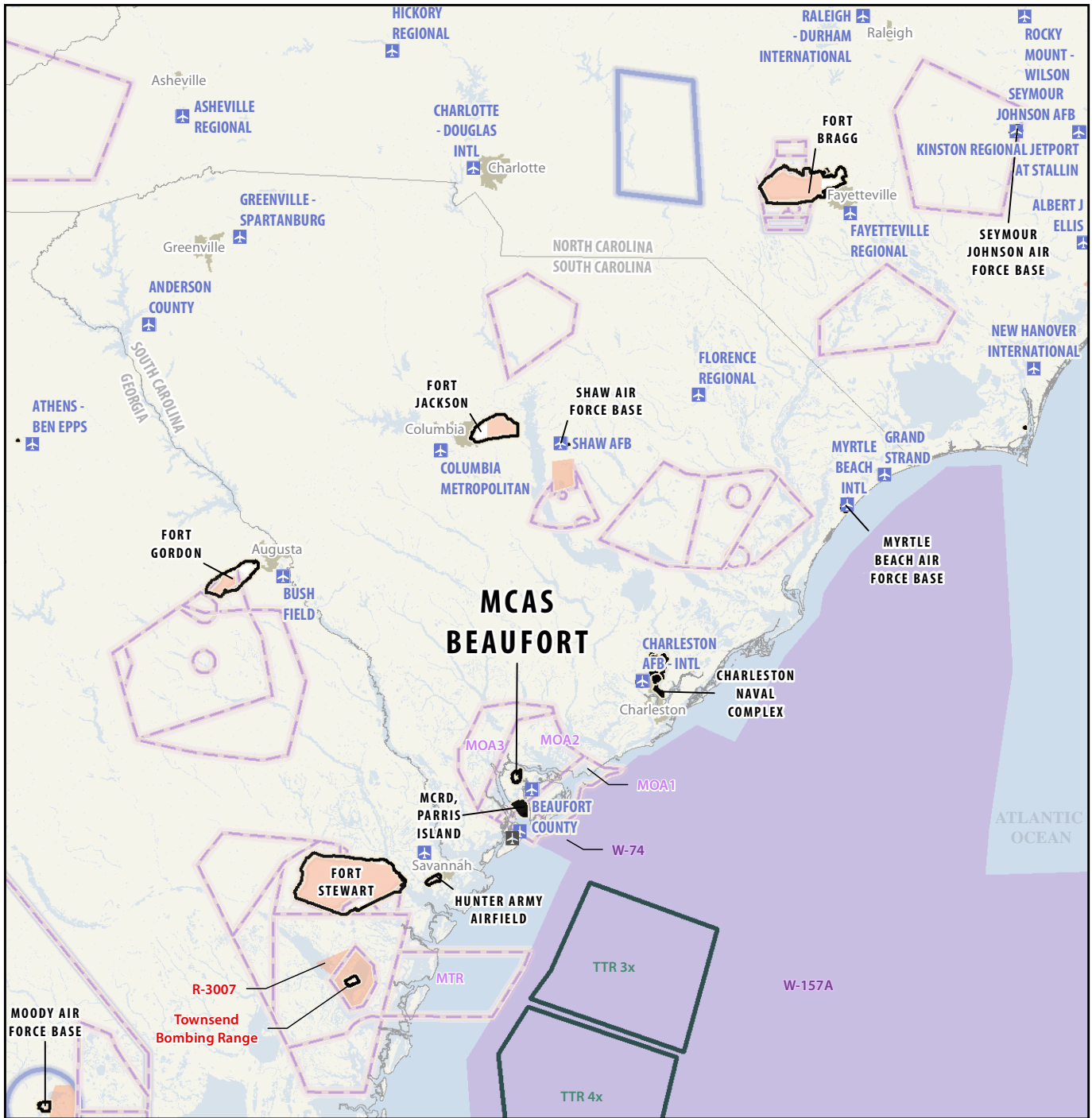
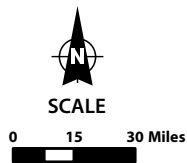


Figure 2-5
Special Use Airspace
MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC



Legend

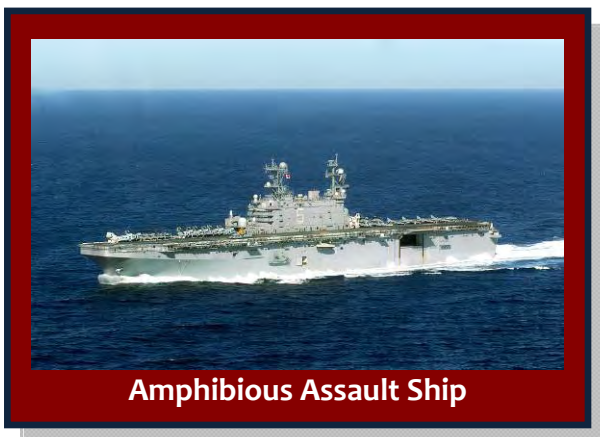
- | | |
|----------------|--------------------------|
| Airport | Special Use Area |
| Military Base | Alert Areas |
| TTR | Military Operating Areas |
| State Boundary | Restricted Areas |
| Urban Area | Warning Areas |
| Waterbody | |

Regional training missions outside the vicinity of MCAS Beaufort utilize an array of shore and offshore assets and related SUAs. Aircraft associated with MCAS Beaufort conduct maneuvers within the Beaufort Tactical Training Range (TTR) which consists of an array of eight offshore towers southwest of MCAS Beaufort. The TTR is located within Special Operating Areas 3X (north range) and 4X (south range) in W-157. W-157, the Beaufort TTR, and the TTR relay site are located off the Georgia coast.

In addition, TBR is a primary training area for MCAS Beaufort aircraft. TBR is routinely used by all services to fine-tune the bombing and air combat skills of fighter pilots; however, the Marine Corps' MAG-31 F/A-18 squadrons are the predominant range users.

TBR SUA consists of a restricted area (R-3007), the coastal MOAs, and military training routes (MTRs) in the vicinity. R-3007 connects to the coastal MOAs and MTRs, an area collectively termed the "Coastal Airspace Complex." The TBR is operated by the Georgia Air National Guard, Combat Readiness Center, Savannah, Georgia. Aircraft operations within the SUAs were not included in the noise analysis for this AICUZ Study due to the distance between the SUA and the airfield and the altitudes in which the aircraft operate.

2.4.3 Projected Operational Areas



To accommodate the F-35B training requirements and STOVL capabilities, MCAS Beaufort, as presented in the *USMC F-35B East Coast Final EIS*, will construct an Amphibious Assault Ship Training Facility which will include a LHD and apron, a FBO landing area, and construction of VL pads. The LHD, FBO landing area, and VL pads are briefly discussed below and presented on Figure 2-2 (see Section 2.4, Operational Areas).

➤ **LHD Training Facility.** Pilots operating the F-35B must conduct specific training operations on land to prepare for flight operations when deployed aboard ships at sea. Therefore, to simulate landing on the flight deck of these ships, the Marine Corps utilizes a

land-based LHD (landing area) to conduct training operations and that can accommodate F-35B STOVL operations. The LHD, when constructed, will consist of an 840-foot-long runway equipped with specialized markings and lighting, and will be parallel to Runway 05/23 on the north side of the runway (see Figure 2-2, presented in Section 2.4, Operational Areas).

- **Forward Base Operations (FBO) Landing Area.** The FBO landing area is used to simulate conditions found at FBO, and is used for training of specific operations that are required for arrival and departure procedures. The FBO landing area, when constructed, will consist of a 3,000-foot-long runway, and will be located parallel to, and on the south side of, Runway 05/23 on the existing taxiway (see Figure 2-2, presented in Section 2.4, Operational Areas).
- **Vertical Landing (VL) Pads.** VL pads are required to accommodate the vertical thrust of the F-35B. It was determined in the *USMC F-35B East Coast Final EIS* that five VL pads would be constructed at MCAS Beaufort to accommodate F-35B STOVL operations. The VL pads will serve as a designated landing point when the F-35B is operating in the STOVL configuration. The VL pads, which consist of reinforced concrete, will be constructed adjacent to the runways in five locations (see Figure 2-2, presented in Section 2.4, Operational Areas).

2.5 LOCAL ECONOMIC IMPACTS AND POPULATION GROWTH

The military creates a stable and consistent source of revenue for the areas in which its installations are located and is not as heavily influenced by fluctuations in the economy that can be experienced by the private sector. Based on 2010 estimates, over 4,700 military personnel, civilians, and dependents work and/or live at MCAS Beaufort.

MCAS Beaufort provides positive economic benefits to the surrounding communities. The employment associated with MCAS Beaufort and its tenants, and the salaries and spending associated with both the personnel and the air station, contribute to both the local and regional economies.

The economic base of Beaufort County is largely dependent on the military, with military expenditures in Beaufort County totaling over \$990 million in 2010 (U.S. Census Bureau [USCB] 2010b). MCAS Beaufort is one of the top employers in the area, with the military contributing to over 50 percent of the economy in northern Beaufort County (Beaufort County 2010). This includes active and inactive duty military pay, military retirement and disability payments, civilian pay, and procurements. In 2009, MCAS Beaufort provided \$33 million towards construction programs, \$485 million in salaries to military and civilian personnel, and \$118 million with the purchase of utilities, contributions, health care, and supplies in the Beaufort area and statewide (MCAS Beaufort 2011). As a result of these expenditures, the military creates a stable and consistent source of revenue for the area's local economy. Other key economic sectors around MCAS Beaufort include service industries, tourism, and the retirement and vacation home industries.



MCAS Beaufort is approximately 4 miles northwest of downtown Beaufort, South Carolina. The City of Beaufort is one of two principal cities of the Hilton Head Island-Beaufort Metropolitan Statistical Area (MSA), which includes Beaufort and Jasper counties. In the 2010 Census, there were 12,361 residents within the City of Beaufort. In 2010, the population of the Hilton Head Island-Beaufort MSA was determined to be 187,010 residents, according to the USCB. South Carolina

population data and growth projections for the City of Beaufort, Beaufort County, and the State of South Carolina are summarized in Table 2-3.

Table 2-3 Population of Counties and Municipalities in the Vicinity of MCAS Beaufort

Population Area	1990	2000	2010	2020	% Growth 2000-2010	% Growth 2010-2020
City of Beaufort	9,576	12,789	14,317	18,652 ^a	11.9%	30.3%
Town of Port Royal	2,966	3,950	10,678	n/a	63%	n/a
Beaufort County	86,425	120,937	162,233	185,220	34.1%	14.2%
State of South Carolina	3,486,703	4,011,832	4,625,364	5,020,400	15.3%	8.5%

Sources: USCB 2009 and 2010a,b; ^aCity of Beaufort 1998, 2003

As shown in Table 2-3, the City of Beaufort, Town of Port Royal, Beaufort County, and the State of South Carolina have experienced a positive rate of growth over the past two decades. The population of Beaufort County, the City of Beaufort, and the State of South Carolina increased by 11.9 percent, 34.1 percent, and 15.3 percent, respectively, from 2000 to 2010. In addition, the population of the Town of Port Royal more than doubled during that same time period. The population of the City of Beaufort and Beaufort County is projected to continue to grow through 2020 at a rate of 30.3 percent and 14.2 percent, respectively, which are both higher than the projected growth rate of 8.5 percent for the State of South Carolina.

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3

3.1 Aircraft Types

3.2 Aircraft Operations

3.3 Flight Tracks and Runway Utilization

AIRCRAFT OPERATIONS

This chapter discusses aircraft types, the number of operations, including projected operations for CY 2023, and flight tracks for MCAS Beaufort. MCAS Beaufort’s operations are dominated by advanced jet aircraft from active duty squadrons and, by CY 2023, will also include advanced pilot training in the F-35B aircraft.

Aircraft operations are the primary source of noise associated with the installation. The level of noise exposure is related to a number of variables including the aircraft type, engine power setting, altitudes flown, direction of the aircraft, duration of run-ups, flight tracks, temperature, relative humidity, frequency, and time of operations. These variables, as they relate to MCAS Beaufort, are discussed in detail below and throughout this AICUZ Study.

3.1 AIRCRAFT TYPES

There are two basic types of aircraft: fixed-wing and rotary-wing. Fixed-wing aircraft lift is generated by forward motion through the air. The term fixed-wing is used to distinguish this aircraft from rotary-wing aircraft, commonly called helicopters, with lift generated by wing motion relative to the aircraft. Only fixed-wing aircraft are permanently stationed at MCAS Beaufort.

Nomenclature following the aircraft identifier often serves as a designator for a specific branch of the military or for different year models of the aircraft. These differences are commonly called “variants” of the aircraft.

3.1.1 Current Fixed-Wing Aircraft

F/A-18 Hornet

The F/A-18 Hornet is an all-weather supersonic aircraft which is used as an attack aircraft as well as a fighter. In its fighter mode, the F/A-18 is primarily used as a fighter escort, for reconnaissance, and for fleet air defense; in its attack mode, it is used for force protection, interdiction, and close and deep air support.

Designed by McDonnell Douglas and Northrop, the F/A-18 Hornet is 56 feet long with a 40-foot wing span and a height of 15.3 feet. The aircraft is powered by two General Electric F404-GE-402 engines that deliver 17,750 pounds-force each. The range of the aircraft is 500+ NM with a maximum airspeed of Mach 1.8 (1,370 miles per hour [mph]). The F/A-18A and C are single seat aircraft. The F/A-18B and D are dual-seats. Currently, the F/A-18 A/C/D models are stationed at MCAS Beaufort.



UC-12M Huron

The C-12 is a twin-turboprop aircraft manufactured by Beech Corporation and is flown by all services. The UC-12M variant is based on the King Air A200C with an additional cargo door for the Marine Corps. These aircraft are used for various duties, including embassy support, medical evacuation, passenger and light

cargo transport, as well as aerial reconnaissance. The aircraft's cabin can be readily assembled to cater to passengers, cargo, or both. The C-12s are powered by two Pratt & Whitney PT-6A-41/42 turboprop engines, which can produce 850 horsepower (hp) each. The aircraft is 43.8 feet long, with a height of 15 feet. The range of the aircraft is approximately 1,710 NM, with a maximum airspeed of approximately 300 mph. Currently, there are two UC-12M aircraft stationed with the Marine Corps at MCAS Beaufort.



3.1.2 Transient Aircraft

The term “transient aircraft” refers to all other aircraft not permanently stationed at MCAS Beaufort and which conduct training or other mission-related operations at the station’s airfield. Transient aircraft that typically use MCAS Beaufort are aircraft conducting air crew training and aircraft providing troop movement and other general military assignments. A wide range of military aircraft use the runways on a transient basis to accomplish specific missions. The P-3 Orion

from Naval Air Station (NAS) Jacksonville is the most common transient aircraft at MCAS Beaufort. Common transient aircraft at MCAS Beaufort are discussed below.

P-3 Orion

The Lockheed P-3 Orion is a four-engine, turboprop, long-range, anti-submarine, warfare and maritime patrol and surveillance aircraft. The P-3 can be outfitted with a variety of sophisticated submarine detection equipment, such as directional frequency and ranging sonobuoys and magnetic anomaly detection equipment. Infrared and long-range electro-optical cameras plus special imaging radar allow the P-3 to monitor activities from a great distance. The aircraft is also used to scout ahead of ground convoys to warn of potential dangers and monitor



P-3 Orion

shipping lanes and coastal waters for threats. The aircraft is powered by four Allison T-56-A-14 engines with 4,600 hp each. The P-3 is 116.8 feet long with a height of 38.7 feet and a wingspan of 99.7 feet. The maximum gross take-off weight of the aircraft is 142,000 pounds and can carry 20,000 pounds of ordnance. The range of the aircraft is approximately 4,830 NM, with a maximum airspeed of 411 knots (473 mph). Currently, the P-3 is the most common transient aircraft at MCAS Beaufort; however, the P-8 Poseidon is projected to replace all P-3s by 2023.

F-5 Tiger II

Designed and built by Northrop, the F-5 is a light tactical fighter mainly used for simulating threat aircraft and tactics for realistic training scenarios. The aircraft is powered by two General Electric J85-GE-21 turbojets engines with 5,000-pound



F-5 Tiger II

thrust. The F-5 is 47.5 feet long with a height of 13 feet and a wingspan of 26.7 feet. The maximum gross take-off weight of the aircraft is 24,722 pounds. The range of the aircraft is approximately 2,314 NM, with a maximum airspeed of Mach 1.4 (1,065 mph). The transient F-5s at MCAS Beaufort are primarily from the Marine Corps VMFT-401 squadron out of MCAS Yuma in Arizona.

MV-22 Osprey

The Osprey is a dual-engine, tilt-rotor aircraft utilized by the Marine Corps in combat assault and support. The aircraft has the capability to take off and land similar to a helicopter. Once airborne, its engine can be rotated to convert the aircraft

to a turboprop airplane capable of high-speed, high-altitude flight with multi-mission capabilities such as amphibious assault, long-range special ops, troop transport, search and rescue, and medical evacuations. The aircraft is powered by two Rolls-Royce AE1107C engines with 6,150 pounds of shaft horsepower each. The range of the aircraft is approximately 879 NM, with a maximum airspeed of 275 knots (316 mph). The transient MV-22s at MCAS Beaufort are from a range of other installations such as MCAS New River in Jacksonville, North Carolina.



MV-22 Osprey

3.1.3 Projected Aircraft

As identified in the *USMC F-35B East Coast Final EIS*, the F-35B Lightning II is scheduled to replace the F/A-18 Hornet at MCAS Beaufort.

F-35B Lightning II

The F-35B is a highly advanced, stealth, supersonic, multi-role, strike-fighter aircraft with STOVL technology that enables the aircraft to take off and land from conventional runways, amphibious ships, aircraft carriers, and expeditionary

airfields. A shaft-driven lift fan, in combination with a vectoring rear exhaust nozzle, gives this fighter the ability to take off in short distances, accelerate to supersonic speeds in level flight, and land vertically. The F-35B is the world's first operational supersonic STOVL aircraft and has a combat radius greater than that of the aircraft it replaces. For the Marine Corps, the F-35B will replace the AV-8B and the F/A-18.



F-35B Joint Strike Fighter

The F-35B design includes a thrust vectoring nozzle which allows the main engine exhaust to be deflected downward at the tail of the aircraft and provides a counter-balancing thrust. This action is commonly called "vectored thrust." Roll control during slow flight is achieved by diverting unheated engine bypass air through wing-mounted thrust nozzles.

P-8 Poseidon



The Boeing P-8 Poseidon is a long-range, anti-submarine warfare, maritime patrol, intelligence, surveillance, and reconnaissance aircraft currently being developed for the DON and Marine Corps. The aircraft is powered by two CFM International 56-7 engines with 27,000-pound thrust each. The P-8 is 129.5 feet long with a height of 42 feet and a wingspan of 123.6 feet. The maximum gross take-off weight of the aircraft is 189,200 pounds. The range of the aircraft is approximately 1,200+ NM, with a maximum airspeed of 490 knots (564 mph). The DON plans to purchase P-8s to replace its fleet of P-3 aircraft.

3.2 AIRCRAFT OPERATIONS

The two major sources of aircraft noise are engine maintenance “run-up” operations and flight operations.

“Aircraft operation” is a common term used to describe the pre-flight and flying activities of an aircraft; these activities make up the two primary sources of aircraft noise at MCAS Beaufort: ground engine maintenance “run-up” operations and flight operations. The level of noise exposure is related to the aircraft type, engine power setting, altitudes flown, direction of the aircraft, durations of run-ups, flight tracks, temperature, relative humidity, frequency, and time of operations.

These variables, as they relate to MCAS Beaufort, are discussed in detail below and throughout this AICUZ Study. Both sources have been incorporated into noise analysis and modeling conducted as part of the *USMC F-35B East Coast Final EIS* and adopted by this AICUZ Study.

3.2.1 Maintenance Run-Up Operations

Aircraft engine maintenance run-up operations are conducted on the flight lines at low power settings (see Figure 2-2, presented in Section 2.4, Operational Areas). In addition, run-up operations at higher power settings, commonly referred to as “high-power operations,” are conducted at the hold short and the approach end of each runway. Noise associated with these operations is included in the noise analysis and has been modeled for incorporation into the MCAS Beaufort noise contours.

3.2.2 Flight Operations

A flight operation refers to any occurrence of an aircraft taking off or landing on the runway at an airfield. A take-off and landing may be part of a training maneuver (or pattern) associated with touch down on the runway or simulated touch down, or may be associated with a departure or arrival of an aircraft to or from anywhere off station.. Certain flight operations are conducted as patterns (e.g., touch-and-go). Departures and arrivals each count as one operation and a pattern counts as two.

Operations conducted at MCAS Beaufort for the F-35B were derived from data provided and approved by the Marine Corps and are based on best available estimates of the training syllabus for this new aircraft, as presented in the *USMC F-35B East Coast Final EIS*. Typical flights at MCAS Beaufort specific to the F-35B include:

- **Departures**
 - F-35B Conventional Departure
 - F-35B Short Take-Off Departure
- **Arrivals**
 - Conventional F-35B Arrivals
 - Straight-In/Full-Stop Arrival
 - Overhead Break Arrival
 - Radar Approach
 - STOVL Arrivals/Landings
 - Slow Approach
 - Rolling Vertical Landing
 - Vertical Landing
- **Pattern Work**
 - Touch-and-Go
 - Ground Control Approach (GCA)
 - Field Carrier Landing Practice (FCLP)

F-35B flight track utilization (and associated noise contours and APZs) adopted for this AICUZ Study were presented in the *USMC F-35B East Coast Final EIS*.

F-35B operations projections used for this AICUZ Study were derived from data provided and approved by the USMC.

As briefly discussed in Section 2.4.1, Airspace, a pilot can operate an aircraft by VFR or IFR. VFR is a standard set of rules that govern the procedures for conducting flight under visual conditions (i.e., pilots remain clear of clouds, avoid other aircraft, and usually fly unassisted by ATC). IFR is a standard set of rules governing the procedures for conducting flights under instrument conditions or when weather becomes degraded. Pilots flying by IFR do so with the assistance of ATC and aircraft instruments.

This AICUZ Study and the noise model (conducted as part of the *USMC F-35B East Coast Final EIS*) differentiate day and night flying operations because the acoustic metric used to model noise differs between day and night operations (see Chapter 4, Aircraft Noise). Acoustical day is from 7:00 a.m. (0700) until 10:00 p.m. (2200), and acoustical night is from 10:00 p.m. (2200) until 7:00 a.m. (0700).

Historic and projected aircraft operations for MCAS Beaufort are presented in Table 1-2 (see Chapter 1), and Table 3-1 provides a detailed list of the projected operations for the F-35B aircraft (CY 2023) that will be conducted at MCAS Beaufort. Operations include those on the conventional runway, VL pads, and the LHD.

Table 3-1 Projected Annual F-35B Air Operations for MCAS Beaufort

Operation Type	Days 0700-2200	Night 2200-0700	Total
Departure	31,970	323	32,293
Arrival	31,971	322	32,293
Pattern Work	34,941	353	35,294
Total	98,882	998	99,881

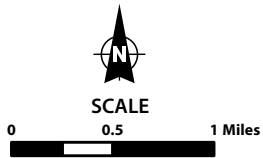
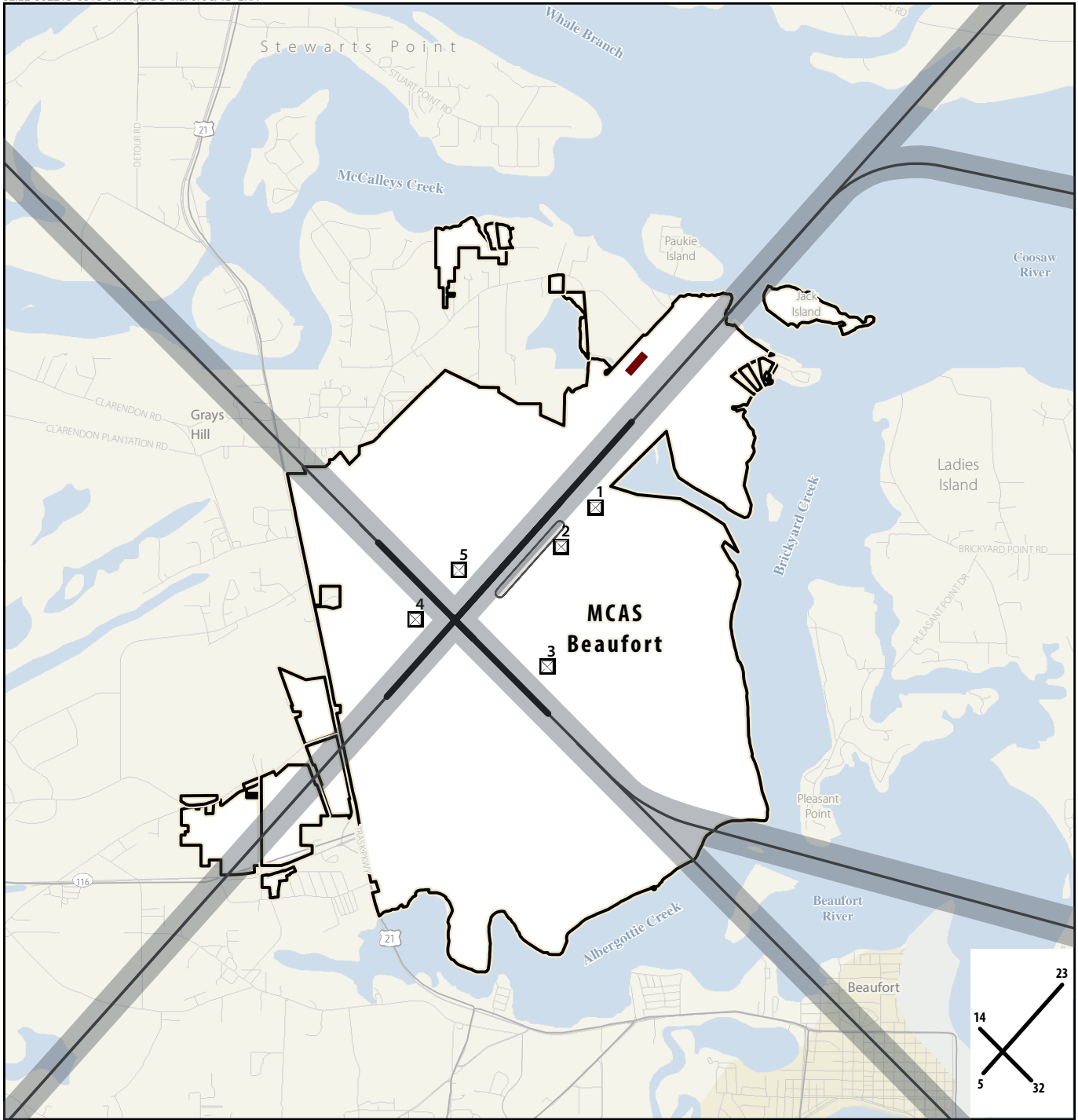
Source: DON 2010 (page D-61 and Table 2-16)

3.3 FLIGHT TRACKS AND RUNWAY UTILIZATION

Flight tracks are graphically represented as single lines, but flights vary due to aircraft performance, pilot technique, and weather conditions, such that the actual flight track is a band, often one-half to several miles wide.

Each airfield has designated runways and those runways have designated flight tracks. Flight tracks are nominal representations of an aircraft's typical route most often utilized for arrivals and departures to demonstrate how the aircraft flies in relation to the airfield. Flight tracks provide safety, consistency, and control of an airfield.

Flight tracks are graphically represented as single lines, but flights vary due to aircraft performance, pilot technique, and weather conditions, such that the actual flight track is most accurately represented as a band or path, often one-half to several miles wide. The flight paths shown in this AICUZ Study are idealized representations (Figures 3-1 through 3-4). As discussed in Section 3.2, aircraft operations were assessed according to flight track/runway for use in developing the noise contours as presented in the *USMC F-35B East Coast Final EIS*.



Legend

- Vertical Landing Pads
- Major Road
- Runway
- FBO
- LHD Facility
- MCAS Beaufort Base Boundary
- Waterbody
- Urban Area
- Arrival Paths

Figure 3-1
Representative Arrival Flight Paths
 MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

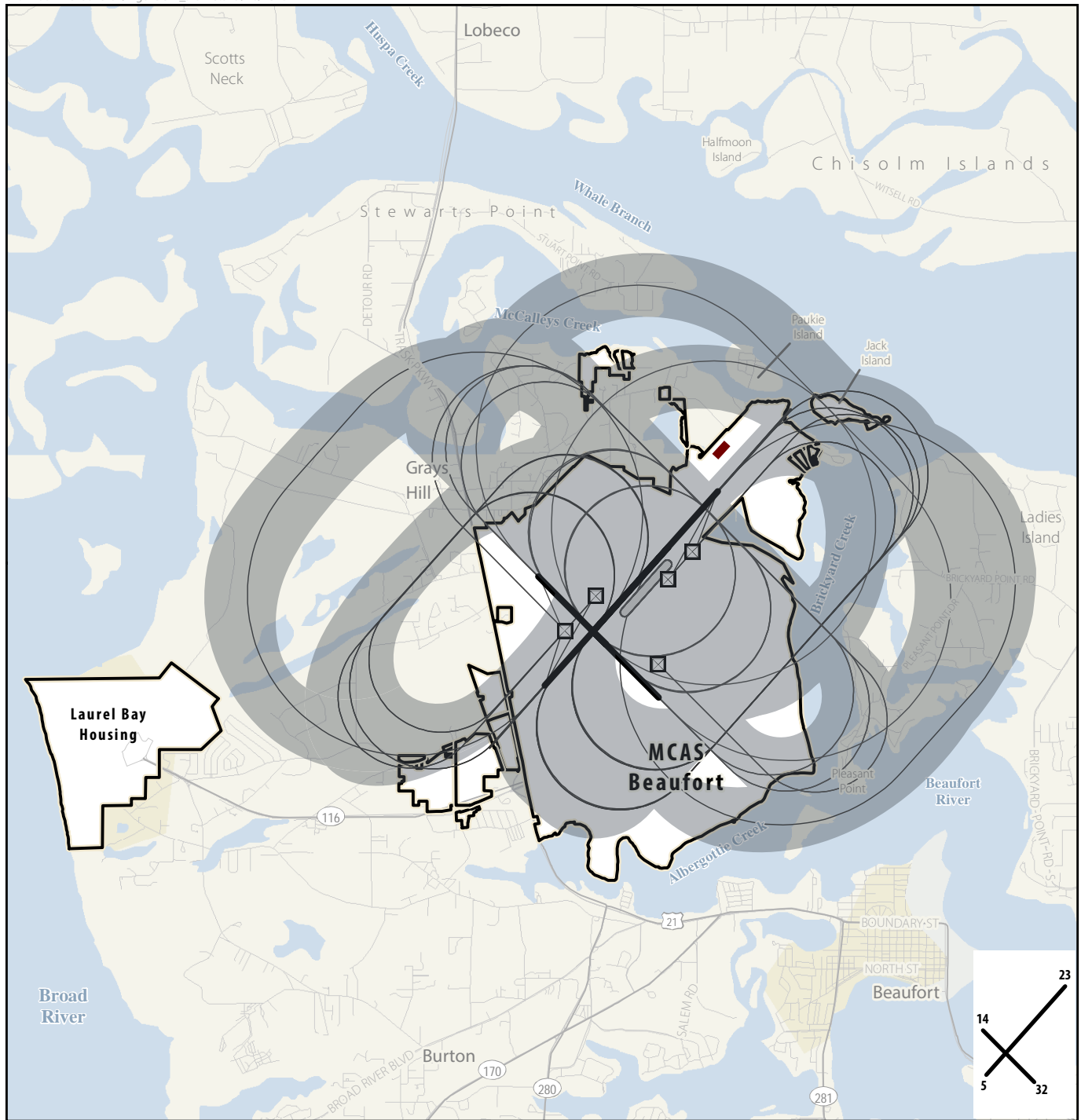
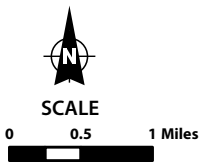
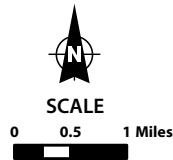
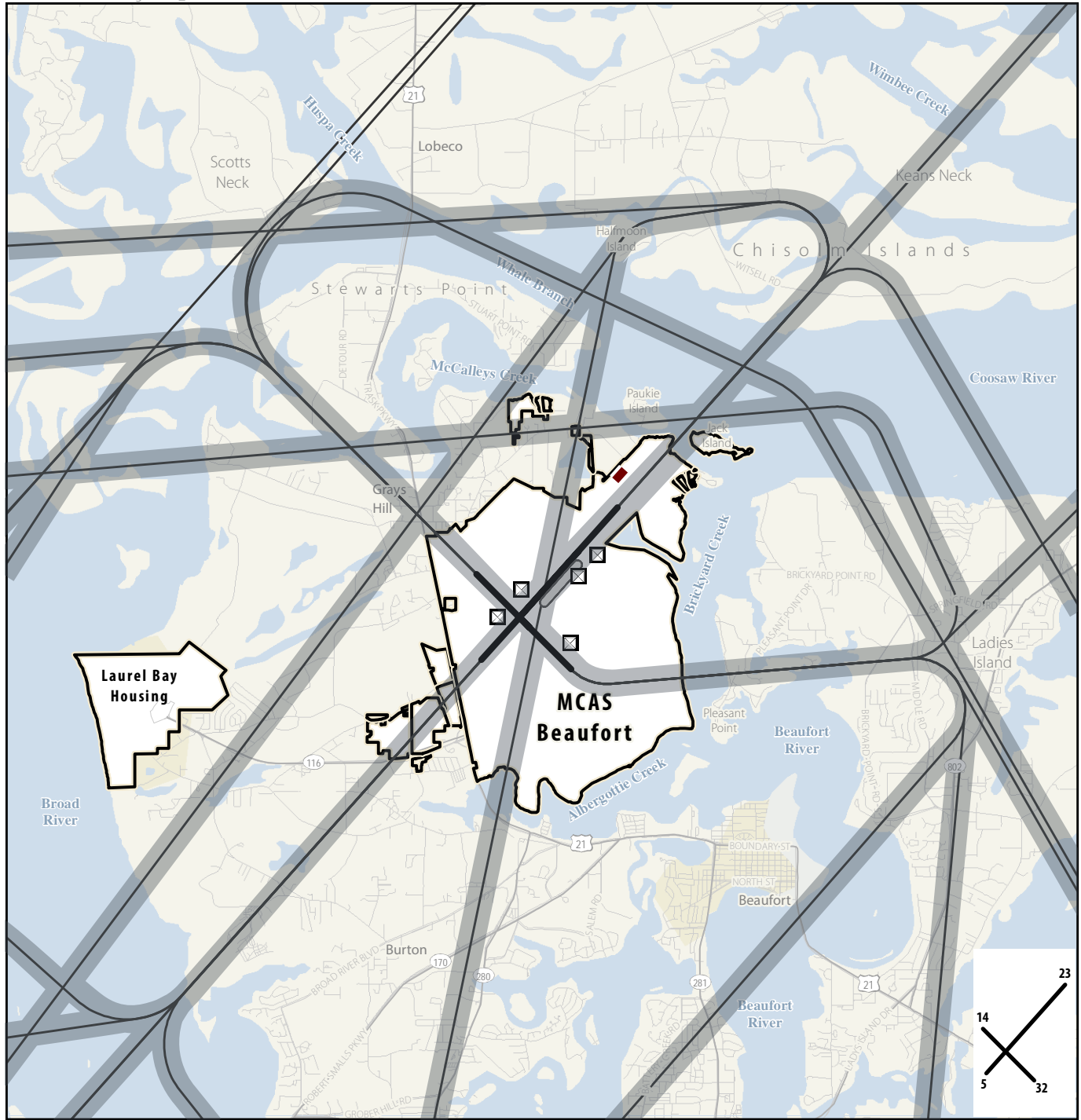


Figure 3-2
Representative Overhead Arrival Flight Paths
MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC



- | | |
|-----------------------|-----------------------------|
| Vertical Landing Pads | Waterbody |
| Major Road | Urban Area |
| Runway | MCAS Beaufort Base Boundary |
| FBO | Overhead Arrival Paths |
| LHD Facility | |

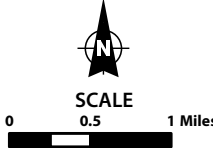
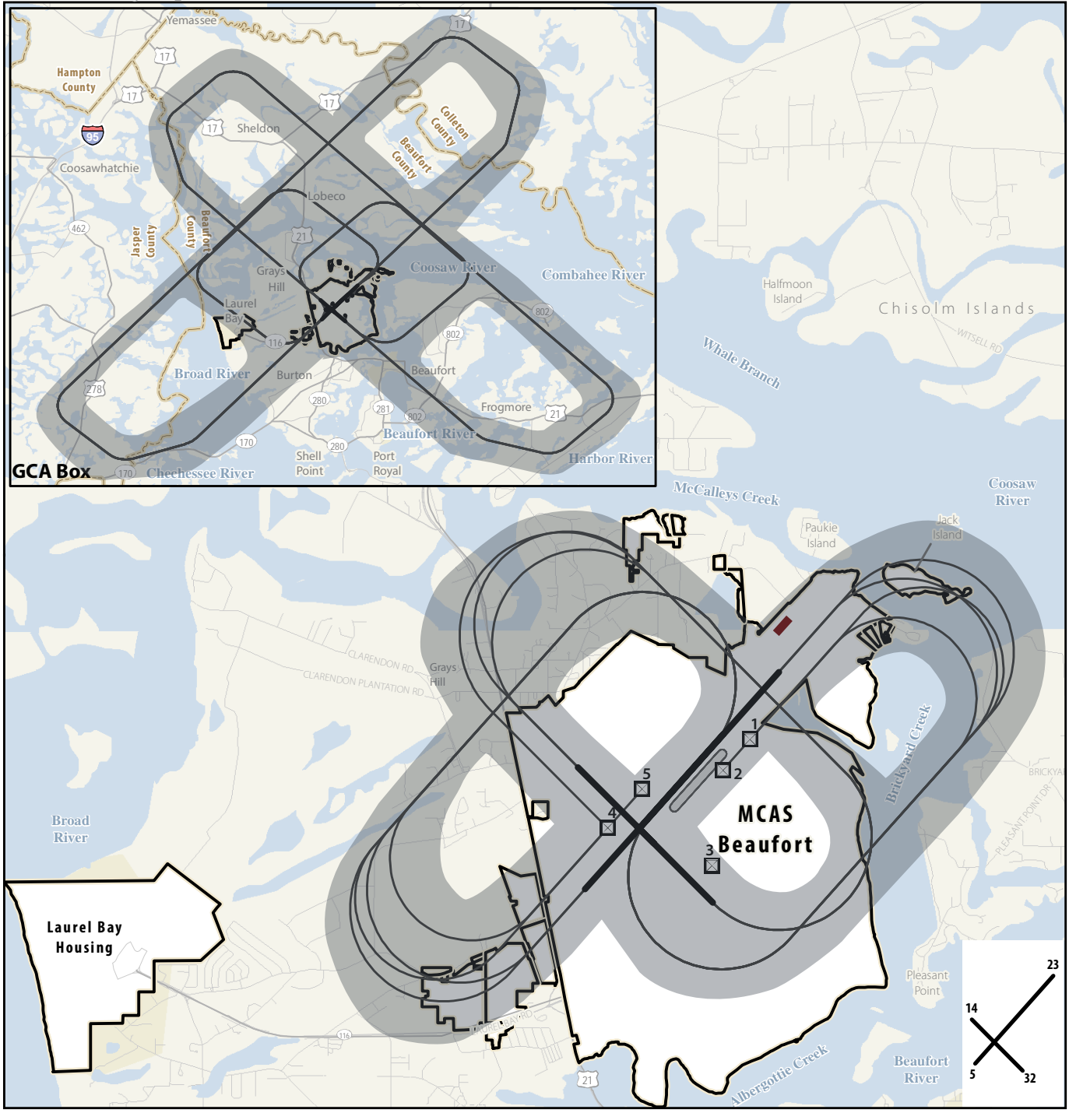
Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.



- Legend**
- Vertical Landing Pads
 - Major Road
 - Runway
 - FBO
 - LHD Facility
 - Waterbody
 - Urban Area
 - MCAS Beaufort Base Boundary
 - Departure Paths

Figure 3-3
Representative Departure Flight Paths
MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.



- Legend**
- Vertical Landing Pads
 - Major Road
 - Runway
 - FBO
 - LHD Facility
 - MCAS Beaufort Base Boundary
 - County Boundary
 - Waterbody
 - Urban Area
 - Pattern Flight Paths

Figure 3-4
Representative Pattern Flight Paths
 MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

4

AIRCRAFT NOISE

- 4.1 What is Sound/Noise?
- 4.2 Airfield Noise Sources and Noise Modeling
- 4.3 2012 Noise Contours
- 4.4 Noise Abatement and Inquiries

Aircraft noise can play a key role in shaping an installation’s relationship with an adjacent community. It is also a key factor in local land use planning. Since there is the potential that noise from aircraft operations may affect areas surrounding MCAS Beaufort, the Marine Corps has established certain areas around the installation as noise zones, using the guidance provided in the AICUZ Instruction. These noise zones provide the community and planning organizations the tools needed to plan compatibly near airfields. The noise zones developed for this AICUZ Study are adopted from the *USMC F-35B East Coast Final EIS*.

4.1 WHAT IS SOUND/NOISE?

Sound is vibrations in the air, which can be generated by a multitude of sources. Some of the sources of noise include roadway traffic, recreational activities, railway activities, and aircraft operations. When the sound becomes invasive or unwanted, it becomes noise. Generally, sound becomes noise to a listener when it interferes with normal activities. For further discussion of noise and its effect on people and the environment, see Appendix A.

In this AICUZ Study, all sound or noise levels are measured in A-weighted decibels (dBA), which represent sound pressure adjusted to the range of human hearing. When the use of A-weighting is understood, the adjective “A-weighted” is often omitted and the measurements are expressed as decibels, or “dB.” In this AICUZ Study, dB units refer to A-weighted sound levels.

On an A-weighted scale, barely audible sound is set at 0 dB, and normal speech has a sound level of approximately 60 to 65 dB. Generally, a sound level above 120 dB will begin to provide discomfort to a listener, and the threshold of pain is 140 dB.

Typical A-Weighted Sound Levels and Common Sounds

0 dB – Threshold of Hearing
 20 dB – Ticking Watch
 45 dB – Bird Calls (distant)
 60 dB – Normal Conversation
 70 dB – Vacuum Cleaner (3 ft)
 80 dB – Alarm Clock (2 ft)
 90 dB – Motorcycle (25 ft)
 100 dB – Ambulance Siren (100 ft)
 110 dB – Chain Saw
 120 dB – Rock Concert
 130 dB – Jackhammer
 140 dB – Threshold of Pain

* Refer to Appendix A for additional examples and details on sound levels.

Common Measurements of Noise/Sound

A-Weighted Decibels, dBA: An expression of the relative loudness of sounds in air as perceived by the human ear where the decibel values of sounds at low frequencies are reduced. By contrast, unweighted decibels make no correction for audio frequency.

Decibels, dB: This unit of measurement is used to represent the intensity of a sound, also called a sound level.

Day-Night Average Sound Level, DNL: A composite metric that incorporates both the intensity of a sound and its duration within a 24-hour period.

* Refer to Appendix A for additional information and details on sound.

The noise exposure from aircraft is measured using the day-night average sound level (DNL) metric. The DNL metric, established in 1980 by the Federal Interagency Committee on Urban Noise (FICUN), presents a reliable measure of community sensitivity to aircraft noise and has become the standard metric used in the United States (except California, which uses a similar metric, the Community Noise Exposure Level [CNEL]).

DNL averages the sound energy from aircraft operations at a location over a 24-hour period. DNL also adds an additional 10 dB to events occurring between 10:00 p.m. (2200 hours) to 7:00 a.m. (0700 hours). This 10-db “night-time penalty” represents the added intrusiveness of sounds due to the increased sensitivity to noise when ambient noise levels are low. By combining factors most noticeable about noise annoyance—maximum noise levels, duration, the number of events over a 24-hour period, and the night-time penalty—DNL provides a single measure of overall noise impact. Scientific studies and social surveys conducted to evaluate community annoyance to all types of environmental noise have found DNL to be the best correlation to community annoyance (FICUN 1980, U.S. Environmental Protection Agency [EPA] 1982, American National Standards Institute [ANSI] 1990, Federal Interagency Committee on Noise [FICON] 1992). Although DNL provides a single measure of overall noise impact, it does not provide specific information on the number of noise events or the individual sound levels that occur during the day. For example, a day-night average sound level of 65 dBA could result from a few noisy events or a large number of quieter events.

The DNL is depicted visually as a noise contour that connects points of equal noise value and are depicted in 5-dBA increments (60, 65, 70, 75, 80, and 85 DNL). Noise levels inside a contour may be similar to those outside a contour line. Where the contour lines are close together, the change in noise level is greater. Where the lines are far apart, the change in noise level is gradual.

The AICUZ Program generally divides noise exposure into three categories known as “noise zones” for land use planning purposes:

- **Noise Zone 1:** Less than 65 DNL; low or no noise impact.

- **Noise Zone 2:** 65 to 75 DNL; moderate impact, where some land use controls are required.
- **Noise Zone 3:** Greater than 75 DNL; most severely impacted area requiring the greatest degree of land use control.

Land use recommendations within these noise zones are discussed and provided in Chapter 6, Land Use Compatibility Analysis. Noise contours represent a single measure of overall noise impact and are discussed further in Section 4.2, Airfield Noise Sources and Noise Modeling.

4.2 AIRFIELD NOISE SOURCES AND NOISE MODELING

The Marine Corps conducts noise studies, as needed, to assess the noise impacts of aircraft operations. This 2013 AICUZ Study presents the projected (2023) noise contours at MCAS Beaufort. The Study utilized NOISEMAP, the only DOD accepted computer modeling program that projects noise impacts around military airfields. As discussed in Section 3.2, Aircraft Operations, the main sources of noise at an airfield are maintenance run-ups and flight operations. As part of the noise analysis for the *USMC F-35B East Coast Final EIS*, data was compiled and incorporated into the model to generate noise contours from the following sources:

- Detailed F-35B flight operations by type of operation and DNL time periods;
- Marine Corps flight tracks and profiles developed specifically for F-35B operations; and
- Referenced acoustic database for the NOISEMAP computer model.

The inputs and data collected and incorporated into the NOISEMAP computer model include:

- Type of operation (i.e., arrival, departure, and pattern);
- Number of operations per day;

- Time of operation;
- Flight track;
- Aircraft power settings, speeds, and altitudes;
- Number and duration of pre-flight and maintenance run-ups;
- Terrain;
- Surface type; and
- Environmental data (temperature and humidity).

NOISEMAP calculates DNL contours resulting from aircraft operations using such variables as power settings, aircraft model and type, maximum sound levels, and duration and flight profiles. The contours generally follow the flight paths of aircraft. Noise contours that were generated based on this information and adopted by this AICUZ Study as the 2013 noise contours are provided in Section 4.3, 2013 Noise Contours.

4.3 2013 NOISE CONTOURS

Noise contours provide MCAS Beaufort, local community planning organizations, and the general public with maps of the noise and potential noise related impacts of aircraft operations. The ability to view the noise contours with respect to land use creates a useable tool to help understand and assess any potential incompatible land uses and plan future development around MCAS Beaufort.

Noise contours presented in this AICUZ Study are identified as the 2013 noise contours, based on the year of the Study's release, but represent the CY 2023 projected operations. Aircraft operations are projected to help ensure that the future operational capability of the air installation is accounted for. This AICUZ Study forecasts aircraft operations as far into the future as possible (often 10 to 15 years) to assess MCAS Beaufort's impact on the local community. Therefore, projected operations are incorporated into this 2013 AICUZ Study.

Noise contours provide a military installation, local planning organizations, and the public with a graphical representation of potential noise related impacts associated with aircraft operations.

These contours can assist in locating, identifying, and addressing any incompatible land uses and assist in plans for future development.

Projected operations for MCAS Beaufort are significantly different from current operations, and include replacement of the F/A-18 with the F-35B aircraft and the addition of the PTC (see Chapter 1, Table 1-2).

The 2013 AICUZ noise contours for MCAS Beaufort are presented in the following sections along with a detailed description of the noise environment for the airfield. Also provided are comparisons and figure overlays for the previous AICUZ (2003) and the 2013 AICUZ noise contours. The comparison helps identify changes to noise exposure based on projected changes in aircraft operations and allows the targeting of land use recommendations to mitigate noise impacts. Land use and recommendations within noise zones for the airfield are provided and discussed in Chapter 6, Land Use Compatibility Analysis.

4.3.1 2013 AICUZ Noise Contours

The concentrations of the 2013 AICUZ noise contours are fairly evenly distributed around MCAS Beaufort in a rough diamond shape (Figure 4-1). Operations are concentrated on Runway 05/23 and show a slight extension of the contours parallel to that runway.

The 65 DNL noise contour extends approximately 3.8 miles off station to the northeast (Runway 23) and 4.3 miles off station to the southwest (Runway 05). Noise contours also follow the arrival and departure operations on Runway 14/32, and the 65 DNL contour extends approximately 3.8 miles off station to the northwest (Runway 14) and 1.9 miles off station to the southeast (Runway 32) (distances measured from the installation boundary to the furthest directional extent of the noise contour).

The greater than 80 DNL contours are almost exclusively on station with minimal areas extending off station. The 75 DNL noise contour extends off station, specifically to the west and northeast. The 60-70 DNL zone follows the diamond shape of the noise contours and, for the most part, is bounded by water at its furthest extent. The total amount of off-station acreage within the 60-65 DNL noise zone is 10,636 acres, excluding areas over water.

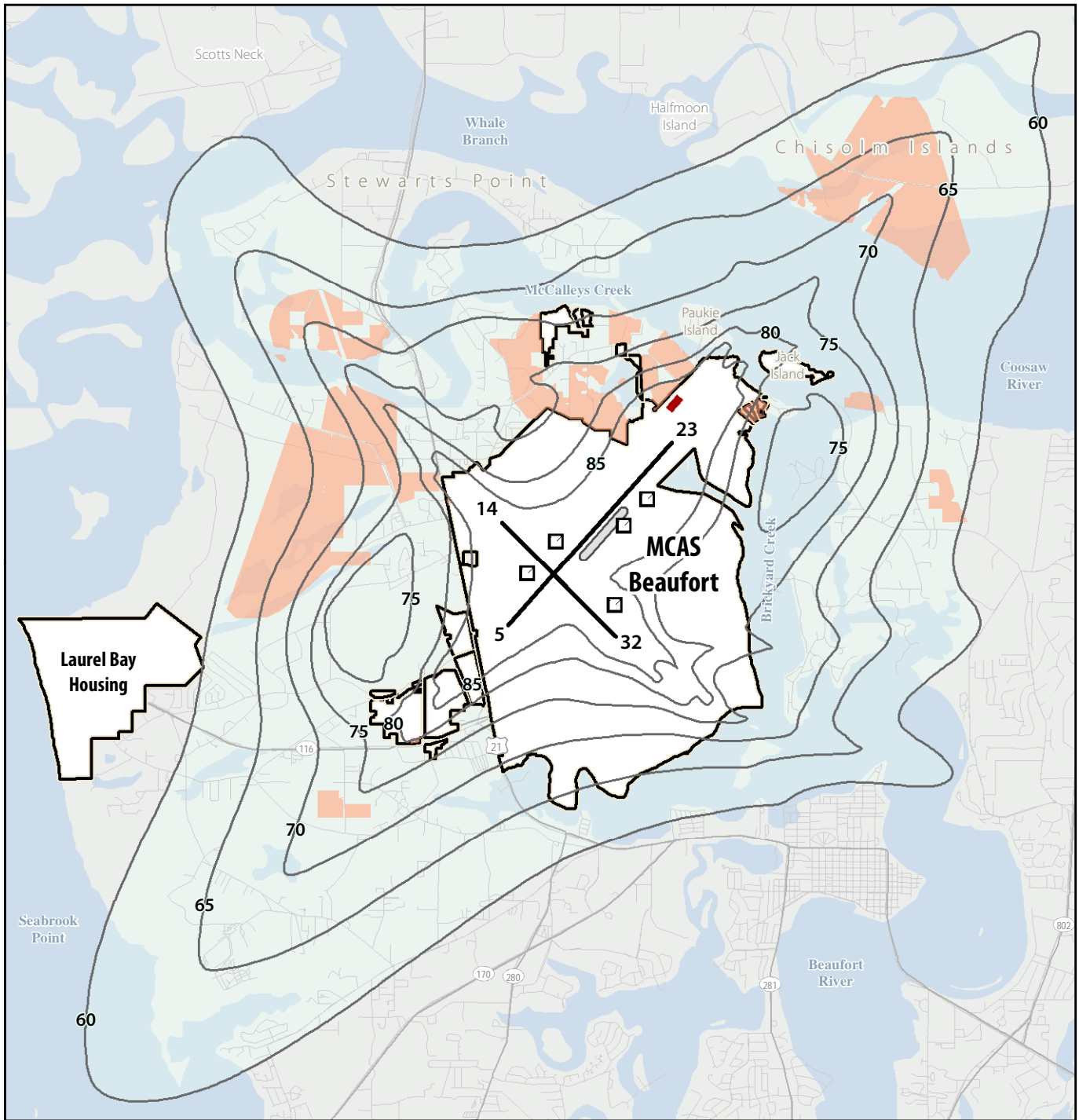
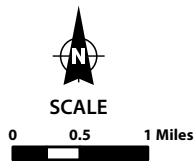


Figure 4-1
AICUZ Noise Contours
MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC



Legend

- Vertical Landing Pads
- 2013 Noise Contour (db DNL)
- Runway
- FBO
- LHD Facility
- Major Road
- MCAS Beaufort Base Boundary
- USMC Land Protected Under Restrictive Easements
- Waterbody

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

Figure 4-2 provides a DNL color gradient of the noise propagating from MCAS Beaufort into the surrounding community. The noise gradient provides a simulated view of the noise propagating from the installation outside the confines of the noise contours. Noise contours show the extent of a certain DNL, while the color gradient shows the fluid concept of noise and that noise does not stop at the contour lines depicted on maps and figures. The highest noise levels are concentrated within the installation boundaries and decrease to much lower levels into the surrounding community. Figure 4-2 also depicts the noise outside the 65 DNL noise contour to 45 DNL, which are considered ambient or background noise levels.

4.3.2 Comparison of 2003 and 2013 AICUZ Noise Contours

The 2013 AICUZ noise contours have changed in size and location from the 2003 AICUZ noise contours (see Figure 4-3 and Table 4-1) and have a net acreage increase compared to the 2003 AICUZ noise contours. The changes are due to a change in aircraft mix, flight patterns, operations, operational levels, and improved noise mapping techniques.

Table 4-1 Land Area within AICUZ Noise Contours for MCAS Beaufort

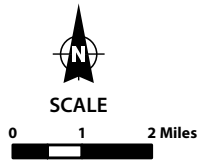
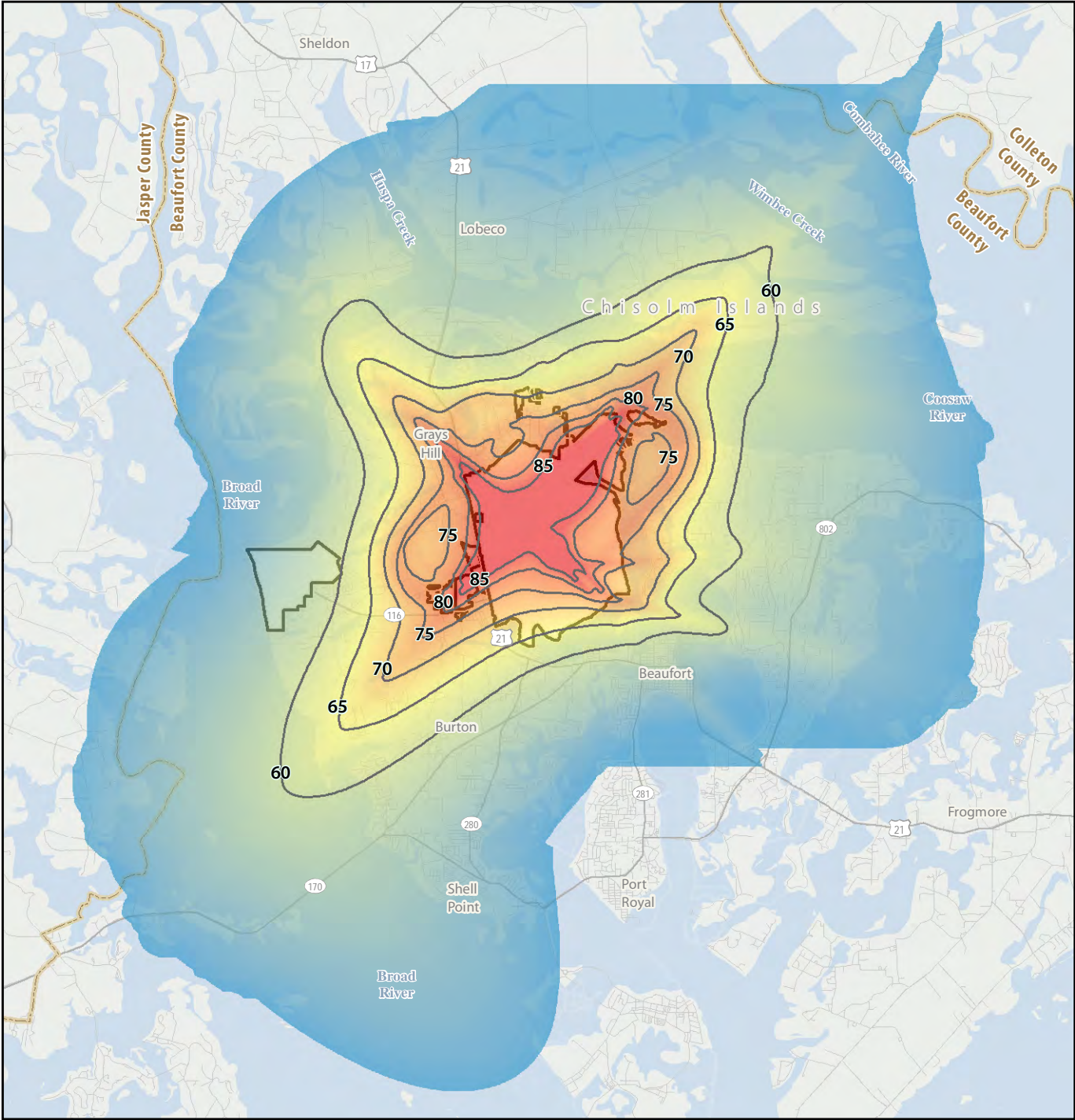
DNL Noise Zone (dB)	2003 AICUZ		2013 AICUZ	
	On Station (acres)	Off Station (acres)	On Station (acres)	Off Station (acres)
60-65	354 ^a	6,599 ^a	30 ^a	10,636 ^a
65-70	350	6,856	325	5,734
70-75	420	2,375	406	3,443
75-80	1,964	3,135	1,241	2,920
80-85	1,316	179	1,064	487
85+	1,412	9	2,401	198
Total Area	5,816	19,113	5,467	23,418

Source: DON 2010, MCAS Beaufort 2013

Note:

Acreage data (which excludes bodies of water) is from the USMC F-35B East Coast Final EIS, except where noted.

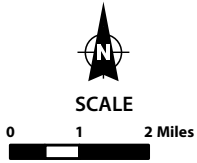
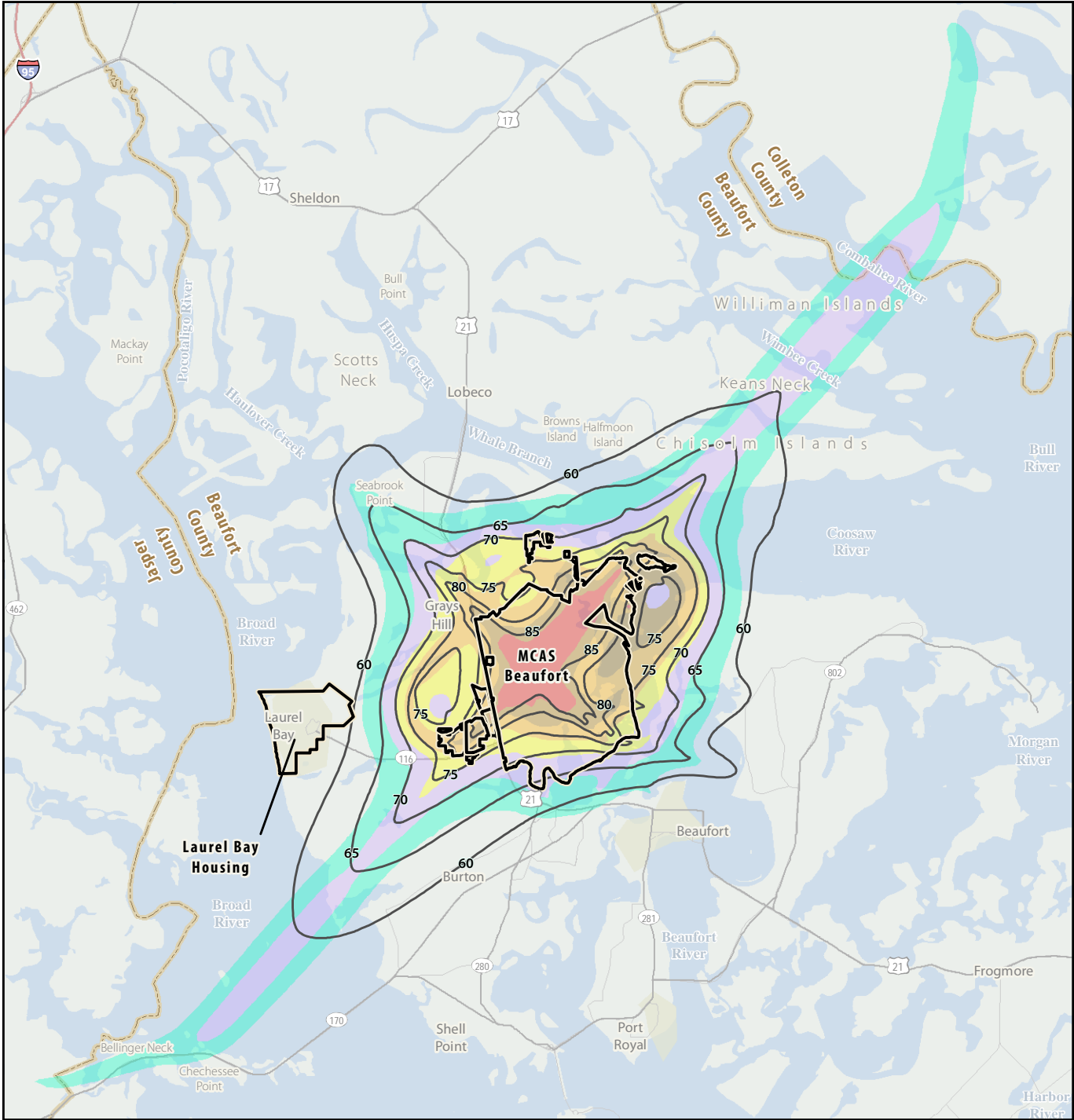
^a Calculated as part of the 2013 AICUZ Study (MCAS Beaufort 2013)



Legend

- 2013 Noise Countour (db DNL)
- Major Road
- ▭ MCAS Beaufort Base Boundary
- ▭ County Boundary
- ▭ Waterbody
- Noise Value
 - High : 85
 - Low : 45

Figure 4-2
AICUZ Noise Gradient
MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC



Legend

- Major Roads
- 2013 Noise Contour (db DNL)
- Urban Area
- Waterbody
- MCAS Beaufort Base Boundary
- 2003 Noise Contour (db DNL)
- 60-65
- 65-70
- 70-75
- 75-80
- 80-85
- 85-90

Figure 4-3
Comparison of 2003 and 2013 AICUZ Noise Contours
 MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC

Therefore, the replacement of the F-18 with the F-35B as the primary aircraft on station was the driver behind the change in noise contours.

4.4 NOISE ABATEMENT AND INQUIRIES

Impacts from noise associated with MCAS Beaufort occur in areas on-station and off-station, with areas in closer proximity to aircraft operations experiencing greater impacts. MCAS Beaufort takes precautions to reduce noise impacts to sensitive areas both on-station and off-station. However, noise inquiries are occasionally filed with the station. Noise abatement procedures instituted by the installation and noise inquiries are discussed below.

4.4.1 Noise Abatement

MCAS Beaufort takes precautions to minimize aircraft noise in the community, also called noise abatement or avoidance. All Marine Corps aviators are briefed on complying with noise abatement procedures. Noise abatement procedures also apply to engine run-up and maintenance operations conducted on station which are written into the Air Operations Manual.

Noise abatement procedures at MCAS Beaufort are listed below:

- Flight crews are briefed on noise abatement procedures;
- Flight crews are periodically briefed on the existing patterns and the need to maintain the published patterns;
- Adherence to FAA regulations to maintain minimum altitudes in congested and rural areas; and
- Avoidance of prolonged periods of high-power turn-ups.

4.4.2 Noise Inquiries

Noise inquiries are related to the intensity and frequency of an event as well as the individual sensitivity of the person impacted. Noise inquiries typically originate from areas within or near the noise zones. By definition, these areas generally experience the highest levels of noise; however, noise inquiries can originate from anywhere within the surrounding community. In general, individual response to noise levels varies and is influenced by factors including:

- Activity the individual is engaged in at the time of the noise event;
- The individual’s general sensitivity to noise;
- Time of day or night;
- Length of time an individual is exposed to a noise;
- Predictability of noise; and
- Weather conditions.

Some people have greater noise sensitivity than others. Generally, a small increase in noise level will not be noticeable; however, as the change in noise level increases, individual perception is greater, as shown in Table 4-2.

Table 4-2 Subjective Responses to Noise

Change	Change in Perceived Loudness
1 decibel	Requires close attention to notice
3 decibels	Barely noticeable
5 decibels	Quite noticeable
10 decibels	Dramatic – twice or half as loud
20 decibels	Striking – fourfold change

As with most airfields, a majority of MCAS Beaufort’s noise inquiries result from individuals near or adjacent to the airfield or located along an arrival or departure flight path. The number of noise inquiries has declined since 9/11 and varied year to year since that time. Fifty-eight inquiries were received in 2010, eighteen were received in 2008 and 2009, and five were received in 2003 (MCAS Beaufort 2011).

MCAS Beaufort

**Online Noise Complaint
Report Form**

[http://www.marines.mil/
unit/mcasbeaufort/Pages/
welcome.aspx](http://www.marines.mil/unit/mcasbeaufort/Pages/welcome.aspx)

Contact Information

MCAS Beaufort
Noise Complaint Hotline
(843) 228-6229

MCAS Beaufort has established a procedure to receive, process, and address noise inquiries. If there are concerns or inquiries about aircraft noise in the area, citizens are encouraged to submit an online Noise Report Form (Appendix C) or contact a representative using the information provided in the margin.

Noise inquiries at MCAS Beaufort are coordinated by the Public Affairs Officer and the Community Plans and Liaison Officer (CP&LO), in coordination with Air Operations personnel. Concerned citizens are encouraged to call the Public Affairs Officer to log their complaint or submit their complaint via the online Noise Report Form. The Public Affairs Officer records the specifics of the caller's concern in a noise complaint form (e.g., date, time, location) (Appendix C). The noise complaint is then discussed and commented on, and the Public Affairs Officer, as needed, provides a response to the complainant.

5

5.1 Flight Safety and Aircraft Mishaps

5.2 Accident Potential Zones

AIRFIELD SAFETY

Community and airfield safety is paramount to the Marine Corps, and is a shared responsibility between the Marine Corps and the surrounding communities, each playing a vital role in its success. As such, the Marine Corps has established a flight safety program and areas of accident potential around MCAS Beaufort to assist in preserving the health, safety, and welfare of the people living near the airfield. Cooperation between the Marine Corps and the communities results in strategic and effective land use planning and development surrounding military airfields. This AICUZ Study provides tools to reach the shared safety goal.

Identifying safety issues assists the community in developing land uses compatible with airfield operations. These issues include hazards around the airfield that obstruct or interfere with aircraft arrivals and departures, pilot vision, communications, or aircraft electronics, and areas of accident potential. While the likelihood of an aircraft mishap occurring is remote, one can occur. Aircraft safety and mishaps at MCAS Beaufort are discussed in detail in the following sections.

In addition, the Marine Corps establish APZs which are conceptually developed based on historical data for aircraft mishaps that have occurred near airfields. This AICUZ Study presents the 2013 APZs for MCAS Beaufort. The accident potential concept describes the probable impact areas if an accident were to occur, which is to be distinguished from the probability of an accident occurring. APZs are not a prediction of the number of accidents that have occurred or the odds of an accident occurring; APZs only reflect the most likely location of an accident. The AICUZ Program recommends certain land uses that concentrate large numbers of people—such as apartments, churches, and schools—be constructed outside the APZs.

5.1 FLIGHT SAFETY AND AIRCRAFT MISHAPS

Flight safety programs are designed to reduce the hazards that can cause aircraft mishaps; the APZs are designed to minimize the potential harm if a mishap does occur.

5.1.1 Flight Safety

Flight safety refers to important safety steps taken and/or measures implemented to ensure both pilot safety during aircraft operations and the safety of those in the community who live and work in the vicinity of an air station. The FAA and the military have defined flight safety zones (imaginary surfaces) below aircraft arrival and departure flight tracks and surrounding the airfield. Heights of structures and trees are restricted in these imaginary surfaces, and the FAA evaluates proposed construction to mitigate impacts. The flight safety zones are designed to reduce the hazards that can cause an aircraft mishap. This section discusses hazards to flight safety that should be avoided in the airfield vicinity and measures to avoid potential pilot interferences.

Bird/Animal Strike Hazards (BASH)

Wildlife represents a significant hazard to flight operations. Birds are drawn to different habitat types found in the airfield environment, including edges, grass, brush, forest, water, and even the warm pavement of the runway. Although most bird and animal strikes do not result in crashes, they cause

structural and mechanical damage to aircraft, as well as loss of flight time. Most collisions occur when the aircraft is at an elevation of less than 1,000 feet. Due to the speed of the aircraft, collisions with wildlife can happen with considerable force. To reduce bird/animal strike hazards (BASH), the FAA and the military recommend that land uses that attract birds be located at least 10,000 feet from active movement areas of the airfield. Land uses that attract birds and other wildlife include transfer stations, landfills, golf courses, wetlands and stormwater ponds, dredge disposal sites, and seafood



processing plants. Design modifications can be used to reduce the attractiveness of these types of land uses to birds and other wildlife.

Electromagnetic Interference (EMI)

New generations of military aircraft are highly dependent on complex electronic systems for navigation and critical flight and mission related functions. Consequently, care should be taken in siting any activities that create EMI. EMI is defined by ANSI as any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics/electrical equipment. It can be induced intentionally, as in electronic warfare, or unintentionally, such as high-tension line leakage. Mega-watt wind turbines cause EMI and pose a hazard to air navigation. Additionally, EMI may be caused by atmospheric phenomena, such as lightning and precipitation static, and by non-telecommunication equipment, such as vehicles and industry machinery. EMI also affects consumer devices, such as cell phones, FM radios, television reception, and garage door openers.

Lighting

Bright lights, either direct or reflected, in the airfield vicinity can impair a pilot's vision, especially at night. A sudden flash from a bright light causes a spot or "halo" to remain at the center of the visual field for a few seconds or more, rendering a person virtually blind to all other visual input. This is particularly dangerous at night when the flash can diminish the eye's adaptation to darkness. Partial recovery of this adaptation is usually achieved in minutes, but full adaptation typically requires 40 to 45 minutes.

Visible lasers, including low-powered legal laser pointers, are emerging as a safety concern for pilots. Visual interference with pilot performance due to lasers can result in temporary flashblindness, glare, disruptions, and distraction. These are most hazardous during critical phases of flight, landings, take-offs, and emergency maneuvers.

Smoke, Dust, and Steam

Industrial or agricultural sources of smoke, dust, and steam in the airfield vicinity could obstruct the pilot's vision during take-off, landing, or other periods of low-altitude flight.

Imaginary Surfaces

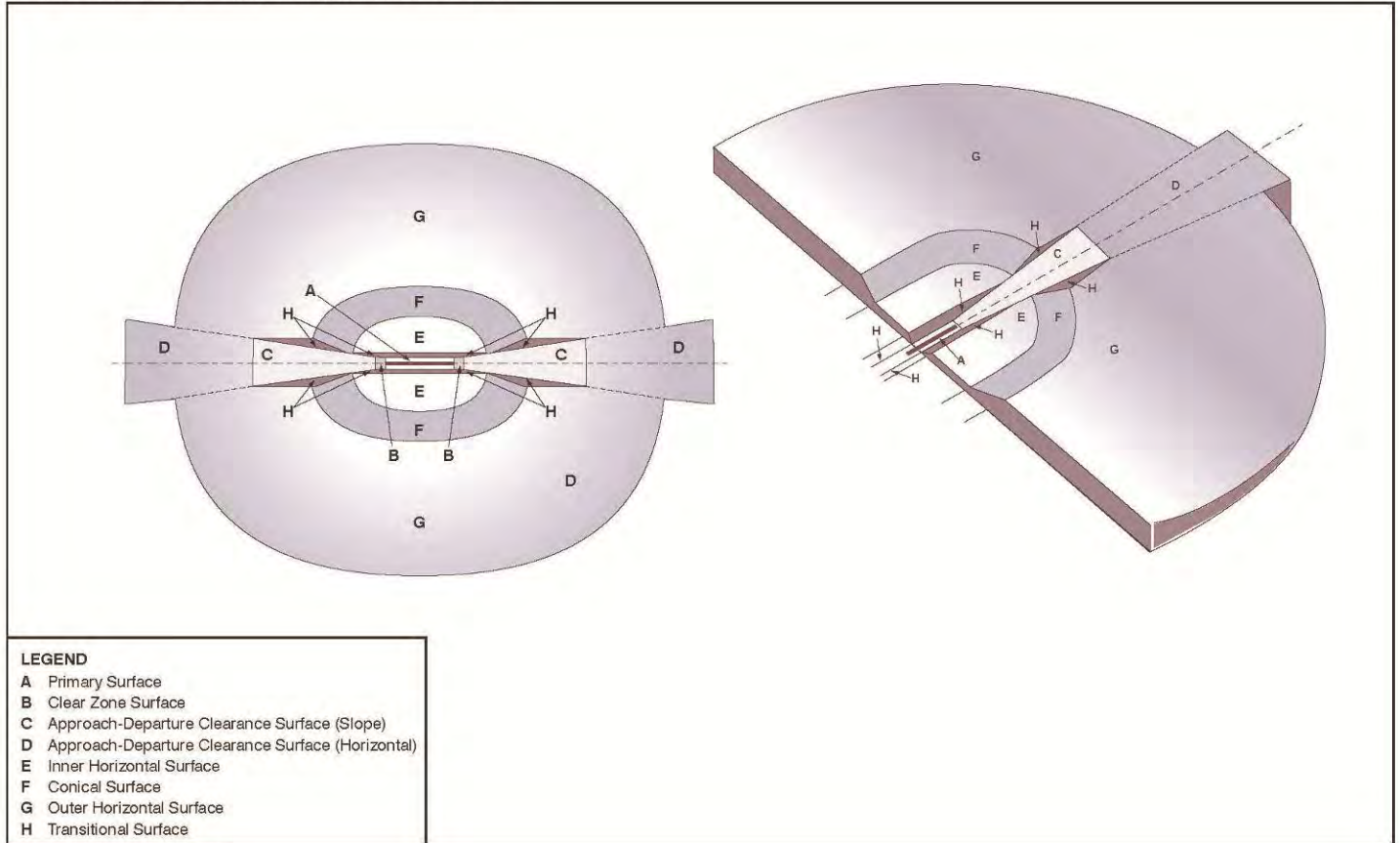
The airspace surrounding an airfield must remain free of obstructions. The DOD, FAA, and Federal Aviation Regulations (FAR) identify a complex series of imaginary planes and transition surfaces that define the airspace that must to remain free of obstructions. Obstruction-free imaginary surfaces ensure safe flight approaches, departures, and pattern operations. Obstructions include natural terrain and man-made features, such as buildings, towers, poles, wind turbines, railroads, and other vertical obstructions to airspace navigation.

Fixed-wing runways and rotary-wing runways/helipads have different imaginary surfaces. Brief descriptions of the imaginary surfaces for fixed-wing Class B runways are provided on Figure 5-1 and in Table 5-1. In general, no aboveground structures are permitted in the primary surface and Clear Zones, and height restrictions apply to transitional surfaces and approach and departure surfaces. These height restrictions are more stringent as one approaches the runway and become less restrictive as the distance from the runway increases.

Imaginary surfaces at MCAS Beaufort are depicted on Figure 5-2. As noted above, each runway has assigned imaginary surfaces; therefore, since MCAS Beaufort has two runways, imaginary surfaces are applied to each runway. In addition, the LHD and VL pads have been assigned imaginary surfaces.

Figure 5-1 Imaginary Surfaces and Transition Planes for Class B Fixed-Wing Runways

02/002376 YZ02.02/Class B Imaginary Surfaces Fixed Wing_top and side views/09/30/11-GR4

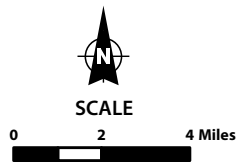
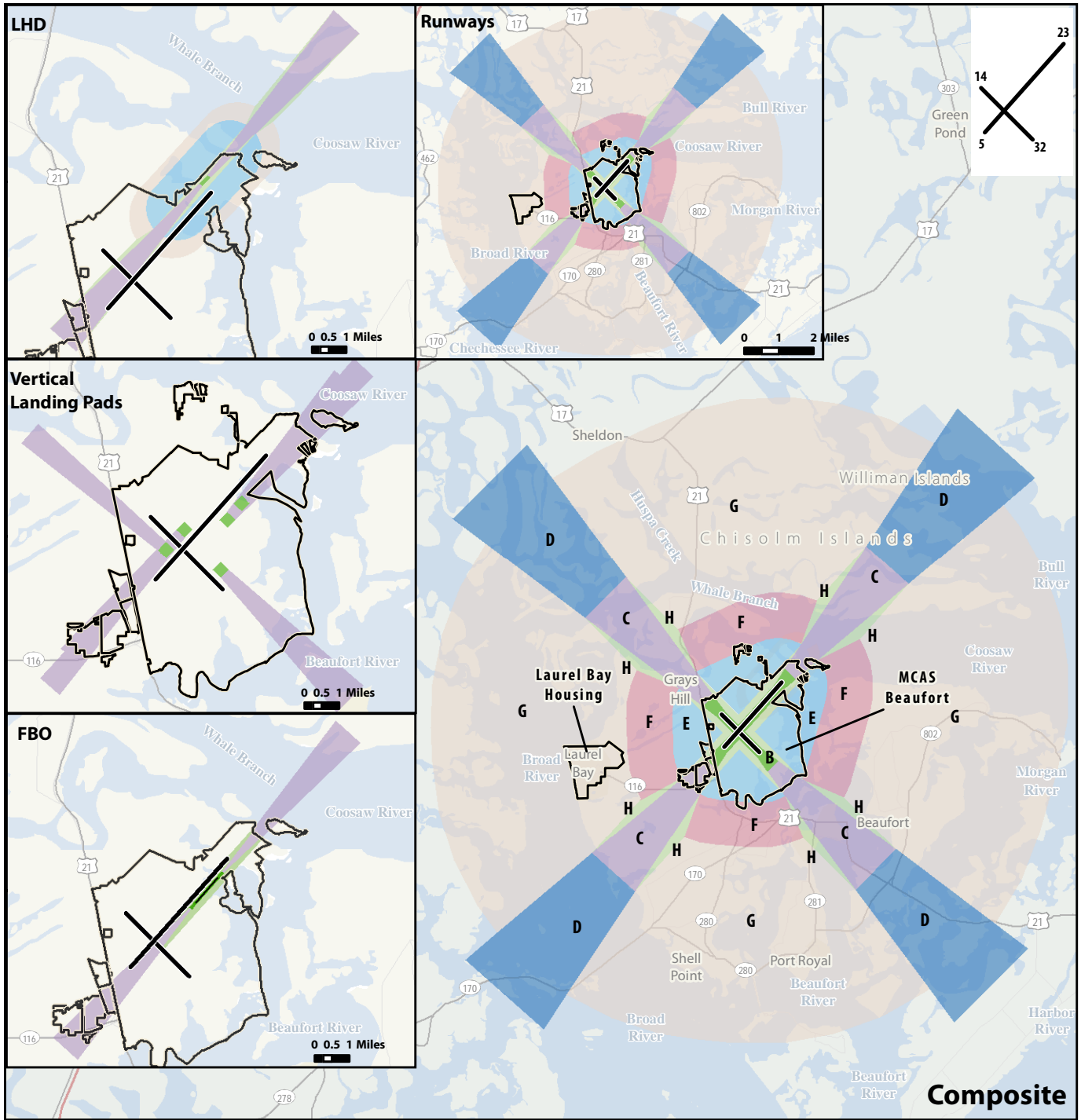


SOURCE: UFC 3-260-01, November 2009

Table 5-1 Imaginary Surfaces – Class B Fixed-Wing Runways

Planes and Surfaces	Geographical Dimensions
Primary Surface	Aligned (longitudinally) with each runway and extending 200 feet from each runway end. The width is 1,500 feet.
Clear Zone	Located immediately adjacent to the end of the runway and extends 3,000 feet beyond the end of the runway and is 1,500 feet wide and flares out to 2,284 feet wide.
Approach-Departure Clearance Surfaces	An inclined or combination inclined and horizontal plane, symmetrical about the runway centerline. The slope of the surface is 50:1 until an elevation of 500 feet and continues horizontally 50,000 feet from the beginning. The outer width is 16,000 feet.
Inner Horizontal Surface	An oval shaped plane 150 feet above the established airfield elevation. Constructed by scribing an arc with a radius of 7,500 feet around the centerline of the runway.
Outer Horizontal Surface	A horizontal plane located 500 feet above the established airfield elevation, extending outward from the conical surface for 30,000 feet.
Conical Surface	An inclined plane that extends from the inner horizontal surface outward and upward at a 20:1 slope and extends for 7,000 feet and to a height of 500 feet above the established airfield elevation.
Transitional Surface	<p>An inclined plane that connects the primary surface and the approach-departure clearance surface to the inner horizontal surface, conical surface, and outer horizontal surface.</p> <p>These surfaces extend outward and upward at right angles to the runway centerline and the runway centerline, extended at a slope of 7:1 from the sides of the primary surface and from the sides of the approach surfaces.</p>

Sources: NAVFAC 1982; DOD 2008



Legend

- Interstate
- Major Road
- Runway
- MCAS Beaufort Base Boundary
- Waterbody
- B: Clear Zone Surface
- C: Approach-Departure Clearance Surface(50:1 SlopeR)
- D: Approach-Departure Clearance Surface (Horizontal)
- E: Inner Horizontal Surface (45.72 m [150'] Elevation)
- F: Conical Surface (20:1 Slope Ratio)
- G: Outer Horizontal Surface (152.40 m [500']Elevation)
- H: Transitional Surface(7:1 Slope Ratio)

Figure 5-2
Imaginary Surfaces, Class B
Fixed-Wing Runway
MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

5.1.2 Aircraft Mishaps

The Marine Corps categorizes aircraft mishaps into one of three classes: Class A, Class B, or Class C. The classification system is based on the severity of injury to individuals involved and total property damage. The most severe is a Class A mishap and the least severe is a Class C mishap.

There have been four Class A mishaps at MCAS Beaufort since 1999, with the last occurring in 2008. There have also been other incidents (Class B and C mishaps) which have occurred at or around the airfield (Naval Safety Center 2010).

5.2 ACCIDENT POTENTIAL ZONES

In the 1970s and 1980s, the military conducted studies of historic accident and operations data throughout the military. The studies showed that most aircraft mishaps occur on or near the runway, diminishing in likelihood with distance. Based on the study, the DOD has identified APZs, or areas where an aircraft accident is most likely to occur if an accident were to take place. Subsequently, APZs are not a prediction of the number of accidents that have occurred or the odds of an accident occurring; APZs only reflect the most likely location of an accident. APZs follow departure, arrival, and pattern flight tracks. They are based upon analysis of historical data and are designed to minimize the potential harm if a mishap does occur by limiting activities in the designated APZ areas. APZs are used by the military and local planning agencies to ensure compatible development within the APZs. Although the likelihood of an accident is remote, the AICUZ guidelines recommend that certain land uses that concentrate large numbers of people, such as apartments, churches, and schools, be avoided within the APZs.

APZs are not a prediction of the number of accidents that have occurred or the odds of an accident occurring; APZs only reflect the most likely location of an accident

The USMC recommends that land uses with a high concentration of people (apartments, churches, schools) be located outside APZs.

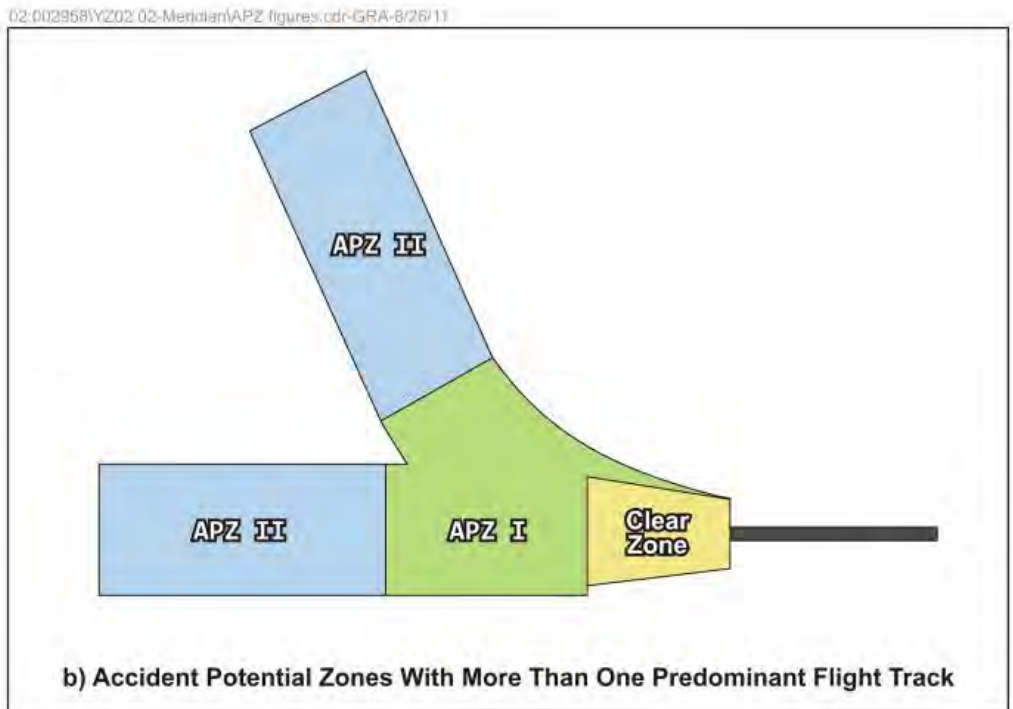
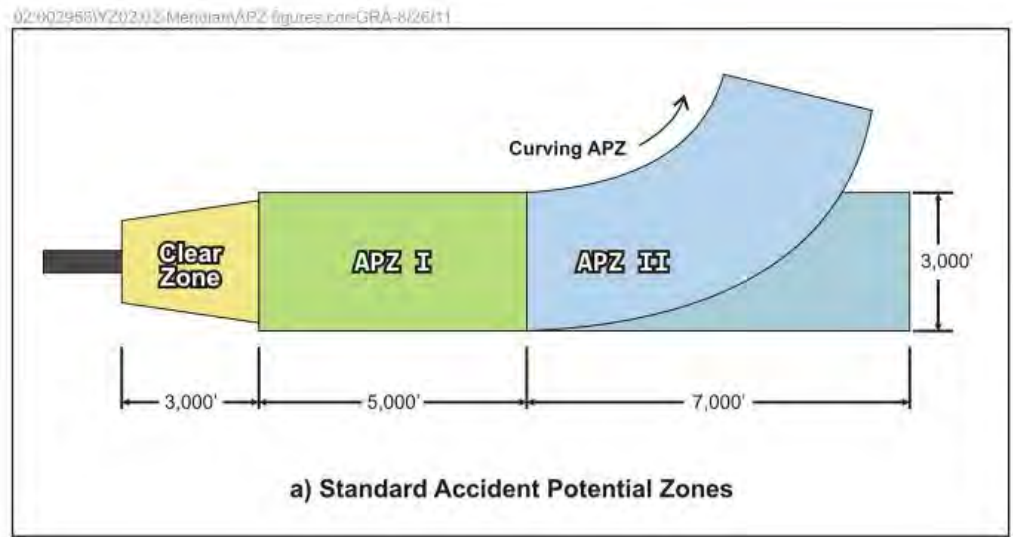
APZ configurations and dimensions are derived from the AICUZ Instruction and have been established for all runway classifications. There are three different APZs: Clear Zone, APZ I, and APZ II. APZs are, in part, based on the number of operations conducted at the airfield and, more specifically, the number of operations conducted for specific flight tracks.

All runways at MCAS Beaufort are classified as Class B runways. The components of standard APZs for Class B runways are defined in the AICUZ Instruction as follows, and identified on Figure 5-3:

- **Clear Zone.** The Clear Zone is a trapezoidal area lying immediately beyond the end of the runway and outward along the extended runway centerline for a distance of 3,000 feet. The Clear Zone measures 1,500 feet in width at the runway threshold and 2,284 feet in width at the outer edge. These Clear Zones are the same as the Clear Zones for imaginary surfaces discussed previously. A Clear Zone is required for all active runways and should remain undeveloped and clear of trees as well as other height structures.
- **APZ I.** APZ I is the rectangular area beyond the Clear Zone. APZ I is provided under flight tracks which experience 5,000 or more annual operations (departures or approaches). APZ I is typically 3,000 feet in width and 5,000 feet in length and may be rectangular or curved to conform to the shape of the predominant flight track.
- **APZ II.** APZ II is the rectangular area beyond APZ I. APZ II is typically 3,000 feet in width by 7,000 feet in length and, as with APZ I, may be curved to correspond with the predominant flight track. When FCLP is an active aspect of aircraft operations at an installation, APZ II extends the entire FCLP track beyond APZ I.

Within the Clear Zone, most uses are incompatible with military aircraft operations. For this reason, the Marine Corps' policy is to acquire real property interests in land within the Clear Zone to ensure incompatible development does not occur. Within APZ I and APZ II, a variety of land uses are compatible; however, people-intensive uses (e.g., schools, apartments, etc.) should be restricted because of the greater risk in these areas.

Figure 5-3 Accident Potential Zones for Class B Runways



An accident is more likely to occur in APZ I than in APZ II, and is more likely to occur in the Clear Zone than in APZ I or APZ II. An APZ II area is designated whenever APZ I is required. APZs extend from the end of the runway, but apply to the predominant arrival and departure flight tracks used by the aircraft. Therefore, if an airfield has more than one predominant flight track to or from the runway, APZs can extend in the direction of each flight track (see Figure 5-3).

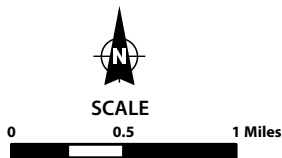
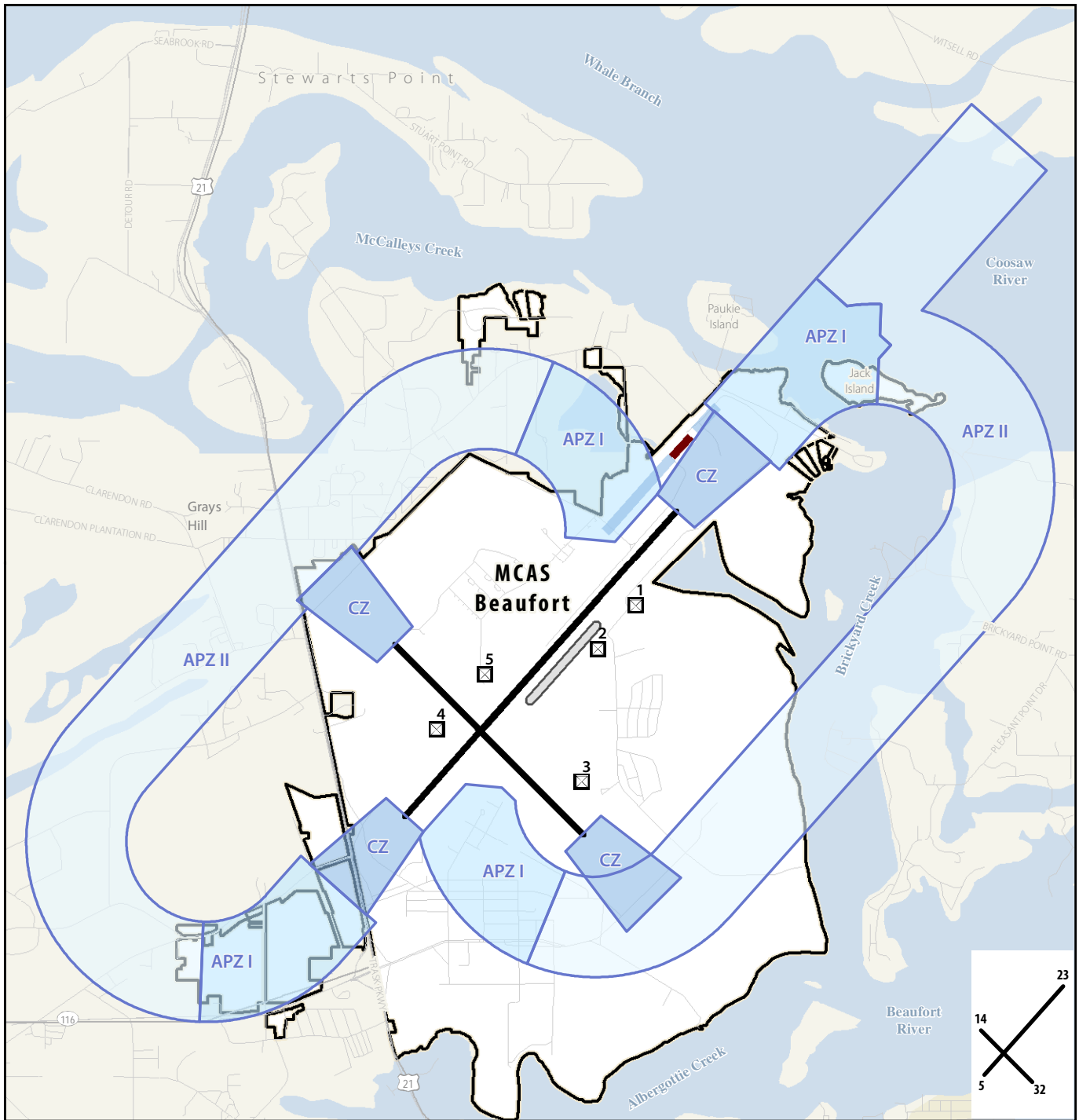
Figure 5-4 illustrates the 2013 AICUZ APZs, as presented in the *USMC F-35B East Coast Final EIS* and adopted by this AICUZ Study. Closed-loop APZs I/II are warranted on Runway 05/23 due to annual FCLP operations. All Clear Zones are located within the installation boundary, as recommended by the AICUZ Instruction.

The APZs presented in this 2013 AICUZ Study and the *USMC F-35B East Coast Final EIS* are reflective of the 2003 AICUZ APZs. The 2013 AICUZ APZs did not change in size or location since the 2003 AICUZ, except for the addition of the LHD Clear Zones, which are contained within the installation boundary. VL pads have Clear Zones that are contained within the installation boundary, as well. The off-station land area remains consistent with the 2003 AICUZ Study analysis. Table 5-2 presents land area within Clear Zones and APZs for MCAS Beaufort. Land use and recommendations within APZs for the airfield are provided and discussed in Section 6.3, Land Use Compatibility Analysis.

Table 5-2 Land Area within Accident Potential Zones for MCAS Beaufort

AICUZ APZ Type	On Station (acres)	Off Station (acres)
Clear Zone	511	0
APZ I	832	431
APZ II	710	2,882
APZ Total Area	2,706	3,324

Note: Acreage data excludes bodies of water.



Legend

- ☒ Vertical Landing Pads
 - Major Road
 - Runway
 - FBO
 - LHD Facility
 - ▭ MCAS Beaufort Base Boundary
 - Waterbody
 - Urban Area
- 2013 Accident Potential Zones
 - Clear Zone
 - APZ I
 - APZ II

Figure 5-4
AICUZ Accident Potential Zones
MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

6

LAND USE COMPATIBILITY ANALYSIS

- 6.1 Land Use Compatibility Guidelines and Classifications
- 6.2 Planning Authority
- 6.3 Land Use Compatibility Analysis

The APZs and noise contours make up the AICUZ footprint for an air installation. The AICUZ footprint defines the minimum area within which land use controls are recommended to protect the public health, safety, and welfare and to preserve the defense flying mission. MCAS Beaufort's AICUZ footprint and related land use recommendations set forth in this AICUZ Study are fundamental tools for compatible land use planning. The Marine Corps recommends that the 2013 AICUZ noise zones and APZs should be adopted into local government planning studies, regulations, ordinances, and processes to best guide compatible development around the installation.

The information presented in this chapter is intended for consideration by MCAS Beaufort, government entities at the city, state, and county levels, surrounding communities, and other interested groups and participating agencies. The purpose of this AICUZ Study is to present data in a community planning format to encourage cooperative land use planning between MCAS Beaufort and the surrounding communities so that future growth and development are compatible with the operational missions and to seek ways to lessen the operational impacts on adjacent land (DON 1988). Although ultimate control over land use and development surrounding the air installation is the responsibility of local governments, this AICUZ Study provides local governments with recommendations to promote compatible development near MCAS Beaufort.

This chapter includes a summary of land use compatibility criteria, a description of the Beaufort area's local planning authorities, and a land use compatibility analysis for existing and future land uses in the vicinity of MCAS Beaufort.

6.1 LAND USE COMPATIBILITY GUIDELINES AND CLASSIFICATIONS

The DOD has developed land use compatibility recommendations for APZs and noise zones. These recommendations, which are found in OPNAVINST 11010.36C/MCO 11010.16 (DON 2008), are intended to serve as guidelines for placement of APZs and noise zones and for development of land uses around military air installations. The guidelines recommend that noise-sensitive land uses (e.g., houses, churches) be placed outside high-noise zones, and people-intensive uses (e.g., apartments, theaters) not be placed in APZs. Certain land uses are considered incompatible with APZs and high-noise zones, while other land uses may be considered compatible or compatible under certain conditions (compatible with restrictions). The land use compatibility analysis conducted for MCAS Beaufort was based on the DOD's land use compatibility recommendations, which are presented in Appendix B.

Table 6-1 shows existing generalized land use classifications and the associated land use compatibility with each land use designation for noise zones and APZs. The generalized land use categories highlighted in Table 6-1 do not represent the local community's land use designations, but provides generic land use categories for the purpose of illustrating a basic understanding of land use compatibility across some common land use types. Local land use and zoning for Beaufort County are discussed in the remainder of this chapter.

Table 6-1 Land Use Classifications and Compatibility Guidelines

Land Use	Land Use Compatibility Noise Zone (DNL)						Land Use Compatibility with APZs		
	Noise Zone 1		Noise Zone 2		Noise Zone 3		Clear Zone	APZ I	APZ II
	<55	55-65	65-70	70-75	75-80	>80			
Single-Unit, Detached (residential)									(1)
Multi-Family Residential, (apartment, transient lodging)									
Public Assembly									
Schools and Hospitals			(2)	(2)					
Manufacturing (ex. petrol/chem.; textile)									
Parks								(4)	(4)
Business Services				(2)	(2)			(3)	(3)
Agriculture, Forestry and Mining									

Source: Adapted from OPNAVINST 11010.36C

Notes:

This generalized land use table provides an overview of recommended land use. To determine specific land use compatibility, see Appendix B.

- (1) Maximum density of 1-2 dwellings per acre.
- (2) Land use and related structures generally compatible; however, measures to achieve Noise Level Reduction (NRL) Standards to achieve a maximum interior noise level of 25 or 30 dB must be incorporated into design and construction of the structures.
- (3) Maximum Floor Area Ratio that limit people density may apply.
- (4) Facilities must be low intensity.

Key:

	Compatible
	Incompatible

6.2 PLANNING AUTHORITY

The development and control of lands outside MCAS Beaufort are dictated by local land use planning, ordinances, and regulations. MCAS Beaufort is located in the City of Beaufort in Beaufort County, South Carolina. Therefore, the land use ordinances covering the off-installation property within the AICUZ footprint are within the jurisdiction of local governments. However, local land use practices by all local governments and stakeholders that influence land development have an impact on MCAS Beaufort. To address potential changes in jurisdictional boundaries surrounding MCAS Beaufort and/or the AICUZ footprint, land use planning programs, policies, and regulations for Beaufort County, the City of Beaufort, and the Lowcountry Council of Governments (LCOG) are examined in this section.

6.2.1 Beaufort County

Beaufort County's Planning Department maintains the responsibility for a variety of functions at the county level. The Planning Department prepares and implements the Beaufort County Comprehensive Plan and cooperates in regional planning efforts with municipalities within Beaufort County as well as adjoining jurisdictions. The Planning Department also prepares and administers local planning and development regulations and community preservation planning. The Planning Department provides staff to various programs and boards, including: Rural and Critical Lands Program; Planning Commission; Corridor Review Board; Historic Preservation Review Board; and other citizen groups and committees that are involved in planning efforts. County projects, such as energy efficiency programs, affordable housing, cultural resource protection, capital improvements planning, environmental protection, and disaster recovery planning, are also supported by Planning Department staff.

The Planning Department recently completed an update (2010) to the Beaufort County Comprehensive Plan. The plan aids county officials, planners, and citizens in their decisions and policies regarding future land use development within the county. As with other comprehensive plans, Beaufort County's Comprehensive Plan is a long-range master plan that directs future growth and development and serves as a guide for making local land use decisions. Beaufort County's first comprehensive plan was adopted in 1997, which built upon the policies and recommendations of the Northern and Southern Beaufort County Regional Plans. The Southern Beaufort County Regional Plan focuses on planning for the amount of growth anticipated over a 20-year span in Hilton Head Island, the Town of Bluffton, and the surrounding unincorporated areas of the county. The Northern Beaufort County Regional Plan represents a current agreement between Beaufort County, the City of Beaufort, and the Town of Port Royal as to how the Northern Beaufort County region would grow and develop.

Beaufort County first adopted zoning regulations in 1990. This ordinance was drafted with no supporting comprehensive plan. After the Beaufort County Council adopted their first comprehensive plan in 1997, the Council immediately began drafting the current Zoning and Development Standards Ordinance, which was adopted in May of 2000. The ordinance was updated after the 2003 AICUZ, Zoning

and Development Standards, Ordinance 2000-37, Section 4.17, which enacted an Airport Overlay District (AOD), and addressed elements of the AICUZ Program, as well as federal aviation regulations. The AOD, adopted in December 2006, under Ordinance 2000-37, was established to protect future development from the effects of aircraft noise and accident potential and to prevent obstruction to air navigation. The AOD defines nine airport noise zones and APZs. These areas coincide with the AICUZ footprint. Allowable land uses, Section 4.17.5 (A) within the AOD, are those uses permitted by the underlying zoning district established by the county zoning ordinance.

6.2.2 City of Beaufort

The local planning authority for the City of Beaufort is the Metropolitan Planning Commission (MPC) for Northern Beaufort County. The Commission was established to perform all planning functions in the area of jurisdiction of the City of Beaufort and the Town of Port Royal and conform to the requirements of the South Carolina Local Government Comprehensive Planning Enabling Act of 1994. MPC is a six-member board; two members are appointed by the City Council, two are appointed by the County Council, and two members are appointed by the Town of Port Royal Town Council. The Commission reviews all matters related to comprehensive planning, land development regulations, zoning, rezoning, and planned unit developments, as well as amendments and interpretations to land use regulations, and makes recommendations to their respective governing Councils.

In 2011 the City of Beaufort reorganizes planning services into the Office of Civic Investment (OCI). The OCI includes the Beaufort Planning and Development Department, and Codes and Zoning Enforcement. The City of Beaufort's Department of Planning and Development Services is comprised of two divisions: Planning and Building Codes. The Planning Division's mission is to provide citizens, businesses, neighborhoods, City staff, and government officials with accurate planning and development information. The Division prepares plans and reports, conducts research, analyzes information, reviews development plans, and formulates recommendations to assist the community in decision making.

MCAS Beaufort was annexed by the City of Beaufort in 1999.

The Planning Department recently completed an update (2009) to the City of Beaufort Comprehensive Plan (*Vision Beaufort 2009 Comprehensive Plan*), outlining policies to guide the physical and economic development of the City and its surrounding planning area. The City Council adopted the initial Comprehensive Plan in 1999, with subsequent updates occurring in 2004 and 2009. The Comprehensive Plan is a long-range master plan that directs future growth and development and serves as a guide for making local land use decisions. The City's Comprehensive Plan has specific language regarding the AICUZ Program and states that lands in proximity to the MCAS operations within the AICUZ footprint should be lightly developed or undeveloped, remaining in a rural or natural state, which would ensure compatibility.

Under the authority of Section 6-29-710 of the Code of Laws of South Carolina, the City of Beaufort adopted a Unified Development Ordinance (UDO) on January 28, 2003, with the latest revision taking place in November 2006. The UDO classifies and regulates the use of land, buildings, and structures within the city limits of the City of Beaufort. The purpose of the UDO is to ensure that development of the City is compatible with existing and future needs of the community and is in accordance with the Comprehensive Plan. The ordinance established limitations on object heights and land uses to prevent the creation of obstructions that would be hazardous to aeronautical operations, or that could increase the risk to the public's health, safety, or well-being in the event of an aviation accident, or that would otherwise impair the full utility and operating capacity of MCAS Beaufort. The ordinance creates specific overlay districts in accordance with the AICUZ map (including the Special Planning Areas) for MCAS Beaufort for three separate purposes: (1) to provide height restrictions conforming to varying obstruction standards; (2) to provide noise mitigation standards to reduce the impact that airport operations have on land uses; and (3) to provide land use limitations based on increased risk of injury, hazards to health, or property damage in the event of an aircraft accident. Permitted and prohibited land uses and, as applicable, and attenuation measures for noise are identified within each zone.

6.2.3 Lowcountry Council of Governments

The State of South Carolina is divided into ten Councils of Government for various planning purposes. MCAS Beaufort is located within the LCOG, which encompasses Beaufort, Colleton, Hampton, and Jasper counties. The LCOG develops and coordinates regional plans that provide local leaders with a view of the region, as a whole, and how the needs and issues of city and county governments within the LCOG interrelate. The LCOG's mission includes serving as an advocate for regionalism and a connection between those local governments and certain state and federal agencies. In carrying out its mission, the LCOG provides local governments with planning and technical support to improve the quality of life in the region, including economic and community development, workforce development, comprehensive planning, and aging.

The LCOG served as the lead for the 2004 Joint Land Use Study (JLUS) for MCAS Beaufort. Other participants included Beaufort County, the City of Beaufort, the Town of Port Royal, and MCAS Beaufort. In 2004, the County Council, City of Beaufort, and Town of Port Royal adopted the Lowcountry JLUS, the purpose of which was to cooperatively plan for and protect the present and future integrity of operations and training at MCAS Beaufort. One of the recommendations that came out of the JLUS was for the three authorities to develop an "AICUZ Overlay" district for all land affected by APZs and/or noise zones associated with the MCAS Beaufort. In December 2006, Beaufort County, the Town of Port Royal, and the City of Beaufort passed coordinated AICUZ Overlay ordinances, based on the 2003 AICUZ Plan, which limited the type and density of development that could occur within the AICUZ boundaries.

In addition, Beaufort County designated a Military Planning Area on the County's future land use map coinciding with the AICUZ footprint (noise and APZs). Land uses designated as most appropriate for the Military Planning Area include low-density, single-family residential, agriculture/open space, industrial uses, and limited commercial.

To prevent long-term incompatible development around MCAS and to provide some economic relief for those landowners affected by the new overlay district, the local governments agreed to explore the feasibility of establishing a Transfer of Development Rights (TDR) program. Beaufort County adopted TDR ordinance in and is beginning implementation.

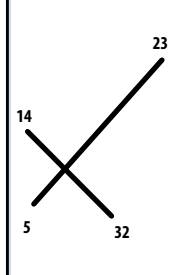
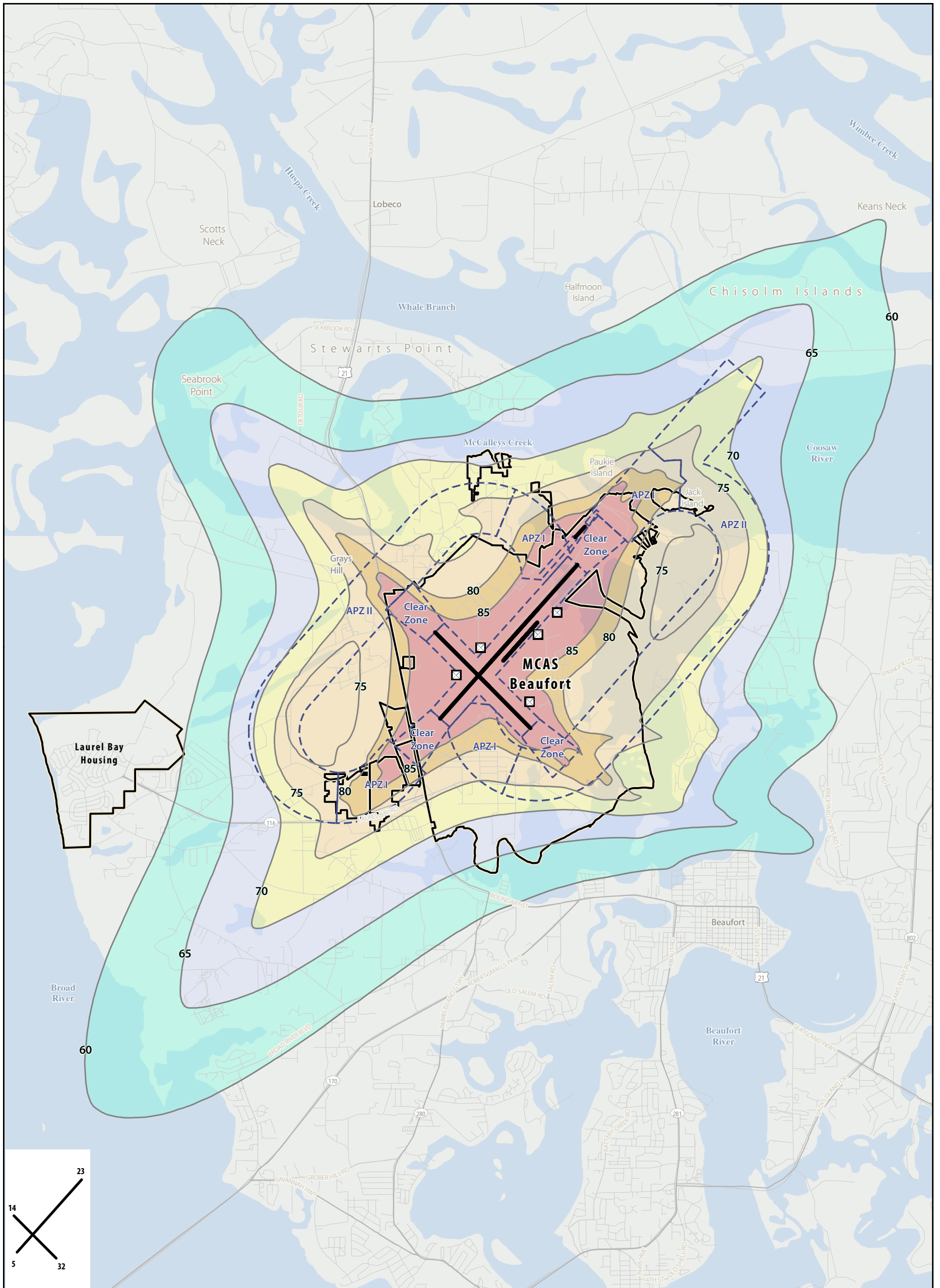
6.2.4 Town of Port Royal

While no lands within the 2013 AICUZ footprint fall within the current jurisdictional boundaries of the Town of Port Royal, it is important to note the land use plans and polices for the Town, due to its close proximity to MCAS Beaufort. As defined by the USCB, the Town of Port Royal is included within the Beaufort Urban Cluster and the larger Hilton Head Island–Beaufort MSA. The local planning authority for the Town is the MPC for Northern Beaufort County, the same as the City of Beaufort.

The Town of Port Royal developed and approved their initial master plan in 1996 and used it as a blueprint to develop a Comprehensive Plan in 1999. The latest update to *The Town of Port Royal Comprehensive Plan* was completed in 2009. The Comprehensive Plan guides day-to-day decision making as well as long-range planning that directs future growth and development in order to achieve the community’s vision and goals. As previously stated, the Town of Port Royal passed an AICUZ Overlay ordinance in 2006, based on the 2003 AICUZ Plan, which limited the type and density of development that could occur within the AICUZ boundaries. This is important due to the proactive annexation efforts of Port Royal.

6.3 LAND USE COMPATIBILITY ANALYSIS

The composite AICUZ map for MCAS Beaufort, which is comprised of the 2013 AICUZ noise contours and APZs, is commonly known as the “AICUZ footprint.” The AICUZ footprint for MCAS Beaufort (Figure 6-1) is used as the basis for the land use compatibility analysis. The land use compatibility assessment and analysis examined existing and future land uses near the installation. Existing land use is the current land use activity, while future land use takes into account planned future land use and recommended zoning designations for property.



Legend

- Vertical Landing Pads
- 2013 Accident Potential Zones
- Major Road
- Runway
- MCAS Beaufort Base Boundary
- Waterbody
- 2013 Noise Contour (db DNL) 60-65
- 65-70
- 70-75
- 75-80
- 80-85
- 85+

Figure 6-1
AICUZ Footprint
MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

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Typical land use categories include residential, commercial, agricultural, and industrial. Patterns of land use arise naturally in communities through customs and practices, and regulations and policies from local government. Local management plans, policies, ordinances, and regulations determine the type and extent of land use allowed in specific areas.

This section includes an analysis of land use compatibility within the MCAS Beaufort AICUZ footprint by examining existing and planned land uses near the installation. The analysis was based on the DODs land use compatibility recommendations which are presented in Appendix B and summarized in Table 6-1 (presented in Section 6.1, Land Use Compatibility Guidelines and Classifications). Land use patterns and zoning in the immediate vicinity of MCAS Beaufort, along with the land use compatibility assessment, are described in this section. It should be noted that both the USMC and Beaufort County have on-going land acquisition initiatives and programs, including the TDR program, which address specific land use compatibility concerns. Properties already purchased by the USMC and/or under restrictive easement limiting the type of development are identified in Section 6.3.1, Existing Land Use, and Section 6.3.2, Existing Zoning. Further discussions regarding the TDR program and other land acquisition efforts are presented in the Chapter 7, Land Use Tools and Recommendations.

6.3.1 Existing Land Use

Land uses surrounding MCAS Beaufort consist of a mix of developed residential and commercial areas, water/wetland areas, rural/undeveloped land, preserved lands, and industrial areas. Figure 6-2 illustrates the composite AICUZ map with existing land uses surrounding MCAS Beaufort. Based on City and County data, the majority of the existing land uses surrounding the MCAS Beaufort consists of neighborhood (residential) and rural/undeveloped land. The undeveloped lands are associated with waterways and marsh lands. The developed land uses in the vicinity of the installation include neighborhood mixed-use, light industrial, and regional commercial.

Beaufort County Existing Land Use Classifications

- Rural/Undeveloped
- Preserved Lands
- Neighborhood Mixed-Use
- Military
- Regional Commercial
- Community Commercial
- Light Industrial

In neighborhood mixed-use areas, residential is the primary use, with some supporting neighborhood retail establishments (Beaufort County 2010). The maximum gross residential density for this designation is approximately two dwelling units per acre; however, that is exceeded in certain areas. The residential uses range from single-family dwellings to medium-density uses in the form of duplex residential structures and manufactured mobile home parks. The majority of the neighborhood mixed-use occurs south of the installation towards the Burton area and downtown City of Beaufort, as well as to the east across the Intracoastal Waterway in the Pleasant Point area on Lady's Island. In addition, there is limited neighborhood mixed-use northwest of the installation across McCalley's Creek.

The light industrial uses surrounding MCAS Beaufort include, but are not limited to, business parks, research and development centers, product assembly, distribution centers, cottage industries, and other light industrial uses (Beaufort County 2010). The majority of the light industrial uses occurs west of the installation, adjacent and west of Highway 21, towards the Laurel Bay area, and is mainly associated with the City of Beaufort's industrial park. However, it is important to note that lands indicated as light industrial uses are, in fact, medium density residential uses in the form of mobile home parks.

Commercial uses are designated either community or regional. According to Beaufort County's land use data, the regional commercial uses are those uses that, due to their size, attract visitors from a larger area of the County and outside the County. Typical uses include "big box" retail uses, chain restaurants, and supporting retail (Beaufort County 2010). Community commercial uses include a shopping district anchored by a grocery store, typically serving a nearby residential area. The lands designated for regional commercial uses are located south of the installation and across Albergotti Creek, along Highway 21, towards the City of Beaufort. There is limited community commercial land uses in the direct vicinity of MCAS Beaufort located just to the west along Highway 21.

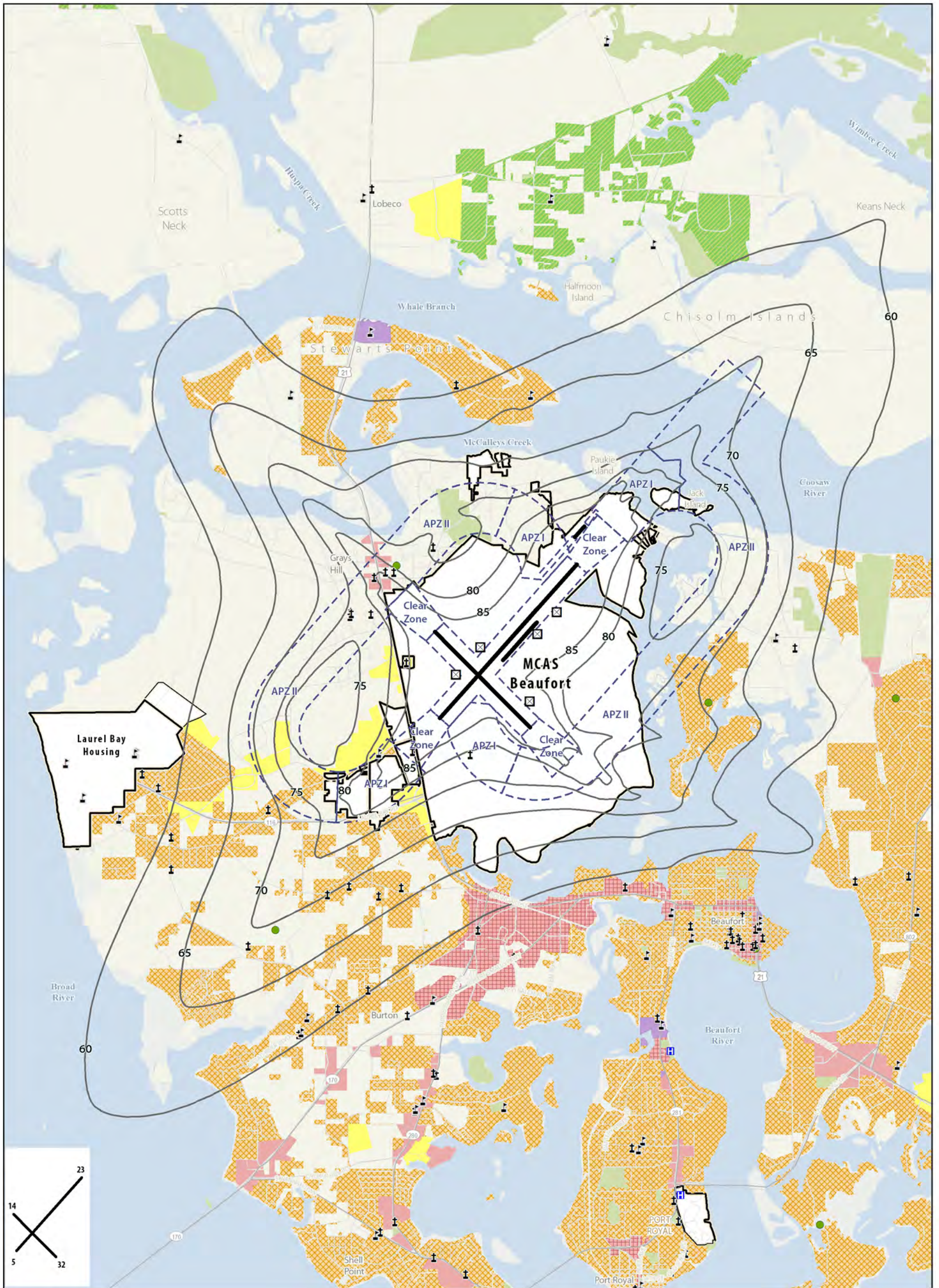
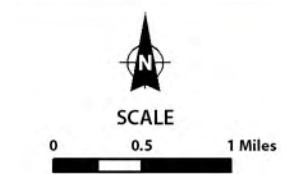


Figure 6-2
AICUZ Footprint with Existing Land Use
MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC



- Legend**
- School
 - Beaufort County Existing Land Use
 - 2013 Noise Contour (db DNL)
 - Church
 - Preserved Lands
 - 2013 Accident Potential Zones
 - Recreational Area
 - Rural/Undeveloped
 - Hospital
 - Rural Community
 - Vertical Landing Pads
 - Neighborhood Mixed
 - Major Road
 - Community Commercial
 - Runway
 - Regional Commercial
 - MCAS Beaufort Base Boundary
 - Light Industrial
 - Military
 - Waterbody
 - School

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

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The vast majority of the remaining land uses surrounding MCAS Beaufort is designated rural/undeveloped. This designation includes low-density residential development, small-scale commercial development, forested/natural, and agricultural land uses. The maximum gross residential density in rural areas is planned for one dwelling unit per 3 acres (Beaufort County 2010). However, that density is exceeded in certain areas, especially with the numerous mobile home parks located west of the installation. The rural/undeveloped lands can also include small institutions such as churches, schools, community centers, and post offices.

There are numerous churches and worship facilities surrounding MCAS Beaufort which are indicated on Figure 6-2. Churches and other types of gathering places are important in the analysis because they are public assembly locations and are considered people-intensive land uses and are incompatible in APZs.

As depicted on Figure 6-2, land acquisition efforts have targeted mostly lands within the rural/undeveloped land use category (as well as preserved lands) to address existing problematic areas or prevent future incompatible land use. Thus, the ownership and/or development rights for these parcels of land (3,148 acres) are under the control of the Marine Corps.

Overall, the existing land use around MCAS Beaufort reveals a pattern of mixed-density development (low to high), as there is a range of residential, commercial, and industrial development. From a land use compatibility standpoint, some of the residential and other uses (i.e., cultural and recreational) surrounding the installation are incompatible in certain APZs and noise zones.

6.3.2 Existing Zoning

Zoning is a term used in urban planning for a system of land use regulations. Zoning is the system used by local governments to control the physical development of the use of land. Zoning codes provide the regulatory framework to direct development and influence how the various uses interact with each other to prevent conflicts and incompatibility. Zoning addresses not only the use of property, but the scale and intensity of the use. The lands surrounding the installation have an array of zoning classifications. The predominant classifications include suburban

MCAS Beaufort

commercial, rural, rural residential, light industrial, urban, and planned unit development. Figure 6-3 illustrates existing zoning surrounding MCAS Beaufort.

AICUZ Overlay District

Beaufort County, the City of Beaufort, and Town of Port Royal adopted the JLUS recommendation to develop the overlay for all land affected by APZs and/or noise zones associated with MCAS Beaufort.

Per the City of Beaufort Comprehensive Plan, an AICUZ Overlay District was established over the lands within the 2003 MCAS Beaufort AICUZ footprint. The Overlay District, implemented as part of the JLUS that was adopted by Beaufort County, aims to ensure the current and long-term viability of the airfield by limiting incompatible land uses and directing compatible land uses within the area. The Beaufort County zoning data designates lands within the AICUZ Overlay District as designated low-density residential and/or rural, with a density threshold of one dwelling unit per 3 acres. The AICUZ Overlay District is a regulatory designation intended to implement specific growth management policies that guide land use activities and construction in a manner compatible with the long-term viability of a military installation. Further discussion of the AICUZ Overlay District is presented in the Section 6.3.3, Future Land Use.

6.3.3 Future Land Use

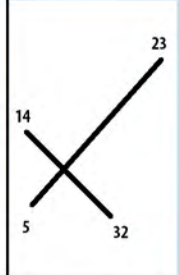
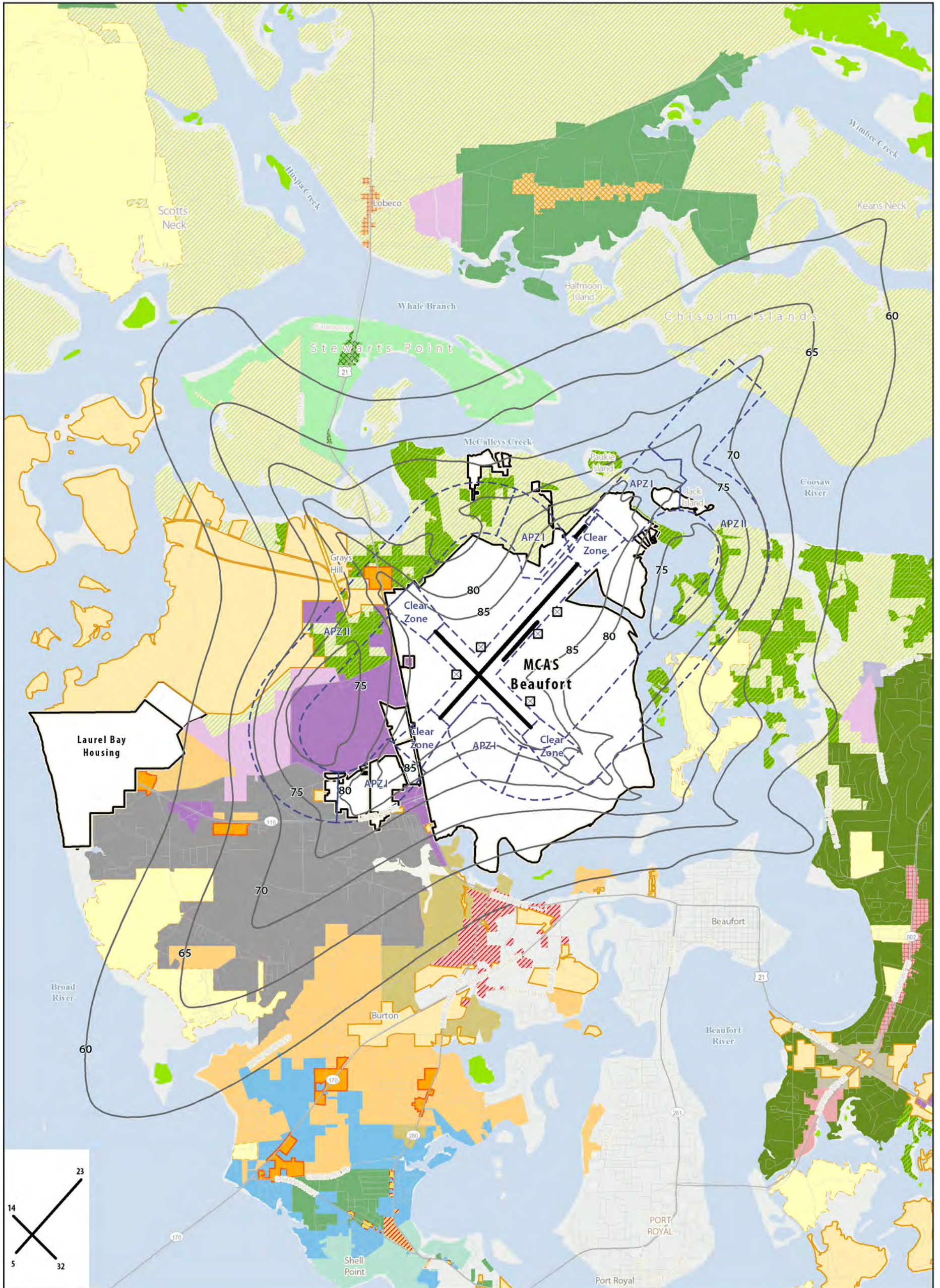
Future development of land is outlined in local land use plans and regulations that are developed and adopted by local authorities. These plans include future land use maps that clearly identify what land use type and intensity will be allowed in specific areas. Both Beaufort County and the City of Beaufort Comprehensive Plan outline future land uses within their jurisdictional boundaries which impact land uses in the vicinity of MCAS Beaufort.

The future land uses around MCAS Beaufort, illustrated on Figure 6-4, include ten classifications: community commercial, core commercial, light industrial, low-density residential, military, neighborhood residential, preserved lands, regional commercial, rural, and urban residential.

Most of the land immediately adjacent to the airfield is designated as a low-density residential district which is consistent with the AICUZ Overlay District. Other adjacent lands include light industrial to the west, and limited community commercial and preserved lands to the north. The light industrial classification is associated with the City of Beaufort's industrial park, and is expected to continue to grow and attract additional industries.

Beaufort County Future Land Use Classifications

- Community Commercial
- Core Commercial
- Light Industrial
- Low-Density Residential
- Military
- Neighborhood Residential
- Preserved Lands
- Regional Commercial
- Rural
- Urban Residential



- Legend**
- ☒ Vertical Landing Pads
 - Major Road
 - Runway
 - ▭ MCAS Beaufort Base Boundary
 - ▭ Waterbody
 - 2013 Noise Contour (db DNL)
 - 2013 Accident Potential Zones
 - ▭ 2013 Accident Potential Zones
 - Beaufort County Zoning
 - ▭ Zoning not available
 - ▭ City of Beaufort
 - ▭ Community Preserve
 - ▭ Community Preservation District
 - ▭ Dale Mixed Use
 - ▭ Expanded Home Business
 - ▭ Industrial Park
 - ▭ Lady's Island Community Preservation
 - ▭ Light Industry
 - ▭ Military
 - ▭ Neighborhood Activity Center
 - ▭ Professional Office District
 - ▭ Planned Unit Development
 - ▭ Rural Business Regional Commercial
 - ▭ Resource Conservation
 - ▭ Rural
 - ▭ Rural Residential
 - ▭ Shell Point Commercial Suburban
 - ▭ Shell Point Stuart Point Mixed Use
 - ▭ Suburban
 - ▭ Suburban Commercial
 - ▭ Town of Port Royal
 - ▭ Transportation
 - ▭ Urban
 - ▭ Village Center

Figure 6-3
AICUZ Footprint with Existing Zoning
MCAS Beaufort
MCAS Beaufort AICUZ
 Beaufort County, SC

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

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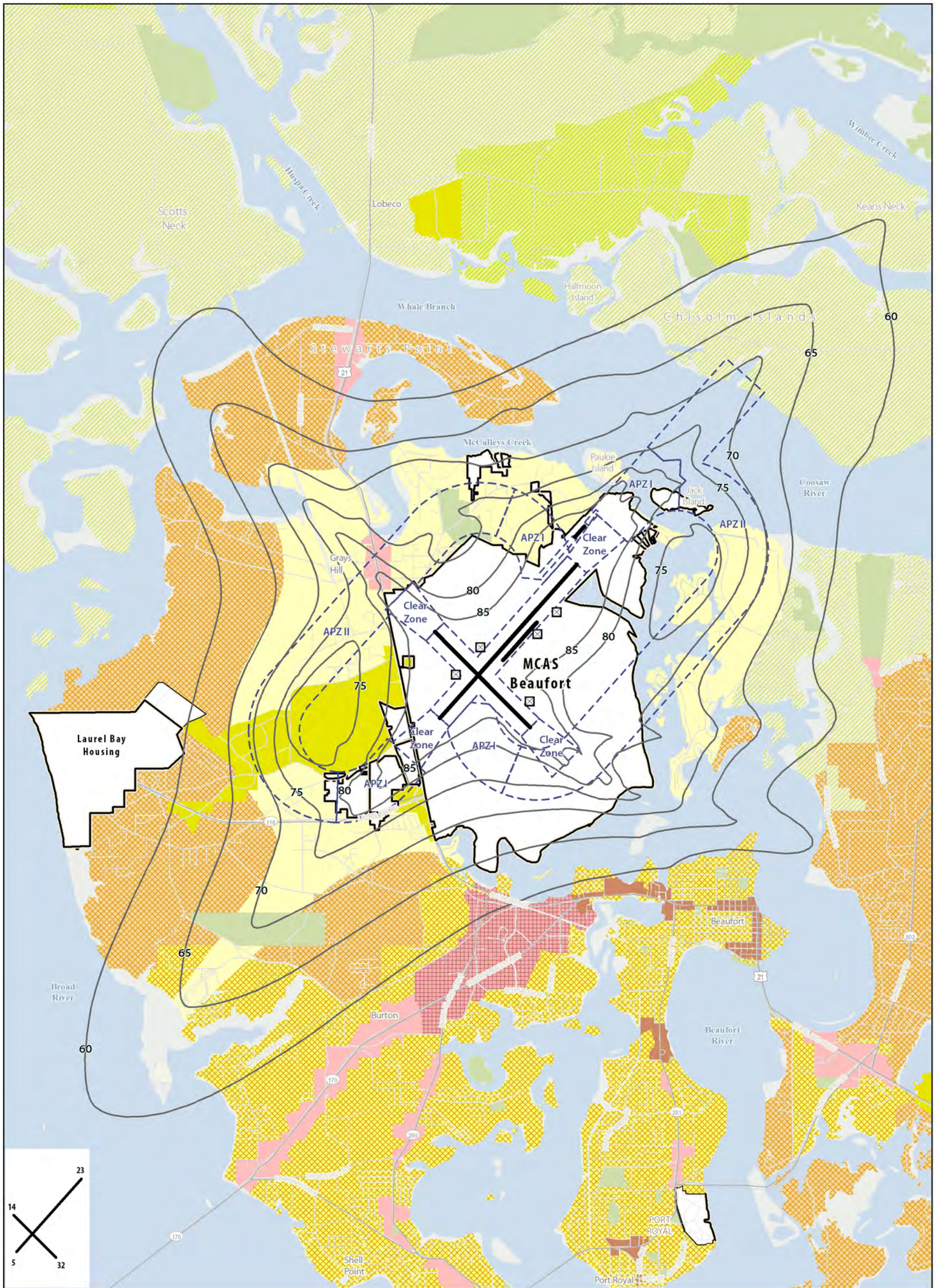


Figure 6-4
AICUZ Footprint
with Future Land Use
MCAS Beaufort
MCAS Beaufort AICUZ
 Beaufort County, SC

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Legend

<ul style="list-style-type: none"> Vertical Landing Pads Major Road Runway MCAS Beaufort Base Boundary Waterbody 	<ul style="list-style-type: none"> Beaufort County Future Land Use Land Use Not Available Air Installation Compatible Use Zone (AICUZ) Preserved Lands Rural Rural Community Neighborhood Residential 	<ul style="list-style-type: none"> Urban Residential Community Commercial Regional Commercial Core Commercial Light Industrial Military 	<ul style="list-style-type: none"> 2013 Noise Contour (db DNL) 2013 Accident Potential Zones 2013 Accident Potential Zones
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Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

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The majority of the remaining land uses surrounding MCAS Beaufort beyond the AICUZ Overlay District are designated neighborhood residential. Lands to the west of the airfield that are currently designated as rural/undeveloped land use (see Figure 6-2) are projected to be neighborhood residential in the future, which may result in increased density. Further indication suggesting future growth surrounding MCAS Beaufort is outlined in the Northern Beaufort County Regional Plan (Beaufort County 2007).

The Northern Beaufort County Regional Plan implemented a regional growth management strategy. The Plan established future growth boundaries for the City of Beaufort and the Town of Port Royal. The lands surrounding MCAS Beaufort are within the projected growth boundary. These growth boundaries identify future areas of urban and suburban development where the municipalities are likely to grow and provide services (Beaufort County 2007). Normally, the areas within a growth boundary are designated for either commercial, light industrial, urban residential, or neighborhood residential uses, and the areas outside the growth areas are designated for rural uses (Beaufort County 2007). However, there are exceptions to this pattern when lands designated low-density residential and rural fall within the growth boundaries. The low-density residential area around MCAS Beaufort, designated as an AICUZ Overlay District, is one of those exceptions.

Based on future land use and growth boundary data, development around MCAS Beaufort is expected to follow current development trends of low to medium-residential and light commercial and industrial. Future development in rural areas is anticipated to be similar to the type and mix of current land uses, with low-density residential development supporting small-scale commercial development and agricultural land uses. The areas with the greatest potential for development that may result in increased densities are northwest, west, and southwest of the installation. The projected uses within these future land use classifications are potentially incompatible in certain noise zones and APZs. However, as illustrated on Figure 6-4, land acquisition efforts have targeted lands predominantly within the rural/undeveloped land use category (as well as preserved lands) to address existing problematic areas or prevent future incompatible land use. An evaluation of specific land use compatibility concerns for MCAS Beaufort is presented in Section 6.3.4, Compatibility Concerns.

6.3.4 Compatibility Concerns

In determining land use compatibility within MCAS Beaufort's noise zones and APZs, both existing and future land uses near the airfield were examined. To analyze whether existing land use is compatible with aircraft operations at MCAS Beaufort, the 2013 AICUZ footprint was graphically overlaid on current Beaufort County land use maps (see Figures 6-2 and 6-3, presented in Sections 6.3.1, Existing Land Use, and 6.3.2, Existing Zoning, respectively). Future land use compatibility was analyzed in a similar manner, with consideration given to zoning and the County's growth boundaries identified in the future land use section of the Beaufort County Comprehensive Plan (Beaufort County 2010). Table 6-1 (presented in Section 6.1, Land Use Compatibility Guidelines and Classifications) provides a generalized breakdown of land use compatibility, and Appendix B provides the complete Marine Corps land use compatibility classifications and the associated land use compatibility designations for noise zones and APZs from MCO 11010.16.

The 2013 AICUZ noise contours and APZs for MCAS Beaufort extend off the installation in all directions and continue to pose a compatibility concern with the surrounding land uses (Figures 6-5, 6-6, 6-7 and 6-8). As illustrated in the composite maps, the 2013 AICUZ noise contours and APZs impact areas off the installation in all directions similar to the 2003 AICUZ noise contours and APZs. Figures 6-5 and 6-7 present the land use compatibility concerns identified around MCAS Beaufort and Figures 6-6 and 6-8 present the future land use compatibility concerns. Areas impacted are mainly classified as rural/undeveloped and neighborhood mixed-use which include low- to medium-density residential areas as well as other incompatibility uses.

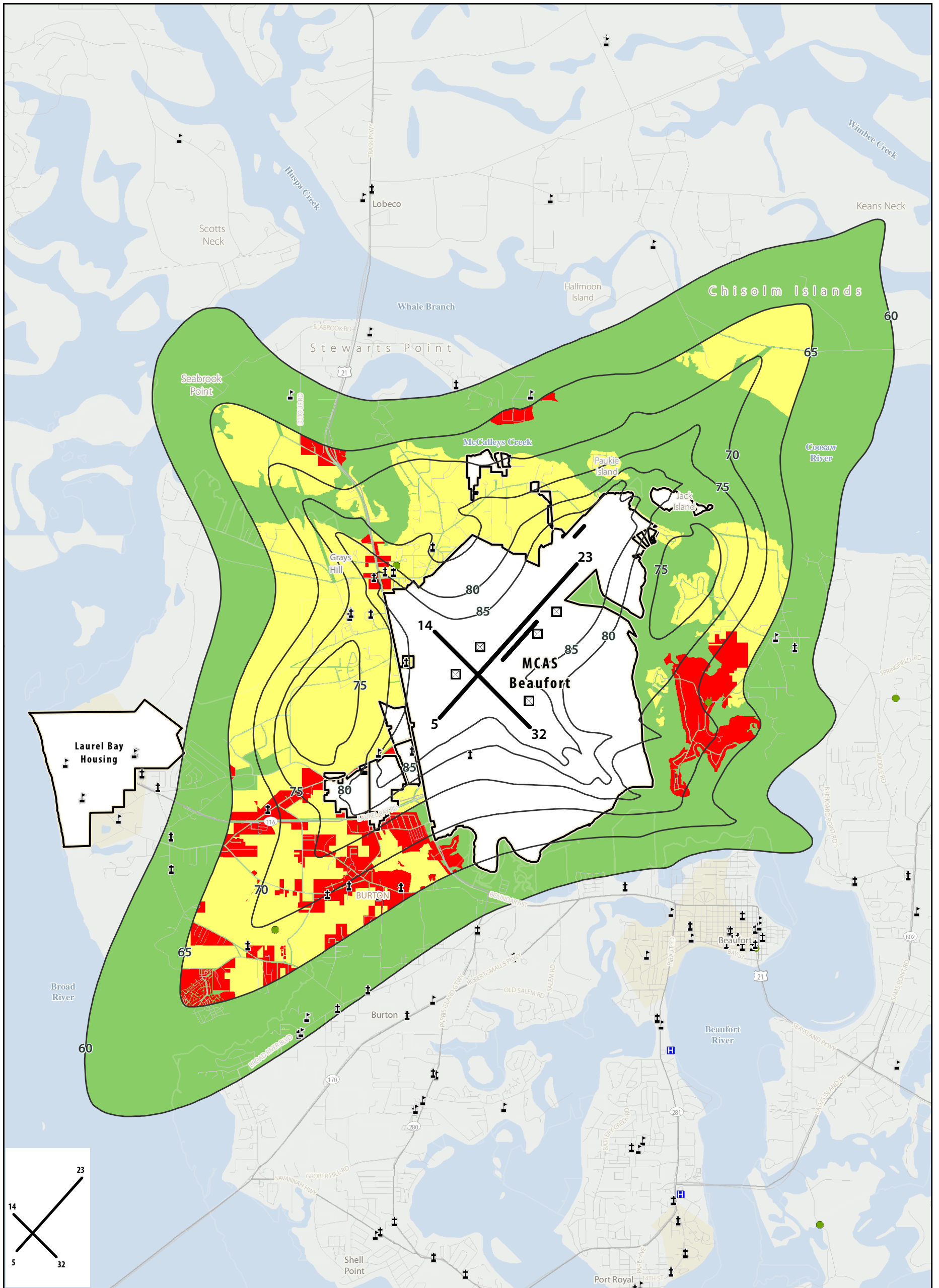


Figure 6-5
Existing AICUZ Compatibility Concerns
within the AICUZ Noise Contours
MCAS Beaufort
MCAS Beaufort AICUZ
 Beaufort County, SC

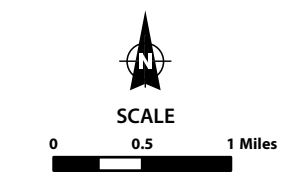
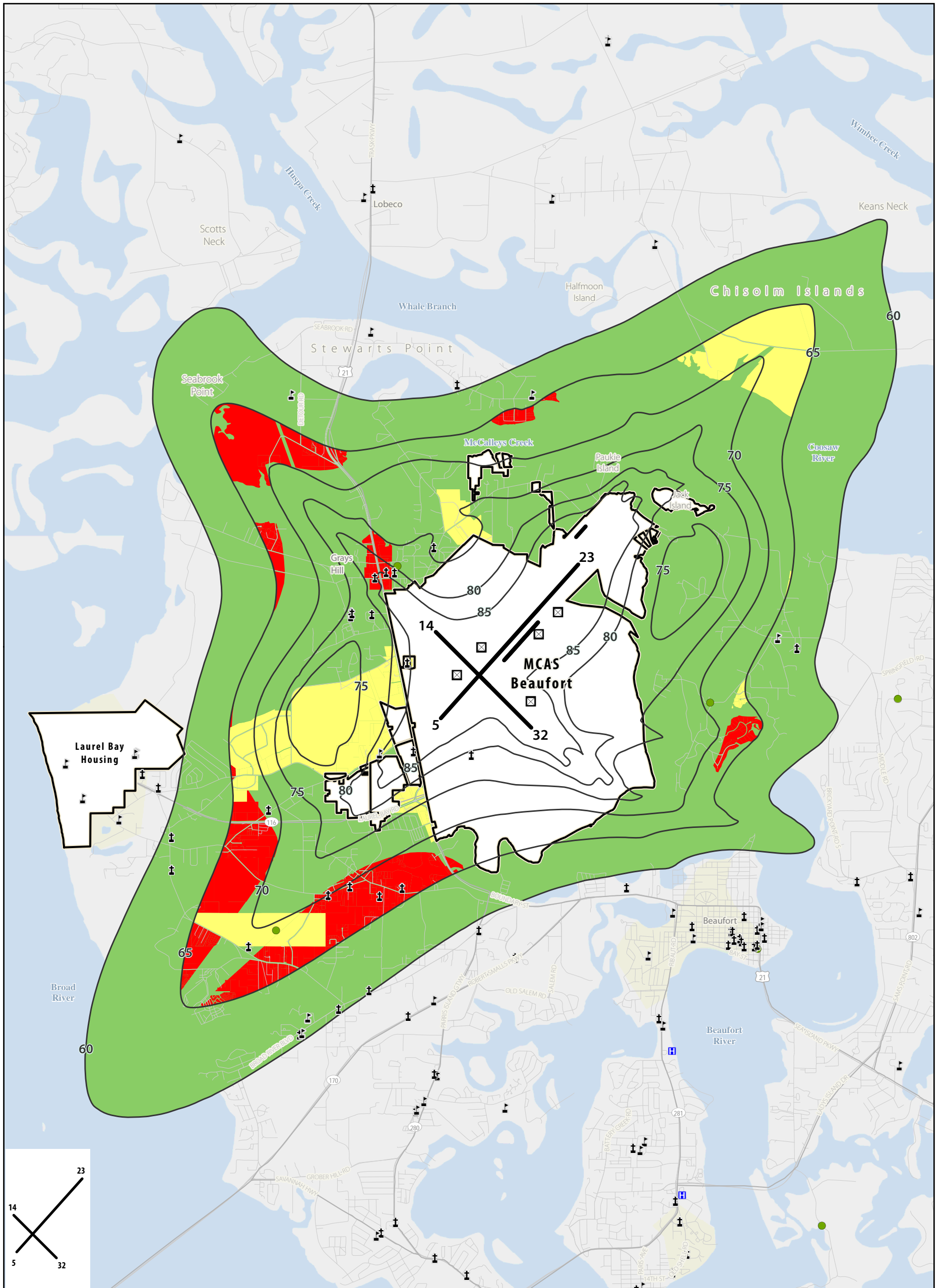
Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

SCALE
 0 0.5 1 Miles

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- Legend**
- School
 - Church
 - Recreational Area
 - Hospital
 - Vertical Landing Pads
 - 2013 Noise Countour (db DNL)
 - Major Road
 - Runway
 - MCAS Beaufort Base Boundary
 - Urban Area
 - Waterbody
 - Compatible
 - Conditionally Compatible
 - Incompatible

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Legend

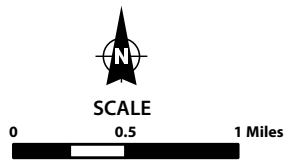
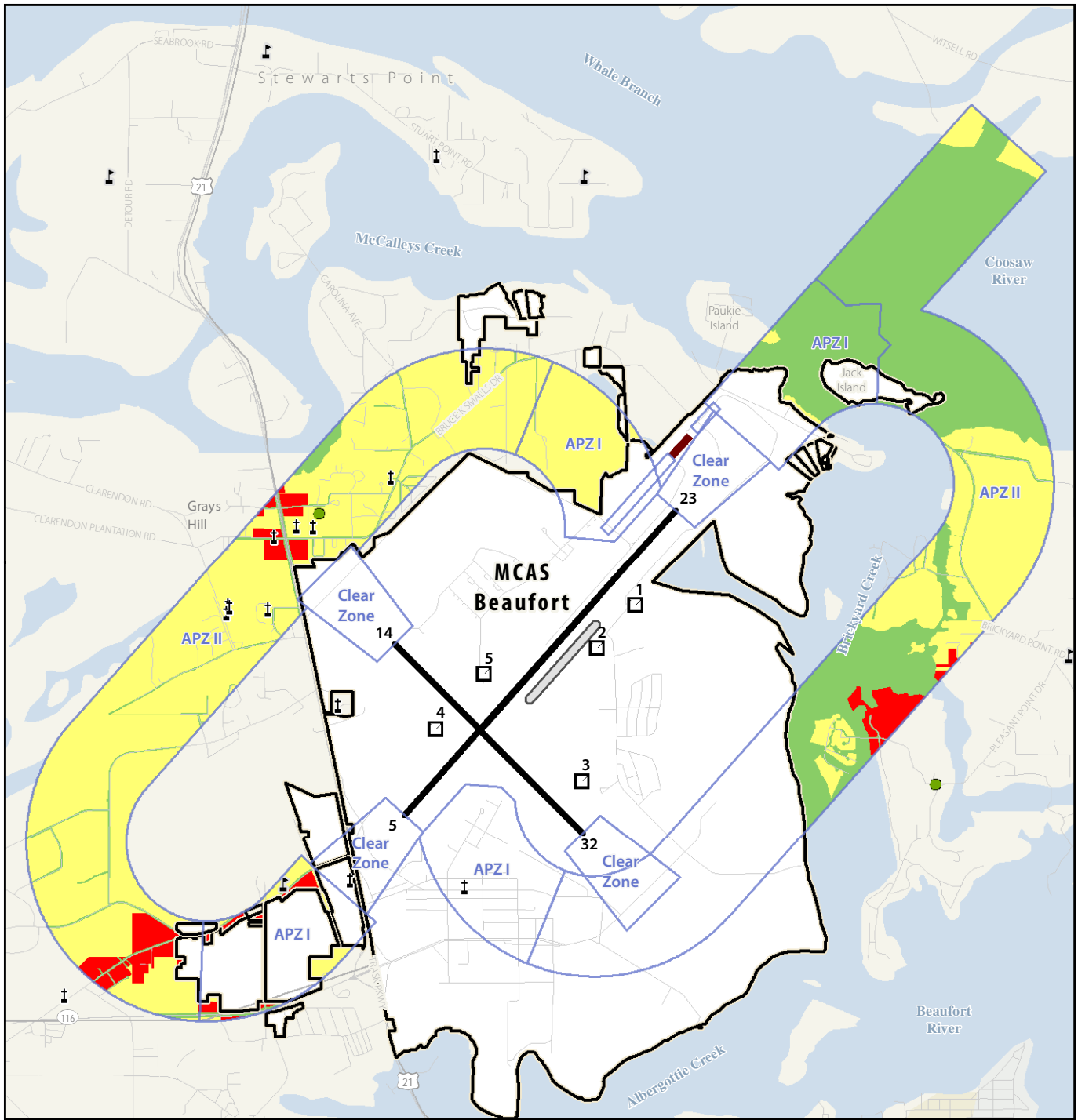
- School
- Church
- Recreational Area
- Hospital
- Vertical Landing Pads
- 2013 Noise Contour (db DNL)
- Major Road
- Runway
- MCAS Beaufort Base Boundary
- Urban Area
- Waterbody
- Future Land Use Compatibility**
- Compatible
- Conditionally Compatible
- Incompatible

Figure 6-6
Future AICUZ Compatibility Concerns
within the AICUZ Noise Contours

MCAS Beaufort
 MCAS Beaufort AICUZ
 Beaufort County, SC

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

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- Legend**
- School
 - Church
 - Recreational Area
 - Hospital
 - Vertical Landing Pads
 - Major Road
 - Runway
 - FBO
 - LHD Facility
 - MCAS Beaufort Base Boundary
 - APZ
 - Waterbody
 - Compatible
 - Conditionally Compatible
 - Incompatible

Figure 6-7
Existing AICUZ Compatibility
Concerns within the AICUZ APZs
MCAS Beaufort
MCAS Beaufort AICUZ
Beaufort County, SC

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.

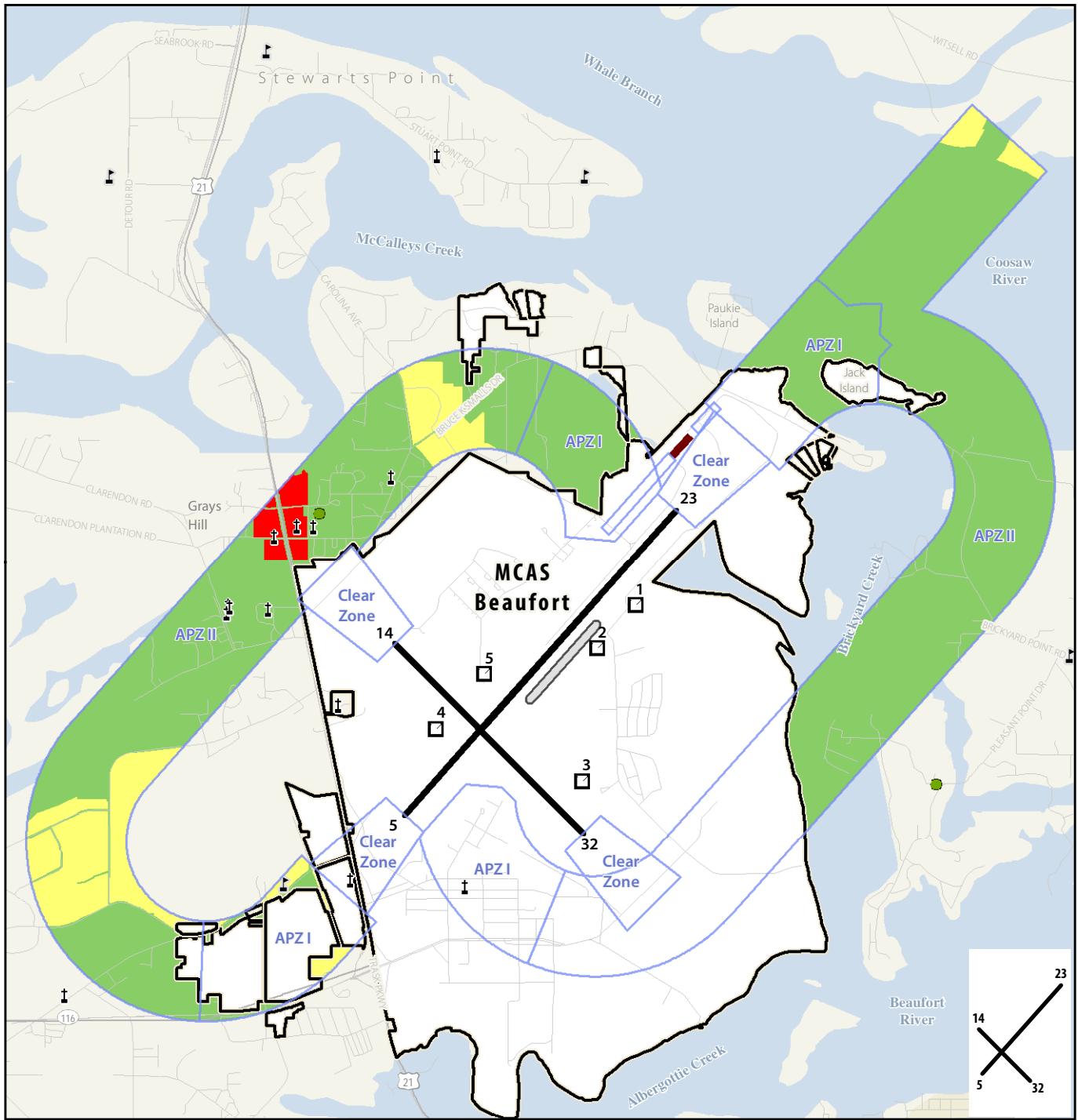
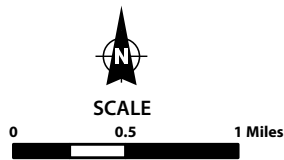


Figure 6-8
Future AICUZ Compatibility
Concerns within the AICUZ APZs
MCAS Beaufort
MCAS Beaufort AICUZ
Beaufort County, SC

Note: The location of Vertical Landing Pads, FBO, and LHD Facility, as well as the Flight Tracks and Noise Contours are based on the 2010 USMC F-35B East Coast Final EIS.



- Legend**
- MCAS Beaufort Base Boundary
 - APZ
 - Waterbody
 - Future Land Use Compatibility
 - Compatible
 - Conditionally Compatible
 - Incompatible
 - School
 - Church
 - Recreational Area
 - Hospital
 - Vertical Landing Pads
 - Major Road
 - Runway
 - FBO
 - LHD Facility

7

LAND USE TOOLS AND RECOMMENDATIONS

- 7.1 Federal/Marine Corps
- 7.2 State/Regional
- 7.3 Local Government
- 7.4 Citizens/Real Estate Professionals/
Businesses

This chapter discusses tools, alternative techniques, and recommendations that can be implemented to manage existing and future development within and around the AICUZ footprint. Successful AICUZ land use compatibility implementation is the collective responsibility of the Marine Corps, federal, state, and regional governments, citizens, business owners, and real estate professionals. This chapter provides tools and recommendations that, when implemented, will continue to advance MCAS Beaufort and community partners to achieve their shared goal, “to protect the health, safety, and welfare of those living near military airfields, while preserving the defense flying mission.”

A wide variety of land use strategies oriented toward the Marine Corps, federal, state, and local levels are available for encouraging compatible land use within the established AICUZ footprints for MCAS Beaufort. This chapter identifies stakeholders and their roles and responsibilities as they relate to successful AICUZ implementation. The federal, state, and local land use planning tools are described along with recommendations for implementation.

The purpose of these tools and recommendations is to provide an information base for MCAS Beaufort, local governments and agencies, and private citizens to use in exploring, modifying, combining, and implementing polices, plans, and regulations necessary to help ensure the goal of the AICUZ Program.

7.1 FEDERAL/MARINE CORPS-LEVEL TOOLS AND RECOMMENDATIONS

Although ultimate control over land use and development in the vicinity of MCAS Beaufort is the responsibilities of the local governments, the Marine Corps has the ability and responsibility to conduct actions and implement programs in support of the local effort. At the installation level, the Installation Commander is responsible for ensuring a successful AICUZ Program. Pursuant to OPNAVINST 11010.36C/MCO 11010.16, the Air Installation Commander at MCAS Beaufort is committed to and shall:

- Maintain an AICUZ Program for the air installation;
- Work with state and local planning officials to implement the objectives of the AICUZ Study;
- Continue to use a CP&LO to assist in the execution of the AICUZ Study by the installation and to act as spokesperson for the Command regarding AICUZ matters;
- Promote attendance at AICUZ seminars by commanding officers, executive officers, air operations and traffic control facility officers, and other aviation related staff to increase awareness of current trends and techniques for AICUZ Program development and implementation;
- Provide assistance in developing AICUZ information, including operational data needed to update the AICUZ Study;
- Work with local decision makers in the surrounding communities to evaluate and justify the retention of land or interest of land required for operational performance; and
- Notify the Chain-of-Command in the AICUZ Program office whenever local conditions merit update or review of the AICUZ Study.

The following are federal- and/or Marine Corps-level regulations, programs, and recommendations that can be used or considered to control development within the AICUZ footprint.

7.1.1 Federal/Marine Corps-Level Tools

Environmental Review

Federal agencies, including the Marine Corps, are required to consider the environmental impacts of any federal project which could impact the environment by conducting a comprehensive environmental review. The National Environmental Policy Act (NEPA) mandates evaluation of the potential environmental effects resulting from proposed federal actions, approvals, or funding. Impacts of the action are generally documented in a Categorical Exclusion, an Environmental Assessment (EA) or an EIS. The environmental review process represents an excellent means for incorporating the fundamentals of the AICUZ Study in the planning review process of a project.

Fundamentals of the AICUZ Study can be incorporated into the environmental review process for federal projects.

Housing and Urban Development (HUD) CFR Part 51 Subpart D

The approval of all mortgage loans from the Federal Housing Administration (FHA) or the U.S. Department of Veterans Affairs (VA) is subject to the requirements of Housing and Urban Development (HUD) CFR Part 51 Subpart D. The regulation sets forth a discretionary policy to withhold funds for housing projects when noise exposure is in excess of prescribed levels. Residential construction is incompatible inside the 65 DNL contour; therefore, if residential units are constructed within this contour, proper sound attenuation should be applied. However, the added construction expense of noise attenuation may make siting in these noise exposure areas financially less attractive. Due to the discretionary makeup of the HUD policy, variances may also be permitted, depending on regional interpretation and local conditions. HUD also has a policy that prohibits funding for projects in Clear Zones and APZs unless the project is compatible with the AICUZ Study.

HUD funding can be withheld from housing projects that are not within prescribed noise exposure levels or projects that are in Clear Zones and APZs.

Executive Order 12372, Intergovernmental Review of Federal Programs (July 1982)

As a result of the Intergovernmental Cooperation Act of 1968, the United States Office of Management and Budget (OMB) requires all federal aid development projects to be coordinated with and reinforce state, regional, and local planning. Executive Order 12372 allows state governments to set up review periods and processes for federal projects and provides an early entry point into the process to introduce AICUZ concepts and to discuss AICUZ issues.

For federal aid projects, Executive Order 12372 allows the introduction of AICUZ concepts and issues early in the review process.

DOD Encroachment Partnering Program

Title 10 United States Code (U.S.C.) § 2684a authorizes the Secretary of Defense or the Secretary of a military department to enter into agreements with an eligible entity or entities to address the use or development of real property in the vicinity of, or ecologically related to, a military installation or military airspace, to limit use of the property that would be incompatible with the mission of the installation or place other constraints on military training, testing, and operations. Eligible entities include a state, a political subdivision of a state, and a private entity that has, as its principal organizational purpose or goal, the conservation, restoration, or preservation of land and natural resources, or a similar purpose or goal.

Encroachment partnering is a cooperative, multi-party, real estate-based program used to mitigate the impacts of off-base land uses that are potentially incompatible with military operations. It implies that the DOD and its partner(s) are both willing and able to contribute to the cost and effort of acquiring these interests.

Encroachment Partnering Agreements provide for an eligible entity to acquire fee title, or a lesser interest, in land for the purpose of limiting encroachment on the mission of a military installation and/or to preserve habitat off the installation to relieve current or anticipated environmental restrictions that might interfere with military operations or training on the installation. The DOD can share the real estate acquisition costs for projects that support the purchase of fee or conservation or other restrictive easement for such property. The eligible entity negotiates and acquires the real estate interest for partnering projects with a voluntary seller. The eligible entity must transfer the agreed upon restrictive easement interest to the United States of America upon the request of the Secretary.

Public Land Acquisition

In accordance with OPNAVINST 11010.36C/MCO 11010.16, the Marine Corps is permitted to acquire interest in properties (acquisition) to protect the operational integrity of its air installations. When threats to operational integrity from incompatible development are identified, and when local communities are unwilling or unable to take the initiative to address the threat using their own authority, consideration can be given to land acquisition. The first priority for acquisition, whether in fee or by restrictive easement, is the Clear Zone. The second priority is other APZs. Noise zones, outside the Clear Zone and APZs, may be considered for acquisition only when all avenues of achieving compatible use zoning or similar protection have been explored and the operational integrity of the installation is clearly threatened. Land can be purchased through negotiation and voluntary agreement of the land, or it can be through condemnation procedures using the power of eminent domain. Other possible actions for acquiring interest in land include easement acquisition, leasehold agreements, development right purchase, and fee title acquisition for full property ownership. MCAS Beaufort has carried out land acquisition efforts in the past, together with local jurisdictions, to control development within the AICUZ footprint based on analysis and recommendations from previous AICUZ studies and JLUS.

If a threat to an installation's operational integrity from incompatible development is identified, and the local community cannot resolve the threat, the Marine Corps can obtain the land through purchase, voluntary agreement, or condemnation.

7.1.2 Federal/Marine Corps-Level Recommendations

Community Outreach Activities

Public relations and education programs are opportunities to share information and educate the public on issues such as noise and compatible land use. The Marine Corps should continue community outreach efforts that have begun at MCAS Beaufort. Initiatives aimed at further protecting Marine Corps assets should continue and/or be expanded. MCAS Beaufort representatives have participated in compatible land use meetings with the local municipalities to identify areas where potential incompatible land uses exist. Future meetings can be used to address current and future aircraft related activity at the MCAS Beaufort, noise inquiries (both the process for submitting inquiries and how the inquiries are resolved), and other relevant topics related to the interaction between the MCAS Beaufort and its neighbors. Marine Corps representatives (i.e., CP&LO) working with the community

The Marine Corps should continue/expand community outreach activities aimed at addressing aircraft related activity, noise inquiries, and topics related to MCAS Beaufort and its neighbors.

MCAS Beaufort

should continue to enhance the lines of communication and all parties' ability to address potential concerns that arise.

Engage in the Local Planning Process

The Marine Corps representative for MCAS Beaufort, including either the Commanding Officer and/or the installation CP&LO should continue to attend public hearings and provide comments on actions that require updating AICUZ planning for MCAS Beaufort, including the 2004 JLUS, comprehensive plans, updates to the General Plans for the City of Beaufort and the Town of Port Royal, capital improvement plans, zoning, building code changes, and other land development regulation updates/amendments impacting the State of South Carolina, Beaufort County, the City of Beaufort, the Town of Port Royal, and MCAS Beaufort.

The Commanding Officer and/or CP&LO should continue to attend public hearings and provide comments on actions affecting AICUZ planning.

Presentation of the AICUZ Program

The AICUZ Program can be a complex subject and process that requires discussion and elaboration for clear understanding. MCAS Beaufort personnel have access to and should make presentations on the updated AICUZ Study and AICUZ Program to individuals or collectively to community decision makers, including regional and local planning councils/commissions, city councils, county legislatures, government councils, and other interested agencies. Presentations on the AICUZ Program's elements provide an opportunity to educate land use decision makers (e.g., infrastructure siting, schools, zoning changes) and to answer questions about the AICUZ Program. The presentation information should be used as part of the community outreach activities and local planning process to inform the general public and local decision makers on AICUZ issues, how the installation contributes to the local economy, and the need for responsible land use planning.

MCAS Beaufort personnel should continue to make presentations to community decision makers regarding the AICUZ Program and updated AICUZ Study. For the public, a website and community outreach materials should be developed.

Noise Inquiry -Monitoring and Response Program

MCAS Beaufort should continue its noise inquiry monitoring program for continuous assessment of noise generated from aircraft operations and prompt responses to inquiries via MCAS Beaufort's website. The noise monitoring program investigates all noise inquiries and emphasizes MCAS Beaufort's commitment to the public that the control of noise is an important issue to the installation. Further, comprehensive records of noise inquiries are maintained and proper responses to

MCAS Beaufort should continue its noise monitoring program to emphasize its commitment to the public regarding the control of noise.

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each inquiry are ensured. A proactive noise response and monitoring response program helps abate future noise inquiries, identifies noise sensitive areas, and determines which operational activities are responsible for the noise inquiries.

Development Rights, Easement and Land Acquisition Programs

OPNAVINST 11010.36C/MCO 11010.16, Section VII, Real Property Guidance outlines conditions for acquisition actions. MCAS Beaufort should continue their land acquisition program and support of local land acquisition initiatives to protect the installation's military mission. The local initiatives include the Beaufort County Rural and Critical Lands (BCRCL) program, the Beaufort County Open Land Trust (BCOLT) partnership, and the joint TDR program. Beaufort County adopted a TDR ordinance for lands within the AICUZ Overlay District. MCAS Beaufort partners with both BCRL and BCOLT on acquiring restrictive easements on lands in which there is a mutual interest (DON 2010). The TDR program was developed to provide economic relief for those landowners affected by the AICUZ Overlay District. The program essentially "transfers" development out of the AICUZ zones and "sends" it to other "receiving" areas within the growth boundary that have been targeted for additional density.

MCAS Beaufort should continue its land acquisition program to protect the mission of the installation and continue its support of the local BCRCL program, BCOLT partnership, and TDR program.

Previous acquisition efforts have been successful in acquiring lands within the Clear Zones. All future efforts and programs should continue to focus on the APZ lands and lands within high-noise zones. The acquisition of fee title or restrictive easements over the impacted lands should support the efforts of the updated 2013 AICUZ by addressing problematic areas. As part of MCAS Beaufort's overall strategy for minimizing incompatible land use, the installation should continue to work with Beaufort County, the City of Beaufort, and the Town of Port Royal in support of their acquisition and conservation efforts.

7.2 STATE/REGIONAL-LEVEL TOOLS AND RECOMMENDATIONS

State regulations and programs for South Carolina that impact land use controls and growth around the MCAS Beaufort can be used to control development within the AICUZ footprint. Regional planning agencies and boards can aid local government in limiting encroachment through policies, plans, programs, and legislation to encourage compatible development in the vicinity of MCAS Beaufort. The following sections are State/Regional-Level tools and recommendations that can be used to control development within the AICUZ footprint.

7.2.1 State/Regional-Level Tools

Growth Management Regulations

South Carolina's Local Government Comprehensive Planning Enabling Act of 1994 grants each South Carolina county and municipality planning commission the authority to develop, adopt, and maintain a comprehensive planning process which will result in the systematic preparation and continual re-evaluation and updating of those elements considered critical, necessary, and desirable to guide the development and redevelopment of its area of jurisdiction. The planning commission recommendations which are provided to the appropriate governing bodies must consider the future growth, development, and redevelopment of its area of jurisdiction and consider the fiscal impact on property owners. The Act mandates that the local planning commission review their comprehensive plan as often as necessary, but not less than once every five years, to determine whether changes in the direction of development of the area or other reasons make it desirable to make additions or amendments to the plan. The periodic reviews and updates to the local plans is an opportunity to revise the AICUZ-specific information within them and implement targeted zoning and land use controls to prevent future incompatibility.

Through the periodic review of county and municipality comprehensive plans, AICUZ-specific information can be revised and future land use incompatibility can be avoided.

Regional Planning Councils

The LCOG is the key regional organization that supports the local governments in the vicinity of MCAS Beaufort. LCOG operations are organized into four broad program areas: community and economic development, workforce development, planning, and aging. The LCOG's staff provides technical and planning assistance to their member governments in the preparation of comprehensive plans, master plans, zoning ordinances, subdivision regulations, capital improvement plans, economic development plans, and grant applications. Through regional plans (i.e., Northern and Southern Beaufort County Regional Plans and the Lowcountry Comprehensive Economic Development Strategy), the LCOG can aid in the community outreach efforts to inform local decision makers about the AICUZ Program and introduce/update land use regulations within their plans to reflect the 2013 AICUZ noise contours, APZs and Clear Zones presented in this AICUZ Study.

The LCOG can aid in community outreach efforts, provide AICUZ Program information to local decision makers, and include land use regulations in their plans based on the 2013 AICUZ noise contours, APZs and Clear Zones.

7.2.2 State/Regional-Level Recommendations

Regional Planning Agencies

The LCOG should coordinate with their local member governments, specifically Beaufort County, the City of Beaufort, and the Town of Port Royal, to update their comprehensive plans, regional plans, zoning ordinances, subdivision regulations, land development codes, and any other applicable land use regulations to reflect the 2013 AICUZ noise contours, APZs and Clear Zones. The efforts of the LCOG should be to encourage local governments to strengthen and update their guidelines by focusing on reducing and mitigating noise, accident potential, height obstructions, and land use incompatibility generated by aircraft operations to ensure compatibility with the recommendations of Marine Corps land use compatibility guidelines shown in Appendix B. In addition, the LCOG's websites should be updated to provide information on MCAS Beaufort's AICUZ Study and provide a link to MCAS Beaufort for information on aircraft operations.

The LCOG should encourage local governments to update their plans, zoning ordinances, regulations, and codes to reflect the 2013 AICUZ noise contours, APZs, and Clear Zones.

7.3 LOCAL GOVERNMENT-LEVEL TOOLS AND RECOMMENDATIONS

While it is the responsibility of MCAS Beaufort to inform and educate community decision makers about the AICUZ Program, it is local land use decisions that will ultimately ensure the operational integrity of the installation. Local governments (Beaufort County, the City of Beaufort, and the Town of Port Royal) have the authority to implement regulations and programs for controlling development and managing and directing growth to ensure land use activity compatible within the AICUZ footprint. These local governments have recognized the benefit of compatible development near MCAS Beaufort and have provided land use controls in those areas encumbered by the AICUZ footprint by incorporating the 2003 AICUZ information into their planning policies and regulations. The following are local government-level tools and recommendations that can be used to continue that process and update relevant land use regulations.

7.3.1 Local Government-Level Tools

Local Government Comprehensive Plans and Planning

Local planning authorities surrounding MCAS Beaufort are Beaufort County, the City of Beaufort, and the Town of Port Royal. Development of the surrounding lands is guided by local comprehensive land use planning and regulations developed and adopted by these authorities. The local comprehensive plans provide public policy in terms of future land use, housing, transportation, infrastructure, conservation, recreation and open space, intergovernmental coordination, and capital improvements. Key components of local comprehensive planning that direct development are the existing and future land use maps as well as zoning.

The local authorities review their comprehensive plan at least once every five years to determine whether changes in the direction of development of the area or other reasons make it desirable to make additions or amendments to the plan. Both Beaufort County and the City of Beaufort have implemented elements of the AICUZ Program in the past and have informed local decision makers and the community about the AICUZ Program to identify/limit potential incompatible land uses. A coordinated AICUZ Overlay District was developed by the local jurisdiction which

Periodic review and updates to the local plans is an opportunity to revise the AICUZ-specific information and implement targeted zoning and land use controls to prevent future incompatibility.

was based on the 2003 AICUZ footprint to limit incompatible land uses. The periodic review and updates to the local plans is an opportunity to revise the AICUZ-specific information and implement targeted zoning and land use controls to prevent future incompatibility.

Joint Land Use Study (JLUS) Planning Initiative

A JLUS is a cooperative planning initiative between an installation and the surrounding city(ies)/county(ies). The JLUS is funded through DOD planning assistance grants to state and local governments. The goal of the JLUS is to promote compatible community growth that supports military training and operational missions. The jurisdictional partnership results in the identification of actions that can be taken jointly by the community and installation to promote compatible development and address current and future incompatible development.

In 2004, the LCOG served as the lead agency formulating the JLUS on behalf of the local community. The study recommended land uses that are compatible with the AICUZ zones and other mitigation measures that prevent noise and safety impacts to existing and future development in these zones. Based on the Study's recommendations, the three jurisdictions developed an AICUZ Overlay District, as previously stated, for all land affected by APZs and/or noise zones associated with MCAS Beaufort. Other key JLUS recommendations implemented, as they relate to the AICUZ Program, include standardizing the AICUZ disclosure process in all real estate transactions and incorporating additional noise attenuation measures into the existing uniform building codes for new construction and the TDR program.

Zoning

Zoning regulates the use of land and the placement and design of structures on the land. Zoning can restrict the density, use, and height of structures, and can prohibit the creation of other hazards, including smoke, radio interference, and glare. Zoning regulations are utilized by the local governments in the vicinity of the MCAS Beaufort to direct development. Zoning does not address the problem of existing incompatible land use within the AICUZ footprint; however, it can be used to address/prevent future non-conforming uses.

The JLUS promotes community growth that is compatible with military training and missions by introducing AICUZ data into local planning and outreach programs and identifying actions that can be taken jointly by the community and installation to promote compatible development.

Zoning regulates the use of land and the placement and design of structures on land for future development, but does not address non-conforming existing development.

The AICUZ Overlay District is a type of zoning regulation that extends over the lands within the AICUZ footprint for MCAS Beaufort. The lands within the AICUZ Overlay District are designated low-density residential and/or rural with density restrictions. The district and rural residential areas are regulatory designations intended to implement specific growth management policies that guide land use activities and construction in a manner compatible with the long-term viability of the military installation.

Building Codes

Local building codes can be used to ensure the noise attenuation measures of the AICUZ Program are implemented. The local building codes may be modified to ensure consistency with the noise attenuation recommendations of the AICUZ Program as part of a new construction permit or for remodeling, expansion, or rebuilding. By using proper sound insulation construction techniques and materials, impacts from aircraft noise can be minimized and interference of regular indoor activities can be reduced. Although building codes will not prevent incompatible development, they can aid in minimizing impacts to the utmost extent possible.

Building codes can aid in minimizing impacts from aircraft noise by ensuring that proper sound attenuation construction techniques are used.

Capital Improvements Programs

Capital improvements projects, such as potable water lines, sewage transmission lines, road paving and/or improvements, new right-of-way acquisition, and schools typically encourage new development in areas where it might not otherwise be economically or environmentally feasible. These types of capital improvements can be used to direct growth and types of growth toward areas compatible with the AICUZ Program and away from areas that are incompatible. Both Beaufort County and the City of Beaufort have capital improvement programs that outline specific projects and timelines for implementation.

Capital improvement projects can be used to direct growth into areas that are compatible with the AICUZ Program.

Purchase/Transfer of Development Rights

The local government may consider the purchase of development rights within the AICUZ footprint. The concept of TDR is a land use planning tool that involves purchasing property development rights from one property (i.e., an area proposed for incompatible residential development near an air station) and transferring those rights to another piece of property (i.e., to an area well outside of

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Local governments can purchase development rights for property so that incompatible development around installations is avoided.

By transferring development rights, property around an installation that is incompatible with noise contours and APZs can be transferred for property that is more favorable to that type of development.

noise contours and APZs that is more conducive to residential development).

Another part of the TDR concept is the potential for developers to receive approvals for increased densities in the receiving areas as an inducement to the developer for agreeing to a TDR. TDRs also require local governments to adopt a TDR ordinance identifying sending and receiving areas in the jurisdiction. As a result of purchasing the rights for property development, incompatible land use can be prevented from occurring near an air station. This program is most effective where development rights of agricultural land are purchased. The land is kept productive and no incompatible land use activities can be developed.

The LCOG is working with Beaufort County, the City of Beaufort, and the Town of Port Royal to plan and initiate a TDR program. The LCOG commissioned a TDR Implementation Study to make recommendations on actions to alleviate development pressure around MCAS Beaufort and encourage future growth in designated receiving areas. The Study identifies lands requiring protection (i.e., AICUZ footprint) and five receiving areas to be used as transfer lands. Beaufort County has already adopted a TDR ordinance for lands within the AICUZ Overlay District.

Public Land Acquisition Programs

Public land acquisition programs can be used for acquisition of land to support the AICUZ Program. Land acquisitions are designed to eliminate land use incompatibilities through voluntary transactions in the real estate market and local development process. Acquisition strategies are particularly effective tools because they advance the complementary goals of shaping future growth away from the airfields, while protecting the environment, maintaining agriculture, and conserving open spaces and rural character. A vital part in implementing acquisition tools is to identify areas of conservation interest. Laying out protection priorities around airfields is important when exploring possible partnerships with non-profit conservation groups and in requesting future acquisition funds.

The BCRCL program is a land acquisition initiative for the fee simple purchase or conservation easement of high-quality lands so that rural and critical lands may be protected. Beaufort County contracted with BCOLT to manage the program, negotiate with property owners, and to assist in the purchase of properties.

To eliminate land use incompatibilities with installations, private lands can be acquired through voluntary real estate transactions.

The BCRC Board prioritizes properties and makes recommendations to the County Council.

Special Planning Districts

Special Planning Districts (SPDs) are established to implement tailor-made policies, development standards, design guidelines, and land uses that overlay the existing zoning for designated areas within jurisdictional boundaries. The AICUZ Overlay District is a type of SPD regulation that extends over the lands within the AICUZ footprint for MCAS Beaufort, and is more restrictive and limits density. Targeted SPDs can help mitigate the negative effects of certain projects or land use activities.

SPDs are created by local governments and commissions to implement tailor-made policies, standards, and land uses that supersede existing zoning.

Real Estate Disclosure

Real estate disclosures allow prospective buyers, lessees, or renters of property in the vicinity of MOAs to make informed decisions regarding the purchase or lease of property. Disclosure of noise and safety zones is a crucial tool in protecting and notifying the community about expected impacts of aviation noise and the location of APZs, subsequently reducing frustration and anti-airport criticism by those who were not adequately informed prior to purchase of properties within impact areas. The City of Beaufort amended their UDO in 2006 based on the JLUS recommendation to require real estate disclosures involving all properties within the AICUZ footprint. Beaufort County also requires real estate disclosures (Appendix D). The AICUZ disclosure form identifies the specific noise zone and APZ that the parcel of property is located within, and the form must be signed at the time of closing by the buyer, seller, and witnesses.

Real estate disclosures should provide information to prospective clients regarding aviation noise and APZs so they can make informed decisions, thereby reducing frustration and criticism of an installation's mission.

7.3.2 Local Government-Level Recommendations

Communication

While it is MCAS Beaufort's responsibility to inform and educate community decision makers about the AICUZ Program, community decision makers should continue to actively inform and request input from MCAS Beaufort regarding land use decisions that could affect the operational integrity of the installation. To communicate with the public, local government websites should update information

Community decision makers should inform and request input from MCAS Beaufort regarding land use decisions that could affect the installation's mission and should provide an AICUZ Program website for the public.

on the AICUZ Program for MCAS Beaufort and provide a link to the MCAS Beaufort website for information on the AICUZ Program.

Land Use Plans and Regulations

Beaufort County, the City of Beaufort, and the Town of Port Royal, as governments with jurisdiction within the AICUZ footprint, have recognized their responsibility in providing land use controls to protect the health, safety, and general welfare of the population. They have all been active participants in reducing and preventing incompatible land uses surrounding MCAS Beaufort. However, as new information becomes available, Beaufort County and city/town governments should update their comprehensive/master plans, zoning ordinances, subdivision regulations, land development codes, and any other applicable land use regulations to reflect any changes to the AICUZ noise contours, APZs, and Clear Zones, and OPNAVINST 11010.36C/MCO 11010.16. Local governments should continue their efforts to strengthen and modify their land use guidelines as they relate to the AICUZ Program and MCAS Beaufort's AICUZ footprint.

County, city, and town governments should update all applicable land use regulations and plans to reflect the 2013 AICUZ noise contours, APZs, Clear Zones, and OPNAVINST 11010.36C/MCO 11010.16.

Joint Land Use Study (JLUS) Planning Initiative

The county and city governments should continue to work with MCAS Beaufort to develop an updated JLUS. Each time an AICUZ is updated, further engagement with the neighboring communities is needed through the JLUS to preserve the operational utility of the air installation.

County and city governments should work with MCAS Beaufort to develop a framework for implementing compatible development and promotes public safety and the installation's mission.

Decisions with Special Planning Districts

Following the recommendations in the previous AICUZ Study and the 2004 JLUS, Beaufort County, the City of Beaufort, and the Town of Port Royal created a special overlay district (AICUZ Overlay District) that regulates land use surrounding MCAS Beaufort. However, the local governments need to understand that the noise contours and APZs that make up the AICUZ footprint are dynamic, and the potential exists for changes in the AICUZ footprint as operational needs to satisfy the military mission change over time. Local governments should update their Airport Overlay Zones with the new AICUZ zones as MCAS Beaufort produces them to provide for community safety and to preserve the operational integrity of the installation.

Local governments should continue to work with MCAS Beaufort to revise and maintain their airport overlay districts

Capital improvement projects should be evaluated for impacts on the AICUZ Program.

Capital Improvement

All capital improvement projects in proximity to the installation should be evaluated and reviewed for potential direct and indirect impacts that such improvements may have on the ability to implement a successful AICUZ Program.

Local governments should amend building codes to include noise attenuation techniques for all new construction within the AICUZ footprint.

Building Codes

Beaufort County and the City of Beaufort enforce the mandatory building codes referenced in Section 6-9-50 of the South Carolina Code of Laws, 1976 as Amended, that addresses proper sound attenuation requirements for new structures and housing. The local governments should continue to monitor and/or amend their building codes, when applicable, to require that noise attenuation techniques be incorporated in the construction of new structures and homes within the AICUZ footprint. Additional insulation and soundproofing should be enforced in the local building codes, as required, for all new single- and multi-family dwellings constructed within the footprint.

Any property affected by noise and/or APZs requires a disclosure statement to be acknowledged by both buyer and seller.

Real Estate Disclosures

Both Beaufort County and the City of Beaufort's AICUZ ordinances require disclosure statements with an acknowledgement by both buyer and seller that the property is affected by noise and/or APZs in the vicinity of MCAS Beaufort. The local governments should continue to ensure that real estate disclosure requirements are adhered to by real estate professionals, buyers, and sellers.

Local governments should continue their land acquisition strategies and TDR, BCRL, and BCOLT programs

Purchase/Transfer of Development Rights

Beaufort County and the City of Beaufort governments should continue their land acquisition and conservation strategies and programs including the TDR, BCRL, and the BCOLT programs. The Marine Corps should continue to encourage local government officials to pursue the necessary ordinances and record keeping capabilities that are required to maintain and expand land acquisition and TDR concepts. In addition, the local governments and organizations should continue to pursue federal and state government grants for funding these programs.

7.4 CITIZENS/REAL ESTATE PROFESSIONALS/ BUSINESSES-LEVEL TOOLS AND RECOMMENDATIONS

The following are actions, procedures, and recommendations that private groups can use or consider to help control development within the 2013 AICUZ footprint.

7.4.1 Private-Level Tools

Business Development and Construction Loans to Private Contractors

Lenders should review AICUZ noise zones and APZs as part of private loan applications. Diligent lending practices will promote the compatible development of the land in the vicinity of MCAS Beaufort and protect both lenders and developers. Local banking and finance institutions should be encouraged to incorporate a “Due Diligence Review” of all loan applications, including a determination of possible noise or APZ impacts on the mortgaged property. The Marine Corps can play a role in this strategy by providing AICUZ seminars to lenders throughout the region, as well as providing the regional HUD office with the latest noise data to review before issuing FHA and VA insurance on mortgage loans for homes scheduled for construction within the AICUZ footprint.

Lenders should review noise zones and APZs to promote compatible development with the installations and protect investors.

Real Estate Professionals Cooperation

Real estate professionals should continue to ensure that prospective buyers or lessees are fully aware of what it means to be within a high-noise zone and/or APZ. Private citizens should be provided all the information available to make informed decisions when purchasing or altering any property in proximity to an air station. The disclosure is supported by the local AICUZ ordinance adopted by Beaufort County and the City of Beaufort that requires local real estate and rental agents to provide prospective purchasers and renters with current information concerning the noise environment and APZs surrounding an airfield. Under the terms of the ordinance, notice in writing would be given to prospective purchasers. Real estate professionals also have the ability to show prospective buyers and lessees properties

Realtors should advise prospective clients about the AICUZ footprint, as the ethical practice of full disclosure is an important element of the AICUZ Program's success.

at a time when noise exposure is expected to be at its worst in order to provide full disclosure. Full disclosure is an important element in the future success of AICUZ.

Private Citizens

Citizens have the ability to choose not to purchase property and/or invest in construction projects on properties within high-noise zones and/or APZs.

7.4.2 Private-Level Recommendations

Business Development and Construction Loans to Private Contractors

Lending institutions should consider whether to limit financing for real estate purchases or construction that is incompatible with the AICUZ Program. This approach encourages evaluation of noise and APZ impacts as part of a lender's investigation of potential loans to private interests for real estate acquisition and development. Diligent lending practices will promote compatible development of the area surrounding MCAS Beaufort, and protect lenders and developers alike. Local banking and financial institutions should be encouraged to incorporate a "Due Diligence Review" of all loan applications to determine possible noise or APZ impacts on the mortgaged property. The Marine Corps can play a role in this strategy by providing AICUZ seminars to lenders throughout the region.

Real Estate Professionals Cooperation

Real estate professionals should continue to comply with the AICUZ ordinance and provide written disclosure to prospective purchasers, renters, or lessees when a property is located within an APZ or a noise zone. Real estate professionals should acknowledge MCAS Beaufort's AICUZ Program on their website and provide a link to the installation's website for additional AICUZ information.

Area real estate professionals should also use the MCAS Beaufort 2013 AICUZ brochure as a tool to identify the location of homes in the region relative to the AICUZ. The AICUZ brochure is produced and distributed by the Marine Corps, as requested, to appropriate government agencies, organizations, businesses, and individuals. Brochures are available at the Public Affairs Office at MCAS Beaufort.

Citizens can choose not to invest in property located the AICUZ footprint.

To promote compatible development around installations, lenders can choose to limit financing for projects that are incompatible with the AICUZ Program.

Real Estate Professionals should provide full disclosure of noise exposure and APZs to prospective clients and acknowledge the AICUZ Program on their websites.

They should also educate themselves on the location of the AICUZ footprint in relation to the properties they are representing.

Properties within the AICUZ footprint should be identified as such on the MLS system.

MCAS Beaufort

Lastly, properties listed on the real estate Multiple Listing Service (MLS) system that are within the AICUZ footprint for MCAS Beaufort should be identified as such. The main goal of real estate professionals should be to make prospective buyers and lessees aware of the potential magnitude of noise exposures they might experience on the property.

Private Citizens

Citizens of the local communities surrounding MCAS Beaufort should educate themselves on the AICUZ Program. Buyers, renters, or lessees of properties near MCAS Beaufort should verify if the property is located within an APZ and/or noise zone. Citizens should also provide sufficient and accurate information when registering a noise inquiry with the installation. The installation needs sufficient and accurate information to assess the potential causes resulting in the inquiry and to assess any practical remedies for reducing future inquiries.

Citizens should educate themselves on the AICUZ Program and inquire about noise zones and APZs when considering an investment in property near an installation. In addition, noise inquiries should provide thorough and accurate information.

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APPENDIX A

DISCUSSION OF NOISE AND ITS EFFECT ON THE ENVIRONMENT

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Discussion of Noise and its Effects on the Environment

March 2012

wyle

Prepared for:
Ecology and Environment, Inc.



Authors:
Wyle Staff

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1 Basics of Sound

Noise is unwanted sound. Sound is all around us; sound becomes noise when it interferes with normal activities, such as sleep or conversation.

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air, and are sensed by the human ear. Whether that sound is interpreted as pleasant (e.g., music) or unpleasant (e.g., jackhammers) depends largely on the listener's current activity, past experience, and attitude toward the source of that sound.

The measurement and human perception of sound involves three basic physical characteristics: intensity, frequency, and duration. First, intensity is a measure of the acoustic energy of the sound vibrations and is expressed in terms of sound pressure. The greater the sound pressure, the more energy carried by the sound and the louder the perception of that sound. The second important physical characteristic of sound is frequency, which is the number of times per second the air vibrates or oscillates. Low-frequency sounds are characterized as rumbles or roars, while high-frequency sounds are typified by sirens or screeches. The third important characteristic of sound is duration or the length of time the sound can be detected.

The loudest sounds that can be detected comfortably by the human ear have intensities that are a trillion times higher than those of sounds that can barely be detected. Because of this vast range, using a linear scale to represent the intensity of sound becomes very unwieldy. As a result, a logarithmic unit known as the decibel (abbreviated dB) is used to represent the intensity of a sound. Such a representation is called a sound level. A sound level of 0 dB is approximately the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level of approximately 60 dB; sound levels above 120 dB begin to be felt inside the human ear as discomfort. Sound levels between 130 to 140 dB are felt as pain (Berglund and Lindvall 1995).

Because of the logarithmic nature of the decibel unit, sound levels cannot be arithmetically added or subtracted and are somewhat cumbersome to handle mathematically. However, some simple rules are useful in dealing with sound levels. First, if a sound's intensity is doubled, the sound level increases by 3 dB, regardless of the initial sound level. For example:

$$60 \text{ dB} + 60 \text{ dB} = 63 \text{ dB, and}$$

$$80 \text{ dB} + 80 \text{ dB} = 83 \text{ dB.}$$

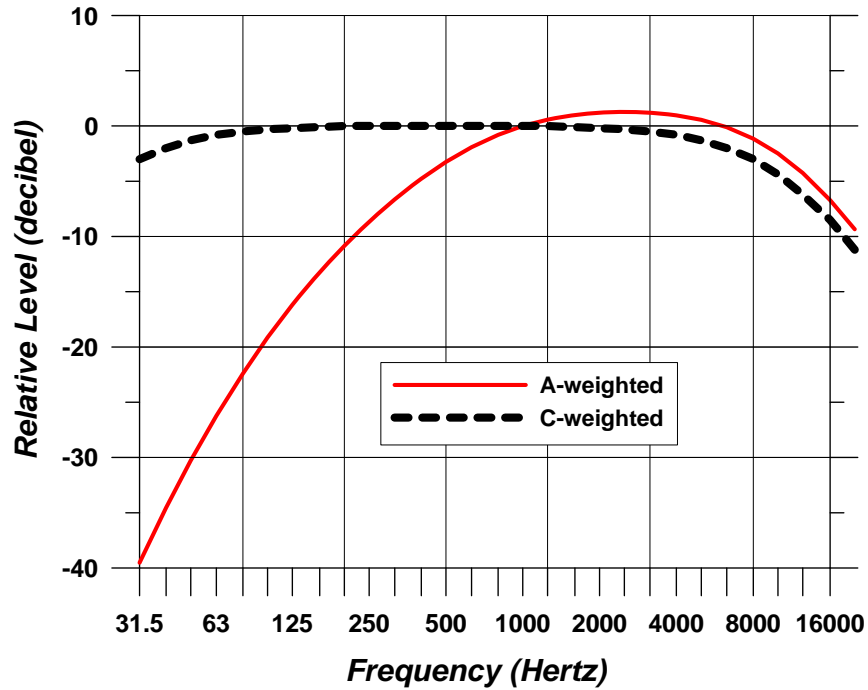
Second, the total sound level produced by two sounds of different levels is usually only slightly more than the higher of the two. For example:

$$60.0 \text{ dB} + 70.0 \text{ dB} = 70.4 \text{ dB.}$$

Because the addition of sound levels is different than that of ordinary numbers, such addition is often referred to as "decibel addition" or "energy addition." The latter term arises from the fact that what we are really doing when we add decibel values is first converting each decibel value to its corresponding acoustic energy, then adding the energies using the normal rules of addition, and finally converting the total energy back to its decibel equivalent.

The minimum change in the sound level of individual events that an average human ear can detect is about 3 dB. On average, a person perceives a change in sound level of about 10 dB as a doubling (or halving) of the sound's loudness, and this relation holds true for loud and quiet sounds. A decrease in sound level of 10 dB actually represents a 90 percent decrease in sound intensity but only a 50 percent decrease in perceived loudness because of the nonlinear response of the human ear (similar to most human senses).

Sound frequency is measured in terms of cycles per second (cps), or hertz (Hz), which is the standard unit for cps. The normal human ear can detect sounds that range in frequency from about 20 Hz to about 15,000 Hz. All sounds in this wide range of frequencies, however, are not heard equally by the human ear, which is most sensitive to frequencies in the 1,000 to 4,000 Hz range. Weighting curves have been developed to correspond to the sensitivity and perception of different types of sound. A-weighting and C-weighting are the two most common weightings. A-weighting accounts for frequency dependence by adjusting the very high and very low frequencies (below approximately 500 Hz and above approximately 10,000 Hz) to approximate the human ear's lower sensitivities to those frequencies. C-weighting is nearly flat throughout the range of audible frequencies, hardly de-emphasizing the low frequency sound while approximating the human ear's sensitivity to higher intensity sounds. The two curves shown in Figure A-1 are also the most adequate to quantify environmental noises.



Source: ANSI S1.4A -1985 "Specification of Sound Level Meters"

Figure A-1. Frequency Response Characteristics of A- and C-Weighting Networks

1.1 A-weighted Sound Level

Sound levels that are measured using A-weighting, called A-weighted sound levels, are often denoted by the unit dBA or dB(A) rather than dB. When the use of A-weighting is understood, the adjective “A-weighted” is often omitted and the measurements are expressed as dB. In this report (as in most environmental impact documents), dB units refer to A-weighted sound levels.

Noise potentially becomes an issue when its intensity exceeds the ambient or background sound pressures. Ambient background noise in metropolitan, urbanized areas typically varies from 60 to 70 dB and can be as high as 80 dB or greater; quiet suburban neighborhoods experience ambient noise levels of approximately 45-50 dB (U.S. Environmental Protection Agency (EPA) 1978).

Figure A-2 is a chart of A-weighted sound levels from typical sounds. Some noise sources (air conditioner, vacuum cleaner) are continuous sounds which levels are constant for some time. Some (automobile, heavy truck) are the maximum sound during a vehicle pass-by. Some (urban daytime, urban nighttime) are averages over extended periods. A variety of noise metrics have been developed to describe noise over different time periods, as discussed below.

Aircraft noise consists of two major types of sound events: aircraft takeoffs and landings, and engine maintenance operations. The former can be described as intermittent sounds and the latter as continuous. Noise levels from flight operations exceeding background noise typically occur beneath main approach and departure corridors, in local air traffic patterns around the airfield, and in areas immediately adjacent to parking ramps and aircraft staging areas. As aircraft in flight gain altitude, their noise contribution drops to lower levels, often becoming indistinguishable from the background.

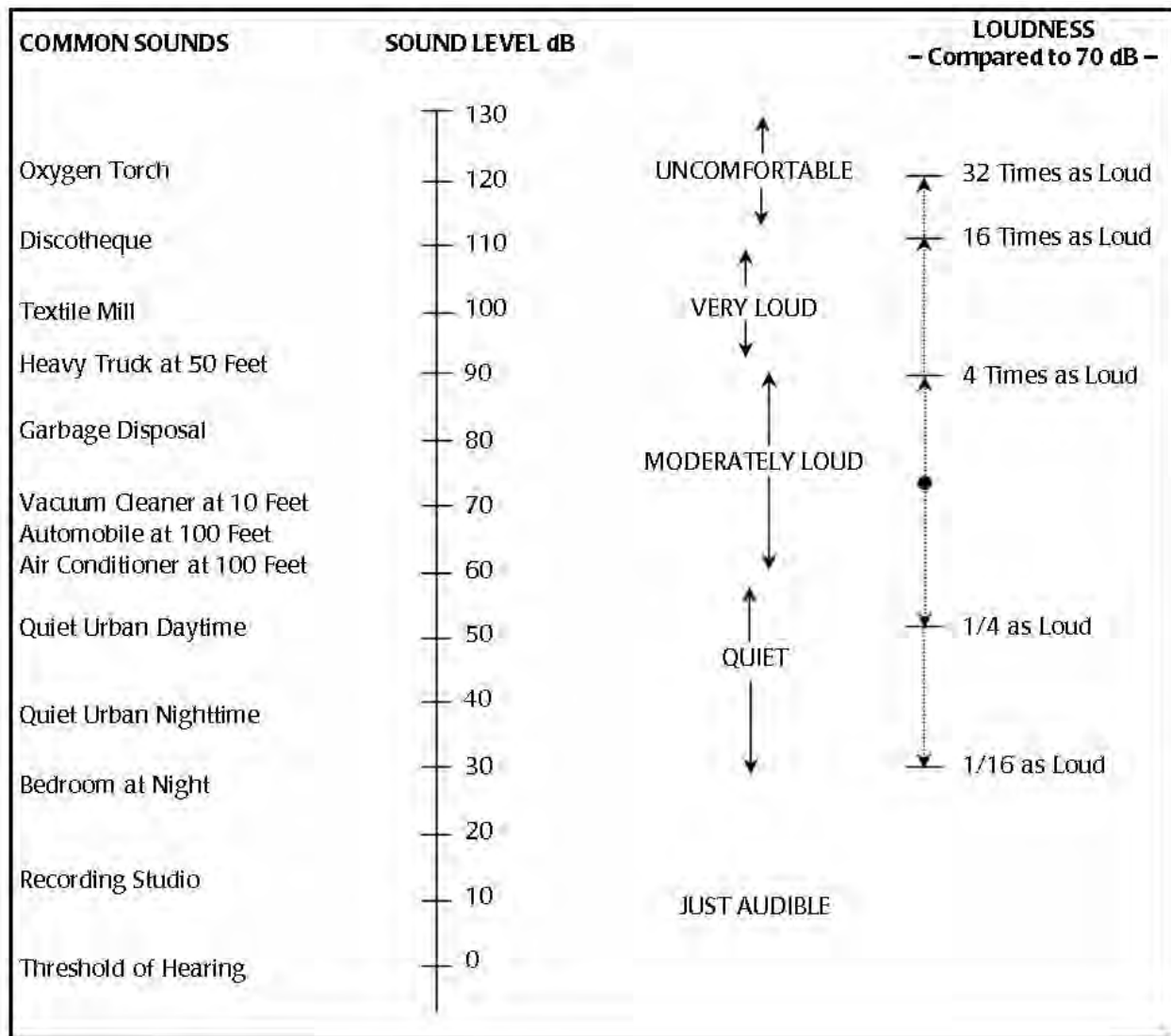
C-weighted Sound Level

Sound levels measured using a C-weighting are most appropriately called C-weighted sound levels (and denoted dBC). C-weighting is nearly flat throughout the audible frequency range, hardly de-emphasizing the low frequency. This weighting scale is generally used to describe impulsive sounds. Sounds that are characterized as impulsive generally contain low frequencies. Impulsive sounds may induce secondary effects, such as shaking of a structure, rattling of windows, inducing vibrations. These secondary effects can cause additional annoyance and complaints.

The following definitions in the American National Standard Institute (ANSI) Report S12.9, Part 4 provide general concepts helpful in understanding impulsive sounds (ANSI 1996).

Impulsive Sound: Sound characterized by brief excursions of sound pressure (acoustic impulses) that significantly exceeds the ambient environmental sound pressure. The duration of a single impulsive sound is usually less than one second (ANSI 1996).

Highly Impulsive Sound: Sound from one of the following enumerated categories of sound sources: small-arms gunfire, metal hammering, wood hammering, drop hammering, pile driving, drop forging, pneumatic hammering, pavement breaking, metal impacts during rail-yard shunting operation, and riveting.



SOURCE: Handbook of Noise Control, C.M. Harris, Editor McGraw-Hill Book Co., 1979, and FICAN 1997

Figure A-2. Typical A-weighted Sound Levels of Common Sounds

High-energy Impulsive Sound: Sound from one of the following enumerated categories of sound sources: quarry and mining explosions, sonic booms, demolition and industrial processes that use high explosives, military ordnance (e.g., armor, artillery and mortar fire, and bombs), explosive ignition of rockets and missiles, explosive industrial circuit breakers, and any other explosive source where the equivalent mass of dynamite exceeds 25 grams.

2 Noise Metrics

In general, a metric is a statistic for measuring or quantifying. A noise metric quantifies the noise environment. There are three families of noise metrics described herein – one for single noise events such as an aircraft flyby, one for cumulative noise events such as a day’s worth of aircraft activity and one which quantifies the events or time relative to single noise events.

Within the single noise event family, metrics described below include Peak Sound Pressure Level, Maximum Sound Level and Sound Exposure Level. Within the cumulative noise events family, metrics described below include Equivalent Sound Level, Day-Night Average Sound Level and several others. Within the events/time family, metrics described below include Number of Events Above a Threshold Level and Time Above a Specified Level.

2.1 Maximum Sound Level (L_{max})

The highest A-weighted integrated sound level measured during a single event in which the sound level changes value with time (e.g., an aircraft overflight) is called the maximum A-weighted sound level or Maximum Sound Level.

During an aircraft overflight, the noise level starts at the ambient or background noise level, rises to the maximum level as the aircraft flies closest to the observer, and returns to the background level as the aircraft recedes into the distance. The L_{max} indicates the maximum sound level occurring for a fraction of a second. For aircraft noise, the “fraction of a second” over which the maximum level is defined is generally one-eighth of a second, and is denoted as “fast” response (ANSI 1988). Slowly varying or steady sounds are generally measured over a period of one second, denoted “slow” response. The L_{max} is important in judging the interference caused by a noise event with conversation, TV or radio listening, sleep, or other common activities. Although it provides some measure of the intrusiveness of the event, it does not completely describe the total event, because it does not include the period of time that the sound is heard.

2.2 Peak Sound Pressure Level (L_{pk})

The Peak Sound Pressure Level, is the highest instantaneous level obtained by a sound level measurement device. The L_{pk} is typically measured using a 20 microseconds or faster sampling rate, and is typically based on unweighted or linear response of the meter.

2.3 Sound Exposure Level (SEL)

Sound Exposure Level is a composite metric that represents both the intensity of a sound and its duration. Individual time-varying noise events (e.g., aircraft overflights) have two main characteristics: a sound level that changes throughout the event and a period of time during which the event is heard. SEL provides a measure of the net impact of the entire acoustic event, but it does not directly represent the sound level heard at any given time. During an aircraft flyover, SEL would include both the L_{max} and the lower noise levels produced during onset and recess periods of the overflight.

SEL is a logarithmic measure of the total acoustic energy transmitted to the listener during the event. Mathematically, it represents the sound level of a constant sound that would, in one second, generate the same acoustic energy as the actual time-varying noise event. For sound from aircraft overflights, which typically lasts more than one second, the SEL is usually greater than the L_{max} because an individual overflight takes seconds and the L_{max} occurs instantaneously. SEL represents the best metric to compare noise levels from overflights.

2.4 Equivalent Sound Level (L_{eq})

A cumulative noise metric useful in describing noise is the Equivalent Sound Level. L_{eq} is the continuous sound level that would be present if all of the variations in sound level occurring over a specified time period were smoothed out as to contain the same total sound energy.

Just as SEL has proven to be a good measure of the noise impact of a single event, L_{eq} has been established to be a good measure of the impact of a series of events during a given time period. Also, while L_{eq} is defined as an average, it is effectively a sum over that time period and is, thus, a measure of the cumulative impact of noise. For example, the sum of all noise-generating events during the period of 7 a.m. to 4 p.m. could provide the relative impact of noise generating events for a school day.

2.5 Day-Night Average Sound Level (DNL or L_{dn}) and Community Noise Equivalent Level (CNEL)

Day-Night Average Sound Level and Community Noise Equivalent Level are composite metrics that account for all noise events in a 24-hour period. In order to account for increased human sensitivity to noise at night, a 10 dB penalty is applied to nighttime events (10:00 p.m. to 7:00 a.m. time period). A variant of the DNL, the CNEL includes a 5 dB penalty on noise during the 7:00 a.m. to 10:00 p.m. time period, and a 10 dB penalty on noise during the 10:00 p.m. to 7:00 a.m. time period. The notations DNL and L_{dn} are both used for Day-Night Average Sound Level and are equivalent.

Like L_{eq} , DNL and CNEL without their penalties are average quantities, mathematically representing the continuous A-weighted or C-weighted sound level that would be present if all of the variations in sound level that occur over a 24-hour period were smoothed out so as to contain the same total sound energy. These composite single-measure time-average metrics account for the SELs, L_{max} , the duration of the events (sorties or operations), and the number of events that occur over a 24-hour period but do not provide specific information on the number of noise events or the individual sound levels that occur during the 24-hour day. Like SEL, neither DNL nor CNEL represent the sound level heard at any particular time, but quantifies the total sound energy received. While it is normalized as an average, it represents all of the sound energy, and is therefore a cumulative measure.

The nighttime penalties in both DNL and CNEL account for the added intrusiveness of sounds that occur during normal sleeping hours, both because of the increased sensitivity to noise during those hours and because ambient sound levels during nighttime are typically about 10 dB lower than during daytime hours. The evening penalty in CNEL accounts for the added intrusiveness of sounds during that period.

The inclusion of daytime, evening and nighttime periods in the computation of the DNL and CNEL reflects their basic 24-hour definition. They can, however, be applied over periods of multiple days. For application to civil airports, where operations are consistent from day to day, DNL and CNEL are usually applied as an annual average.

The logarithmic nature of the decibel unit causes the noise levels of the loudest events to control the 24-hour average. A DNL of 65 dB could result from a very few noisy events or a large number of quieter events.

As a simple example of this characteristic, consider a case in which only one aircraft overflight occurs during the daytime over a 24-hour period, creating a sound level of 100 dB for 30 seconds. During the remaining 23 hours, 59 minutes, and 30 seconds of the day, the ambient sound level is 50 dB. The DNL for this 24-hour period is 65.9 dB. Assume, as a second example that 10 such 30-second overflights occur during daytime hours during the next 24-hour period, with the same ambient sound level of 50 dB during the remaining 23 hours and 55 minutes of the day. The DNL for this 24-hour period is 75.5 dB. Clearly, the averaging of noise over a 24-hour period does not ignore the louder single events and tends to emphasize both the sound levels and number of those events.

Daily average sound levels are typically used for the evaluation of community noise effects (i.e., long-term annoyance), and particularly aircraft noise effects. In general, scientific studies and social surveys have found a high correlation between the percentages of groups of people highly annoyed and the level of average noise exposure measured in DNL (EPA 1978 and Schultz 1978).

2.6 Onset-Rate Adjusted Monthly Day-Night Average Sound Level (L_{dnmr}) and Onset-Rate Adjusted Monthly Community Noise Equivalent Level ($CNEL_{mr}$)

Military aircraft utilizing Special Use Airspace (SUA) such as Military Training Routes (MTRs), Military Operating Areas (MOAs) and Restricted Areas/Ranges generate a noise environment that is somewhat different from that associated with airfield operations. As opposed to patterned or continuous noise environments associated with airfields, flight activity in SUAs is highly sporadic and often seasonal ranging from ten per hour to less than one per week. Individual military overflight events also differ from typical community noise events in that noise from a low-altitude, high-air-speed flyover can have a rather sudden onset, exhibiting a rate of increase in sound level (onset rate) of up to 150 dB per second.

To represent these differences, the conventional SEL metric is adjusted to account for the “surprise” effect of the sudden onset of aircraft noise events on humans with an adjustment ranging up to 11 dB above the normal SEL (Stusnick, et al. 1992). Onset rates between 15 to 150 dB per second require an adjustment of 0 to 11 dB, while onset rates below 15 dB per second require no adjustment. The adjusted SEL is designated as the onset-rate adjusted sound exposure level (SEL_r).

Because of the sporadic characteristic of SUA activity and so as not to dilute the resultant noise exposure, the month with the most operations or sorties from a yearly tabulation for the given SUA is examined -- the so-called busiest month. The cumulative exposure to noise in these areas is computed by DNL over the busy month, but using SEL_r instead of SEL. This monthly average is denoted L_{dnmr} . If onset rate adjusted DNL is computed over a period other than a month, it would be designated L_{dnr} and the period must be specified. In the state of California, a variant of the L_{dnmr} includes a penalty for evening operations (7 p.m. to 10 p.m) and is denoted $CNEL_{mr}$.

2.7 Number-of-Events Above (NA) a Threshold Level (L)

The Number-of-events Above metric (NA) provides the total number of noise events that exceed the selected noise level threshold during a specified period of time. Combined with the selected threshold level (L), the NA metric is symbolized as NAL. The threshold L can be defined in terms of either the SEL or L_{max} metric, and it is important that this selection is reflected in the nomenclature. When labeling a contour line or point of interest (POI) on a map the NAL will be followed by the number of events in parentheses for that line or POI. For example, the noise environment at a location where 10 events exceed an SEL of 90 dB, over a given period of time, would be represented by the nomenclature NA90SEL(10). Similarly, for L_{max} it would be NA90 L_{max} (10). The period of time can be an average 24-hour day, daytime, nighttime, school day, or any other time period appropriate to the nature and application of the analysis.

NA can be portrayed for single or multiple locations, or by means of noise contours on a map similar to the common DNL contours. A threshold level is selected that best meets the need for that situation. An L_{max} threshold is normally selected to analyze speech interference, whereas an SEL threshold is normally selected for analysis of sleep disturbance.

The NA metric is the only supplemental metric that has been developed that combines single-event noise levels with the number of aircraft operations. In essence, it answers the question of how many aircraft (or range of aircraft) fly over a given location or area at or above a selected threshold noise level.

2.8 Time Above (TA) a Specified Level (L)

The Time Above (TA) metric is a measure of the total time that the A-weighted aircraft noise level is at or above a defined sound level threshold. Combined with the selected threshold level (L), the TA metric is symbolized as TAL. TA is not a sound level, but rather a time expressed in minutes. TA values can be calculated over a full 24-hour annual average day, the 15-hour daytime and 9-hour nighttime periods, a school day, or any other time period of interest, provided there is operational data to define the time period of interest.

TA has application for describing the noise environment in schools, particularly when comparing the classroom or other noise sensitive environments for different operational scenarios. TA can be portrayed by means of noise contours on a map similar to the common DNL contours.

The TA metric is a useful descriptor of the noise impact of an individual event or for many events occurring over a certain time period. When computed for a full day, the TA can be compared alongside the DNL in order to determine the sound levels and total duration of events that contribute to the DNL. TA analysis is usually conducted along with NA analysis so the results show not only how many events occur above the selected threshold(s), but also the total duration of those events above those levels for the selected time period.

3 Noise Effects

This noise effects section includes discussions of annoyance, speech interference and sleep disturbance, and the effects of noise on hearing, health, performance, learning, animals, property values, terrain and archaeological sites.

3.1 Annoyance

The primary effect of aircraft noise on exposed communities is one of long-term annoyance, defined by the Environmental Protection Agency (EPA) as any negative subjective reaction on the part of an individual or group. The scientific community has adopted the use of long-term annoyance as a primary indicator of community response because it attempts to account for all negative aspects of effects from noise, e.g., increased annoyance due to being awakened the previous night by aircraft and interference with everyday conversation.

Numerous laboratory studies and field surveys have been conducted to measure annoyance and to account for a number of variables, many of which are dependent on a person's individual circumstances and preferences. Laboratory studies of individual response to noise have helped isolate a number of the factors contributing to annoyance, such as the intensity level and spectral characteristics of the noise, duration, the presence of impulses, pitch, information content, and the degree of interference with activity. Social surveys of community response to noise have allowed the development of general dose-response relationships that can be used to estimate the proportion of people who will be highly annoyed by a given noise level. The results of these studies have formed the basis for criteria established to define areas of compatible land use.

A wide variety of responses have been used to determine intrusiveness of noise and disturbances of speech, sleep, audio/video entertainment, and outdoor living; but the most useful metric for assessing peoples' responses to noise is the percentage of the population expected to be "highly annoyed." The concept of "percent highly annoyed" has provided the most consistent response of a community to a particular noise environment. In his synthesis of several different social surveys that employed different response scales, Schultz (1978) defined "highly annoyed" respondents as those respondents whose self-described annoyance fell within the upper 28 percent of the response scale where the scale was numerical or un-named. For surveys where the response scale was named, Schultz counted those who claimed to be highly annoyed, combining the responses of "very annoyed" and "extremely annoyed." Schultz's definition of "percent highly annoyed" (%HA) became the basis for the Federal policy on environmental noise. Daily average sound levels are typically used for the evaluation of community noise effects, such as long-term annoyance.

In general, scientific studies and social surveys have found a correlation between the percentages of groups of people highly annoyed and the level of average noise exposure. Thus, the results are expressed as the average %HA at various exposure levels measured in DNL. The classic analysis is Schultz's original 1978 study, whose results are shown in Figure A-3. This figure is commonly referred to as the Schultz curve. It represents the synthesis of a large number of social surveys (161 data points in all), that relates the long-term community response to various types of noise sources, measured using the DNL metric.

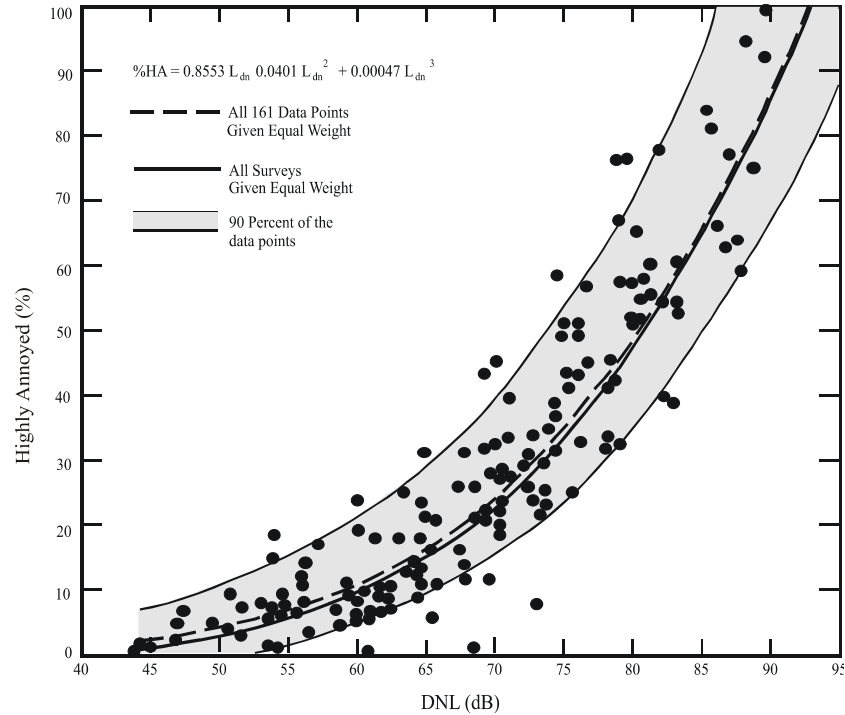
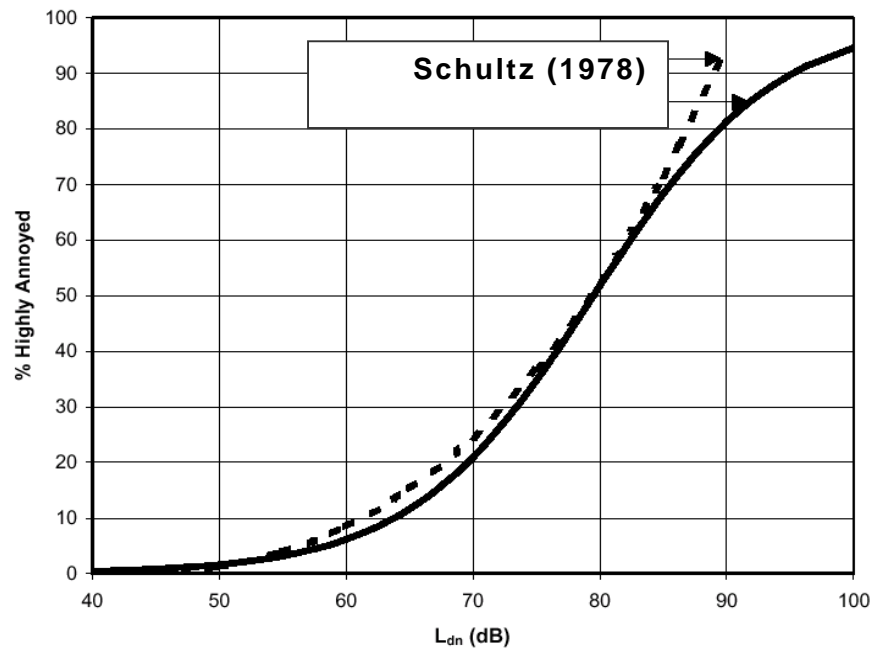


Figure A-3. Community Surveys of Noise Annoyance

An updated study of the original Schultz data based on the analysis of 400 data points collected through 1989 essentially reaffirmed this relationship. Figure A-4 shows an updated form of the curve fit in comparison with the original Schultz curve (Finegold 1994). The updated fit, which does not differ substantially from the original, is the preferred form in the U.S. The relationship between %HA and DNL is:

$$\%HA = 100/[1 + \exp(11.13 - 0.141L_{dn})]$$



SOURCE:(Schultz, 1978) and Current (Finegold, et al. 1994) Curve Fits

Figure A-4. Response of Communities to Noise; Comparison of Original

In general, correlation coefficients of 0.85 to 0.95 are found between the percentages of groups of people highly annoyed and the level of average noise exposure. However, the correlation coefficients for the annoyance of individuals are relatively low, on the order of 0.5 or less. This is not surprising, considering the varying personal factors that influence the manner in which individuals react to noise.

A number of non-acoustic factors have been identified that may influence the annoyance response of an individual. Newman and Beattie (1985) divided these factors into emotional and physical variables.

Emotional Variables:

- Feelings about the necessity or preventability of the noise;
 - Judgment of the importance and value of the activity that is producing the noise;
 - Activity at the time an individual hears the noise;
 - Attitude about the environment;
 - General sensitivity to noise;
 - Belief about the effect of noise on health; and
 - Feeling of fear associated with the noise.
- Physical Variables:
- Type of neighborhood;
 - Time of day;

- Season;
- Predictability of noise;
- Control over the noise source; and
- Length of time an individual is exposed to a noise.

The low correlation coefficients for individuals’ reactions reflect the large amount of scatter among the data drawn from the various surveys and point to the substantial uncertainty associated with the equation representing the relationship between %HA and DNL. Based on the results of surveys it has been observed that noise exposure can explain less than 50 percent of the observed variance in annoyance, indicating that non-acoustical factors play a major role. As a result, it is not possible to accurately predict individual annoyance in any specific community based on the aircraft noise exposure. Nevertheless, changes in %HA can be useful in giving the decision maker more information about the relative effects that different alternatives may have on the community.

The original Schultz curve and the subsequent updates do not separate out the annoyance from aircraft noise and other transportation noise sources. This was an important element, in that it allowed Schultz to obtain some consensus among the various social surveys from the 1960s and 1970s that were synthesized in the analysis. In essence, the Schultz curve assumes that the effects of long-term annoyance on the general population are the same, regardless of whether the noise source is road, rail, or aircraft. In the years after the classical Schultz analysis, additional social surveys have been conducted to better understand the annoyance effects of various transportation sources.

Miedema & Vos (1998) present synthesis curves for the relationship between DNL and percentage “Annoyed” and percentage “Highly Annoyed” for three transportation noise sources. Separate, non-identical curves were found for aircraft, road traffic, and railway noise. Table A-1 illustrates that, for a DNL of 65 dB, the percent of the people forecasted to be Highly Annoyed is 28 percent for air traffic, 18 percent for road traffic, and 11 percent for railroad traffic. For an outdoor DNL of 55 dB, the percent highly annoyed would be close to 12 percent if the noise is generated by aircraft operations, but only 7 percent and 4 percent, respectively, if the noise is generated by road or rail traffic. Comparing the levels on the Miedema & Vos curve to those on the updated Schultz curve indicates that the percentage of people highly annoyed by aircraft noise may be higher than previously thought when the noise is solely generated by aircraft activity.

Table A-1. Percent Highly Annoyed for Different Transportation Noise Sources

DNL (dB)	Percent Highly Annoyed (% HA)			
	Miedema and Vos			Schultz Combined
	Air	Road	Rail	
55	12	7	4	3
60	19	12	7	6
65	28	18	11	12
70	37	29	16	22
75	48	40	22	36

Source: Miedema & Vos 1998

As noted by the World Health Organization (WHO), even though aircraft noise seems to produce a stronger annoyance response than road traffic, caution should be exercised when interpreting synthesized data from different studies (WHO 2000). The WHO noted that five major parameters should be randomly distributed for the analyses to be valid: personal, demographic, and lifestyle factors, as well as the duration of noise exposure and the population experience with noise.

The FICON found that the updated Schultz curve remains the best available source of empirical dosage effect information to predict community response to transportation noise without any segregation by transportation source (FICON 1992); a position held by the FICAN in 1997 (FICAN 1997). However, FICON also recommended further research to investigate the differences in perceptions of aircraft noise, ground transportation noise (highways and railroads), and general background noise.

3.2 Speech Interference

Speech interference associated with aircraft noise is a primary cause of annoyance for communities. The disruption of routine activities such as radio or television listening, telephone use, or family conversation gives rise to frustration and irritation. The quality of speech communication is particularly important in classrooms and offices. In industrial settings it can cause fatigue and vocal strain in those who attempt to communicate over the noise.

The disruption of speech in the classroom is a primary concern, due to the potential for adverse effects on children's learning ability. There are two aspects to speech comprehension:

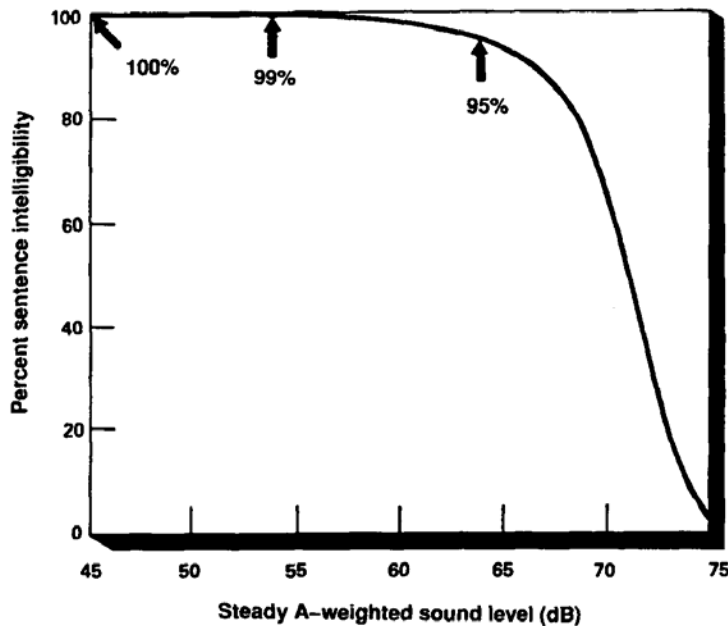
1. *Word Intelligibility* - the percent of words transmitted and received. This might be important for students in the lower grades who are learning the English language, and particularly for students who have English as a Second Language.
2. *Sentence Intelligibility* – the percent of sentences transmitted and understood. This might be important for high-school students and adults who are familiar with the language, and who do not necessarily have to understand each word in order to understand sentences.

For teachers to be clearly understood by their students, it is important that regular voice communication is clear and uninterrupted. Not only does the background sound level have to be low enough for the teacher to be clearly heard, but intermittent outdoor noise events also need to be minimized. It is therefore important to evaluate the steady background level, the level of voice communication, and the single-event level due to aircraft overflights that might interfere with speech.

Several research studies have been conducted and guideline documents been developed resulting in a fairly consistent set of noise level criteria for speech interference. This section provides an overview of the results of these studies.

U.S. Federal Criteria for Interior Noise

In 1974, the EPA identified a goal of an indoor 24-hour average sound level $L_{eq(24)}$ of 45 dB to minimize speech interference based on the intelligibility of sentences in the presence of a steady background noise (EPA 1974). Intelligibility pertains to the percentage of speech units correctly understood out of those transmitted, and specifies the type of speech material used, i.e. sentences or words. The curve displayed in Figure A-5 shows the effect of steady indoor background sound levels on sentence intelligibility. For an average adult with normal hearing and fluency in the language, steady background sound levels indoors of less than 45 dB L_{eq} are expected to allow 100 percent intelligibility of sentences.



Source: EPA 1974

Figure A-5. Speech Intelligibility Curve

The curve shows 99 percent sentence intelligibility for background levels at a L_{eq} of 54 dB, and less than 10 percent intelligibility for background levels above a L_{eq} of 73 dB. Note that the curve is especially sensitive to changes in sound level between 65 dB and 75 dB - an increase of 1 dB in background sound level from 70 dB to 71 dB results in a 14 percent decrease in sentence intelligibility, whereas a 1 dB increase in background sound level from 60 dB to 61 dB results in less than 1 percent decrease in sentence intelligibility.

Classroom Criteria

For listeners with normal hearing and fluency in the language, complete sentence intelligibility can be achieved when the signal-to-noise ratio (i.e., the difference between the speech level and the level of the interfering noise) is in the range 15-18 dB (Lazarus 1990).

Both the ANSI and the American Speech-Language-Hearing Association (ASHLA) recommend at least a 15 dB signal-to-noise ratio in classrooms, to ensure that children with hearing impairments and language disabilities are able to enjoy high speech intelligibility (ANSI 2002; ASHLA 1995). As such, provided that the average adult male or female voice registers a minimum of 50 dB L_{max} in the rear of the classroom, the ANSI standard requires that the continuous background noise level indoors must not exceed a L_{eq} of 35 dB (assumed to apply for the duration of school hours).

The WHO reported for a speaker-to-listener distance of about 1 meter, empirical observations have shown that speech in relaxed conversations is 100 percent intelligible in background noise levels of about 35 dB, and speech can be fairly well understood in the presence of background levels of 45 dB. The WHO recommends a guideline value of 35 dB L_{eq} for continuous background levels in classrooms during school hours (WHO 2000).

Bradley suggests that in smaller rooms, where speech levels in the rear of the classroom are approximately 50 dB L_{max} , steady-state noise levels above 35 dB L_{eq} may interfere with the intelligibility of speech (Bradley 1993).

For the purposes of determining eligibility for noise insulation funding, the Federal Aviation Administration (FAA) guidelines state that the design objective for a classroom environment is 45 dB L_{eq} resulting from aircraft operations during normal school hours (FAA 1985).

However, most aircraft noise is not continuous and consists of individual events where the sound level exceeds the background level for a limited time period as the aircraft flies over. Since speech interference in the presence of aircraft noise is essentially determined by the magnitude and frequency of individual aircraft flyover events, a time-averaged metric alone, such as L_{eq} , is not necessarily appropriate when evaluating the overall effects. In addition to the background level criteria described above, single-event criteria, which account for those sporadic intermittent outdoor noisy events, are also essential to specifying speech interference criteria.

In 1984, a report to the Port Authority of New York and New Jersey recommended utilizing the Speech Interference Level (SIL) metric for classroom noise criteria (Sharp and Plotkin 1984). This metric is based on the maximum sound levels in the frequency range (approximately 500 Hz to 2,000 Hz) that directly affects speech communication. The study identified an SIL (the average of the sound levels in the 500, 1000, and 2000 Hz octave-bands) of 45 dB as the desirable goal, which was estimated to provide 90 percent word intelligibility for the short time periods during aircraft over-flights. Although early classroom level criteria were defined in terms of SIL, the use and measurement of L_{max} as the primary metric has since become more popular. Both metrics take into consideration the L_{max} associated with intermittent noise events and can be related to existing background levels when determining speech interference percentages. An SIL of 45 dB is approximately equivalent to an A-weighted L_{max} of 50 dB for aircraft noise (Wesler 1986).

In 1998, a report also concluded that if an aircraft noise event's indoor L_{max} reached the speech level of 50 dB, 90 percent of the words would be understood by students seated throughout the classroom (Lind, Pearsons, and Fidell 1998). Since intermittent aircraft noise does not appreciably disrupt classroom communication at lower levels and other times, the authors also adopted an indoor L_{max} of 50 dB as the maximum single-event level permissible in classrooms. Note that this limit was set based on students with normal hearing and no special needs; at-risk students may be adversely affected at lower sound levels.

Bradley recommends SEL as a better indicator of indoor estimated speech interference in the presence of aircraft overflights (Bradley 1985). For acceptable speech communication using normal vocal efforts, Bradley suggests that the indoor SEL be no greater than 64 dB. He assumes a 26 dB outdoor-to-indoor noise reduction that equates to 90 dB SEL outdoors. Aircraft events producing outdoor SEL values greater than 90 dB would result in disruption to indoor speech communication. Bradley's work indicates that, for speakers talking with a casual vocal effort, 95 percent intelligibility would be achieved when indoor SEL values did not exceed 60 dB, which translates approximately to an L_{max} of 50 dB.

In the presence of intermittent noise events, ANSI states that the criteria for allowable background noise level can be relaxed since speech is impaired only for the short time when the aircraft noise is close to its maximum value. Consequently, they recommend when the background noise level of the noisiest hour is dominated by aircraft noise, the indoor criteria (35 dB L_{eq} for continuous background noise) can be increased by 5 dB to an L_{eq} of 40 dB, as long as the noise level does not exceed 40 dB for more than 10 percent of the noisiest hour. (ANSI 2002).

The WHO does not recommend a specific indoor L_{max} criterion for single-event noise, but does place a guideline value at L_{eq} of 35 dB for overall background noise in the classroom. However, WHO does report that "for communication distances beyond a few meters, speech interference starts at sound pressure levels below 50 dB for octave bands centered on the main speech frequencies at 500 Hz, 1kHz, and 2 kHz." (WHO 2000). One can infer this can be approximated by an L_{max} value of 50 dB.

The United Kingdom Department for Education and Skills (UKDFES) established in its classroom acoustics guide a 30-minute time-averaged metric [$L_{eq(30min)}$] for background levels and $L_{A1,30}$ min for intermittent noises, at thresholds of 30-35 dB and 55 dB, respectively. $L_{A1,30}$ min represents the A-weighted sound level that is exceeded one percent of the time (in this case, during a 30 minute teaching session) and is generally equivalent to the L_{max} metric (UKDFES 2003).

Summary

As the previous section demonstrates, research indicates that it is not only important to consider the continuous background levels using time-averaged metrics, but also the intermittent events, using single-event metrics such as L_{max} . Table A-2 provides a summary of the noise level criteria recommended in the scientific literature.

Table A-2. Indoor Noise Level Criteria Based on Speech Intelligibility

Source	Metric/Level (dB)	Effects and Notes
U.S. FAA (1985)	L_{eq} (during school hours) = 45 dB	Federal assistance criteria for school sound insulation; supplemental single-event criteria may be used
Lind et al. (1998), Sharp and Plotkin (1984), Wesler (1986)	L_{max} = 50 dB / SIL 45	Single event level permissible in the classroom
WHO (1999)	L_{eq} = 35 dB L_{max} = 50 dB	Assumes average speech level of 50 dB and recommends signal to noise ratio of 15 dB
U.S. ANSI (2002)	L_{eq} = 40 dB, Based on Room Volume	Acceptable background level for continuous noise/ relaxed criteria for intermittent noise in the classroom
U.K. DFES (2003)	$L_{eq(30min)}$ = 30-35 dB L_{max} = 55 dB	Minimum acceptable in classroom and most other learning environs

When considering intermittent noise caused by aircraft overflights, a review of the relevant scientific literature and international guidelines indicates that an appropriate criteria is a limit on indoor background noise levels of 35 to 40 dB L_{eq} and a limit on single events of 50 dB L_{max} .

3.3 Sleep Disturbance

The disturbance of sleep is a major concern for communities exposed to nighttime aircraft noise. There have been numerous research studies that have attempted to quantify the complex effects of noise on sleep. This section provides an overview of the major noise-induced sleep disturbance studies that have been conducted, with particular emphasis placed on those studies that have influenced U.S. federal noise policy. The studies have been separated into two groups:

1. Initial studies performed in the 1960s and 1970s, where the research was focused on laboratory sleep observations.
2. Later studies performed in the 1990s up to the present, where the research was focused on field observations, and correlations to laboratory research were sought.

Initial Studies

The relationship between noise levels and sleep disturbance is complex and not fully understood. The disturbance depends not only on the depth of sleep, but also on the previous exposure to aircraft noise, familiarity with the surroundings, the physiological and psychological condition of the recipient, and a host of other situational factors. The most readily measurable effect of noise on sleep is the number of arousals or awakenings, and so the body of scientific literature has focused on predicting the percentage of the population that will be awakened at various noise levels. Fundamentally, regardless of the tools used to measure the degree of sleep disturbance (awakenings, arousals, etc.), these studies have grouped the data points into bins to predict the percentage of the population likely to be disturbed at various sound level thresholds.

FICON produced a guidance document that provided an overview of the most pertinent sleep disturbance research that had been conducted throughout the 1970s (FICON 1992). Literature reviews and meta-analysis conducted between 1978 and 1989 made use of the existing datasets that indicated the effects of nighttime noise on various sleep-state changes and awakenings (Lukas 1978; Griefahn 1978; Peasons et. al. 1989). FICON noted that various indoor A-weighted sound levels – ranging from 25 to 50 dB were observed to be thresholds below which significant sleep effects were not expected. Due to the large variability in the data, FICON did not endorse the reliability of the results.

However, FICON did recommend the use of an interim dose-response curve—awaiting future research—which predicted the percent of the exposed population expected to be awakened as a function of the exposure to single event noise levels expressed in terms of SEL. This curve was based on the research conducted for the U.S. Air Force (Finegold 1994). The dataset included most of the research performed up to that point, and predicted that ten percent of the population would be awakened when exposed to an interior SEL of approximately 58 dB. The data utilized to derive this relationship were primarily the results of controlled laboratory studies.

Recent Sleep Disturbance Research – Field and Laboratory Studies

It was noted in the early sleep disturbance research that the controlled laboratory studies did not account for many factors that are important to sleep behavior, such as habituation to the environment and previous exposure to noise and awakenings from sources other than aircraft noise. In the early 1990s, field studies were conducted to validate the earlier laboratory work. The most significant finding from these studies was that an estimated 80 to 90 percent of sleep disturbances were not related to individual outdoor noise events, but were instead the result of indoor noise sources and other non-noise-related factors. The results showed that there was less of an effect of noise on sleep in real-life conditions than had been previously reported from laboratory studies.

FICAN

The interim FICON dose-response curve that was recommended for use in 1992 was based on the most pertinent sleep disturbance research that was conducted through the 1970s, primarily in laboratory settings. After that time, considerable field research was conducted to evaluate the sleep effects in peoples’ normal, home environment. Laboratory sleep studies tend to show higher values of sleep disturbance than field studies because people who sleep in their own homes are habituated to their environment and, therefore, do not wake up as easily (FICAN 1997).

Based on the new information, FICAN updated its recommended dose-response curve in 1997, depicted as the lower curve in Figure A-6. This figure is based on the results of three field studies (Ollerhead 1992; Fidell et. al. 1994; Fidell et al. 1995a and 1995b), along with the datasets from six previous field studies.

The new relationship represents the higher end, or upper envelope, of the latest field data. It should be interpreted as predicting the “maximum percent of the exposed population expected to be behaviorally awakened” or the “maximum percent awakened” for a given residential population. According to this relationship, a maximum of 3 percent of people would be awakened at an indoor SEL of 58 dB, compared to 10 percent using the 1992 curve. An indoor SEL of 58 dB is equivalent to outdoor SEL’s of 73 and 83 dB respectively assuming 15 and 25 dB noise level reduction from outdoor to indoor with windows open and closed, respectively.

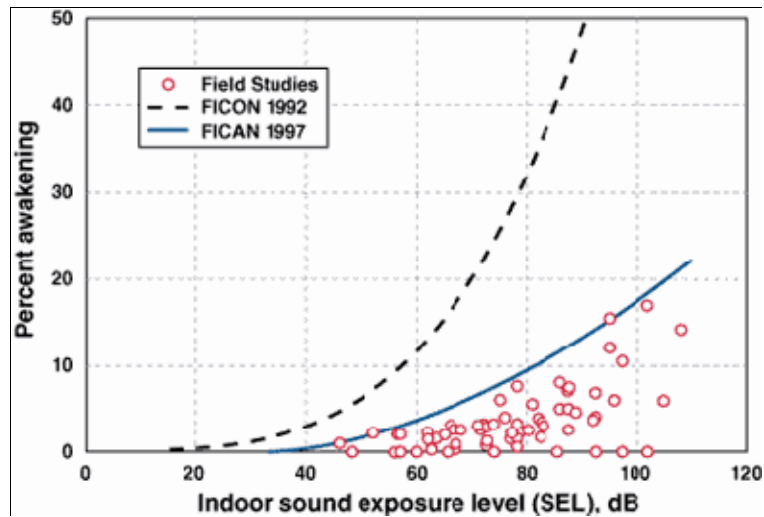


Figure A-6. FICAN's 1997 Recommended Sleep Disturbance Dose-Response Relationship

The FICAN 1997 curve is represented by the following equation:

$$\text{Percent Awakenings} = 0.0087 \times [\text{SEL} - 30]^{1.79}$$

Note the relatively low percentage of awakenings to fairly high noise levels. People think they are awakened by a noise event, but usually the reason for awakening is otherwise. For example, the 1992 UK CAA study found the average person was awakened about 18 times per night for reasons other than exposure to an aircraft noise – some of these awakenings are due to the biological rhythms of sleep and some to other reasons that were not correlated with specific aircraft events.

Number of Events and Awakenings

In recent years, there have been studies and one proposal that attempted to determine the effect of multiple aircraft events on the number of awakenings. The German Aerospace Center (DLR) conducted an extensive study focused on the effects of nighttime aircraft noise on sleep and other related human performance factors (Basner 2004). The DLR study was one of the largest studies to examine the link between aircraft noise and sleep disturbance and involved both laboratory and in-home field research phases. The DLR investigators developed a dose-effect curve that predicts the number of aircraft events at various values of L_{max} expected to produce one additional awakening over the course of a night. The dose-effect curve was based on the relationships found in the field studies.

In July 2008 ANSI and the Acoustical Society of America (ASA) published a method to estimate the percent of the exposed population that might be awakened by multiple aircraft noise events based on statistical assumptions about the probability of awakening (or not awakening) (ANSI 2008). This method relies on probability theory rather than direct field research/experimental data to account for multiple events.

Figure A-7 depicts the awakenings data that form the basis and equations of ANSI S12.9-2008. The curve labeled 'Eq. (B1)' is the relationship between noise and awakening endorsed by FICAN in 1997. The ANSI recommended curve labeled 'Eq. (1)' quantifies the probability of awakening for a population of sleepers who are exposed to an outdoor noise event as a function of the associated indoor SEL in the bedroom. This curve was derived from studies of behavioral awakenings associated with noise events in "steady state" situations where the population has been exposed to the noise long enough to be habituated. The data points in Figure A-7 come from these studies. Unlike the FICAN curve, the ANSI 2008 curve represents the average of the field research data points.

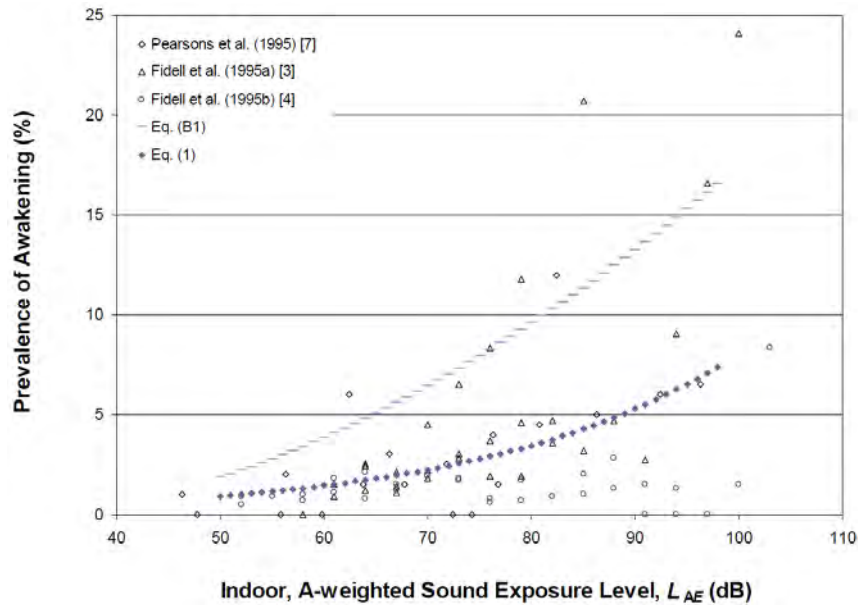


Figure A-7. Plot of Sleep Awakening Data versus Indoor SEL

In December 2008, FICAN recommended the use of this new estimation procedure for future analyses of behavioral awakenings from aircraft noise. In that statement, FICAN also recognized that additional sleep disturbance research is underway by various research organizations, and results of that work may result in additional changes to FICAN's position. Until that time, FICAN recommends the use of ANSI S12.9-2008.

3.4 Noise-Induced Hearing Impairment

Residents in surrounding communities express concerns regarding the effects of aircraft noise on hearing. This section provides a brief overview of hearing loss caused by noise exposure. The goal is to provide a sense of perspective as to how aircraft noise (as experienced on the ground) compares to other activities that are often linked with hearing loss.

Hearing Threshold Shifts

Hearing loss is generally interpreted as a decrease in the ear's sensitivity or acuity to perceive sound; i.e. a shift in the hearing threshold to a higher level. This change can either be a Temporary Threshold Shift (TTS), or a Permanent Threshold Shift (PTS) (Berger 1995).

TTS can result from exposure to loud noise over a given amount of time, yet the hearing loss is not necessarily permanent. An example of TTS might be a person attending a loud music concert. After the concert is over, the person may experience a threshold shift that may last several hours, depending upon the level and duration of exposure. While experiencing TTS, the person becomes less sensitive to low-level sounds, particularly at certain frequencies in the speech range (typically near 4,000 Hz). Normal hearing ability eventually returns, as long as the person has enough time to recover within a relatively quiet environment.

PTS usually results from repeated exposure to high noise levels, where the ears are not given adequate time to recover from the strain and fatigue of exposure. A common example of PTS is the result of working in a loud environment such as a factory. It is important to note that a temporary shift (TTS) can eventually become permanent (PTS) over time with continuous exposure to high noise levels. Thus, even if the ear is given time to recover from TTS, repeated occurrence of TTS may eventually lead to permanent hearing loss. The point at which a Temporary Threshold Shift results in a Permanent Threshold Shift is difficult to identify and varies with a person's sensitivity.

Criteria for Permanent Hearing Loss

Considerable data on hearing loss have been collected and analyzed by the scientific/medical community. It has been well established that continuous exposure to high noise levels will damage human hearing (EPA 1978). The Occupational Safety and Health Administration (OSHA) regulation of 1971 standardizes the limits on workplace noise exposure for protection from hearing loss as an average level of 90 dB over an 8-hour work period or 85 dB over a 16-hour period (the average level is based on a 5 dB decrease per doubling of exposure time) (US Department of Labor 1970). Even the most protective criterion (no measurable hearing loss for the most sensitive portion of the population at the ear's most sensitive frequency, 4,000 Hz, after a 40-year exposure) is an average sound level of 70 dB over a 24-hour period.

The US EPA established 75 dB for an 8-hour exposure and 70 dB for a 24-hour exposure as the average noise level standard requisite to protect 96 percent of the population from greater than a 5 dB PTS (EPA 1978). The National Academy of Sciences Committee on Hearing, Bioacoustics, and Biomechanics identified 75 dB as the minimum level at which hearing loss may occur (CHABA 1977). Finally, the WHO has concluded that environmental and leisure-time noise below an L_{eq24} value of 70 dB "will not cause hearing loss in the large majority of the population, even after a lifetime of exposure" (WHO 2000).

Hearing Loss and Aircraft Noise

The 1982 EPA Guidelines report specifically addresses the criteria and procedures for assessing the noise-induced hearing loss in terms of the Noise-Induced Permanent Threshold Shift (NIPTS), a quantity that defines the permanent change in hearing level, or threshold, caused by exposure to noise (EPA, 1982). Numerically, the NIPTS is the change in threshold averaged over the frequencies 0.5, 1, 2, and 4 kHz that can be expected from daily exposure to noise over a normal working lifetime of 40 years, with the exposure beginning at an age of 20 years. A grand average of the NIPTS over time (40 years) and hearing sensitivity (10 to 90 percentiles of the exposed population) is termed the Average NIPTS or Ave NIPTS for short. The Average Noise Induced Permanent Threshold Shift (Ave. NIPTS) that can be expected for noise exposure as measured by the DNL metric is given in Table A-3.

Table A-3. Ave. NIPTS and 10th Percentile NIPTS as a Function of DNL

DNL	Ave. NIPTS dB*	10th Percentile NIPTS dB*
75-76	1.0	4.0
76-77	1.0	4.5
77-78	1.6	5.0
78-79	2.0	5.5
79-80	2.5	6.0
80-81	3.0	7.0
81-82	3.5	8.0
82-83	4.0	9.0
83-84	4.5	10.0
84-85	5.5	11.0

* Rounded to the nearest 0.5 dB

For example, for a noise exposure of 80 dB DNL, the expected lifetime average value of NIPTS is 2.5 dB, or 6.0 dB for the 10th percentile. Characterizing the noise exposure in terms of DNL will usually overestimate the assessment of hearing loss risk as DNL includes a 10 dB weighting factor for aircraft operations occurring between 10 p.m. and 7 a.m. If, however, flight operations between the hours of 10 p.m. and 7 a.m. account for 5 percent or less of the total 24-hour operations, the overestimation is on the order of 1.5 dB.

From a civilian airport perspective, the scientific community has concluded that there is little likelihood that the resulting noise exposure from aircraft noise could result in either a temporary or permanent hearing loss. Studies on community hearing loss from exposure to aircraft flyovers near airports showed that there is no danger, under normal circumstances, of hearing loss due to aircraft noise (Newman and Beattie 1985). The EPA criterion ($L_{eq24} = 70$ dBA) can be exceeded in some areas located near airports, but that is only the case outdoors. Inside a building, where people are more likely to spend most of their time, the average noise level will be much less than 70 dBA (Eldred and von Gierke 1993). Eldred and von Gierke also report that “several studies in the U.S., Japan, and the U.K. have confirmed the predictions that the possibility for permanent hearing loss in communities, even under the most intense commercial take-off and landing patterns, is remote.”

With regard to military airbases, as individual aircraft noise levels are increasing with the introduction of new aircraft, a 2009 DoD policy directive requires that hearing loss risk be estimated for the at risk population, defined as the population exposed to DNL greater than or equal to 80 dB and higher (DoD 2009). Specifically, DoD components are directed to “use the 80 Day-Night A-Weighted (DNL) noise contour to identify populations at the most risk of potential hearing loss”. This does not preclude populations outside the 80 DNL contour, i.e. at lower exposure levels, from being at some degree of risk of hearing loss. However, the analysis should be restricted to populations within this contour area, including residents of on-base housing. The exposure of workers inside the base boundary area should be considered occupational and evaluated using the appropriate DoD component regulations for occupational noise exposure.

With regard to military airspace activity, studies have shown conflicting results. A 1995 laboratory study measured changes in human hearing from noise representative of low-flying aircraft on MTRs (Nixon, et al. 1993). The potential effects of aircraft flying along MTRs is of particular concern because of maximum overflight noise levels can exceed 115 dB, with rapid increases in noise levels exceeding 30 dB per second. In this study, participants were first subjected to four overflight noise exposures at A-weighted levels of 115 dB to 130 dB. Fifty percent of the subjects showed no change in hearing levels, 25 percent had a temporary 5 dB *increase* in sensitivity (the people could hear a 5 dB wider range of sound than before exposure), and 25 percent had a temporary 5 dB decrease in sensitivity (the people could hear a 5 dB narrower range of sound than before exposure). In the next phase, participants were subjected to a single overflight at a maximum level of 130 dB for eight successive exposures, separated by 90 seconds or until a temporary shift in hearing was observed. The temporary hearing threshold shifts showed an *increase* in sensitivity of up to 10 dB.

In another study of 115 test subjects between 18 and 50 years old in 1999, temporary threshold shifts were measured after laboratory exposure to military low-altitude flight noise (Ising, et al. 1999). According to the authors, the results indicate that repeated exposure to military low-altitude flight noise with L_{max} greater than 114 dB, especially if the noise level increases rapidly, may have the potential to cause noise induced hearing loss in humans.

Summary

Aviation and typical community noise levels near airports are not comparable to the occupational or recreational noise exposures associated with hearing loss. Studies of aircraft noise levels associated with civilian airport activity have not definitively correlated permanent hearing impairment with aircraft activity. It is unlikely that airport neighbors will remain outside their homes 24 hours per day, so there is little likelihood of hearing loss below an average sound level of 75 dB DNL. Near military airbases, average noise levels above 75 dB may occur, and while new DoD policy dictates that NIPTS be evaluated, no research results to date have definitively related permanent hearing impairment to aviation noise.

3.5 Nonauditory Health Effects

Studies have been conducted to determine whether correlations exist between noise exposure and cardiovascular problems, birth weight, and mortality rates. The nonauditory effect of noise on humans is not as easily substantiated as the effect on hearing. The results of studies conducted in the United States, primarily concentrating on cardiovascular response to noise, have been contradictory (Cantrell 1974). Cantrell concluded that the results of human and animal experiments show that average or intrusive noise can act as a stress-provoking stimulus. Prolonged stress is known to be a contributor to a number of health disorders. Kryter and Poza (1980) state, “It is more likely that noise-related general ill-health effects are due to the psychological annoyance from the noise interfering with normal everyday behavior, than it is from the noise eliciting, because of its intensity, reflexive response in the autonomic or other physiological systems of the body.” Psychological stresses may cause a physiological stress reaction that could result in impaired health.

The National Institute for Occupational Safety and Health and EPA commissioned CHABA in 1981 to study whether established noise standards are adequate to protect against health disorders other than hearing defects. CHABA’s conclusion was that:

Evidence from available research reports is suggestive, but it does not provide definitive answers to the question of health effects, other than to the auditory system, of long-term exposure to noise. It seems prudent, therefore, in the absence of adequate knowledge as to whether or not noise can produce effects upon health other than damage to auditory system, either directly or mediated through stress, that insofar as feasible, an attempt should be made to obtain more critical evidence.

Since the CHABA report, there have been more recent studies that suggest that noise exposure may cause hypertension and other stress-related effects in adults. Near an airport in Stockholm, Sweden, the prevalence of hypertension was reportedly greater among nearby residents who were exposed to energy averaged noise levels exceeding 55 dB and maximum noise levels exceeding 72 dB, particularly older subjects and those not reporting impaired hearing ability (Rosenlund, et al. 2001). A study of elderly volunteers who were exposed to simulated military low-altitude flight noise reported that blood pressure was raised by L_{\max} of 112 dB and high speed level increase (Michalak, et al. 1990). Yet another study of subjects exposed to varying levels of military aircraft or road noise found no significant relationship between noise level and blood pressure (Pulles, et al. 1990).

The U.S. Department of the Navy prepared a programmatic Environmental Assessment (EA) for the continued use of non-explosive ordnance on the Vieques Inner Range. Following the preparation of the EA, it was learned that research conducted by the University of Puerto Rico, Ponce School of Medicine, suggested that Vieques fishermen and their families were experiencing symptoms associated with vibroacoustic disease (VAD) (U.S. Department of the Navy 2002). The study alleged that exposure to noise and sound waves of large pressure amplitudes within lower frequency bands, associated with Navy training activities—specifically, air-to-ground bombing or naval fire support—was related to a larger prevalence of heart anomalies within the Vieques fishermen and their families. The Ponce School of Medicine study compared the Vieques group with a group from Ponce Playa. A 1999 study conducted on Portuguese aircraft-manufacturing workers from a single factory reported effects of jet aircraft noise exposure that involved a wide range of symptoms and disorders, including the cardiac issues on which the Ponce School of Medicine study focused. The 1999 study identified these effects as VAD.

Johns Hopkins University (JHU) conducted an independent review of the Ponce School of Medicine study, as well as the Portuguese aircraft workers study and other relevant scientific literature. Their findings concluded that VAD should not be accepted as a syndrome, given that exhaustive research across a number of populations has not yet been conducted. JHU also pointed out that the evidence supporting the existence of VAD comes largely from one group of investigators and that similar results would have to be replicated by other investigators. In short, JHU concluded that it had not been established that noise was the causal agent for the symptoms reported and no inference can be made as to the role of noise from naval gunfire in producing echocardiographic abnormalities (U.S. Department of the Navy 2002).

Most studies of nonauditory health effects of long-term noise exposure have found that noise exposure levels established for hearing protection will also protect against any potential nonauditory health effects, at least in workplace conditions. One of the best scientific summaries of these findings is contained in the lead paper at the National Institutes of Health Conference on Noise and Hearing Loss, held on 22 to 24 January 1990 in Washington, D.C.:

“The nonauditory effects of chronic noise exposure, when noise is suspected to act as one of the risk factors in the development of hypertension, cardiovascular disease, and other nervous disorders, have never been proven to occur as chronic manifestations at levels below these criteria (an average of 75 dBA for complete protection against hearing loss for an 8-hour day). At the recent (1988) International Congress on Noise as a Public Health Problem, most studies attempting to clarify such health effects did not find them at levels below the criteria protective of noise-induced hearing loss, and even above these criteria, results regarding such health effects were ambiguous. Consequently, one comes to the conclusion that establishing and enforcing exposure levels protecting against noise-induced hearing loss would not only solve the noise-induced hearing loss problem, but also any potential nonauditory health effects in the work place” (von Gierke 1990).

Although these findings were specifically directed at noise effects in the workplace, they are equally applicable to aircraft noise effects in the community environment. Research studies regarding the nonauditory health effects of aircraft noise are ambiguous, at best, and often contradictory. Yet, even those studies that purport to find such health effects use time-average noise levels of 75 dB and higher for their research.

For example, two UCLA researchers apparently found a relationship between aircraft noise levels under the approach path to Los Angeles International Airport (LAX) and increased mortality rates among the exposed residents by using an average noise exposure level greater than 75 dB for the “noise-exposed” population (Meacham and Shaw 1979). Nevertheless, three other UCLA professors analyzed those same data and found no relationship between noise exposure and mortality rates (Frerichs, et al. 1980).

As a second example, two other UCLA researchers used this same population near LAX to show a higher rate of birth defects for 1970 to 1972 when compared with a control group residing away from the airport (Jones and Tauscher 1978). Based on this report, a separate group at the Center for Disease Control performed a more thorough study of populations near Atlanta’s Hartsfield International Airport (ATL) for 1970 to 1972 and found no relationship in their study of 17 identified categories of birth defects to aircraft noise levels above 65 dB (Edmonds, et al. 1979).

In summary, there is no scientific basis for a claim that potential health effects exist for aircraft time-average sound levels below 75 dB.

The potential for noise to affect physiological health, such as the cardiovascular system, has been speculated; however, no unequivocal evidence exists to support such claims (Harris 1997). Conclusions drawn from a review of health effect studies involving military low-altitude flight noise with its unusually high maximum levels and rapid rise in sound level have shown no increase in cardiovascular disease (Schwartz and Thompson 1993). Additional claims that are unsupported include flyover noise producing increased mortality rates and increases in cardiovascular death, aggravation of post-traumatic stress syndrome, increased stress, increase in admissions to mental hospitals, and adverse effects on pregnant women and the unborn fetus (Harris 1997).

3.6 Performance Effects

The effect of noise on the performance of activities or tasks has been the subject of many studies. Some of these studies have established links between continuous high noise levels and performance loss. Noise-induced performance losses are most frequently reported in studies employing noise levels in excess of 85 dB. Little change has been found in low-noise cases. It has been cited that moderate noise levels appear to act as a stressor for more sensitive individuals performing a difficult psychomotor task.

While the results of research on the general effect of periodic aircraft noise on performance have yet to yield definitive criteria, several general trends have been noted including:

- A periodic intermittent noise is more likely to disrupt performance than a steady-state continuous noise of the same level. Flyover noise, due to its intermittent nature, might be more likely to disrupt performance than a steady-state noise of equal level.
- Noise is more inclined to affect the quality than the quantity of work.
- Noise is more likely to impair the performance of tasks that place extreme demands on the worker.

3.7 Noise Effects on Children

In response to noise-specific and other environmental studies, Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks (1997), requires federal agencies to ensure that policies, programs, and activities address environmental health and safety risks to identify any disproportionate risks to children.

A review of the scientific literature indicates that there has not been a tremendous amount of research in the area of aircraft noise effects on children. The research reviewed does suggest that environments with sustained high background noise can have variable effects, including noise effects on learning and cognitive abilities, and reports of various noise-related physiological changes.

3.7.1 Effects on Learning and Cognitive Abilities

In 2002 ANSI refers to studies that suggest that loud and frequent background noise can affect the learning patterns of young children (ANSI 2002). ANSI provides discussion on the relationships between noise and learning, and stipulates design requirements and acoustical performance criteria for outdoor-to-indoor noise isolation. School design is directed to be cognizant of, and responsive to surrounding land uses and the shielding of outdoor noise from the indoor environment. The ANSI acoustical performance criteria for schools include the requirement that the one-hour-average background noise level shall not exceed 35 dBA in core learning spaces smaller than 20,000 cubic-feet and 40 dBA in core learning spaces with enclosed volumes exceeding 20,000 cubic-feet. This would require schools be constructed such that, in quiet neighborhoods indoor noise levels are lowered by 15 to 20 dBA relative to outdoor levels. In schools near airports, indoor noise levels would have to be lowered by 35 to 45 dBA relative to outdoor levels (ANSI 2002).

The studies referenced by ANSI to support the new standard are not specific to jet aircraft noise and the potential effects on children. However, there are references to studies that have shown that children in noisier classrooms scored lower on a variety of tests. Excessive background noise or reverberation within schools causes interferences of communication and can therefore create an acoustical barrier to learning (ANSI 2002). Studies have been performed that contribute to the body of evidence emphasizing the importance of communication by way of the spoken language to the development of cognitive skills. The ability to read, write, comprehend, and maintain attentiveness, are, in part, based upon whether teacher communication is consistently intelligible (ANSI 2002).

Numerous studies have shown varying degrees of effects of noise on the reading comprehension, attentiveness, puzzle-solving, and memory/recall ability of children. It is generally accepted that young children are more susceptible than adults to the effects of background noise. Because of the developmental status of young children (linguistic, cognitive, and proficiency), barriers to hearing can cause interferences or disruptions in developmental evolution.

Research on the impacts of aircraft noise, and noise in general, on the cognitive abilities of school-aged children has received more attention in recent years. Several studies suggest that aircraft noise can affect the academic performance of schoolchildren. Although many factors could contribute to learning deficits in school-aged children (e.g., socioeconomic level, home environment, diet, sleep patterns), evidence exists that suggests that chronic exposure to high aircraft noise levels can impair learning.

Specifically, elementary school children attending schools near New York City's two airports demonstrated lower reading scores than children living farther away from the flight paths (Green, et al. 1982). Researchers have found that tasks involving central processing and language comprehension (such as reading, attention, problem solving,

and memory) appear to be the most affected by noise (Evans and Lepore 1993; Hygge 1994; and Evans, et al. 1998). It has been demonstrated that chronic exposure of first- and second-grade children to aircraft noise can result in reading deficits and impaired speech perception (i.e., the ability to hear common, low-frequency [vowel] sounds but not high frequencies [consonants] in speech) (Evans and Maxwell 1997).

The Evans and Maxwell (1997) study found that chronic exposure to aircraft noise resulted in reading deficits and impaired speech perception for first- and second-grade children. Other studies found that children residing near the Los Angeles International Airport had more difficulty solving cognitive problems and did not perform as well as children from quieter schools in puzzle-solving and attentiveness (Bronzaft 1997; Cohen, et al. 1980). Children attending elementary schools in high aircraft noise areas near London's Heathrow Airport demonstrated poorer reading comprehension and selective cognitive impairments (Haines, et al. 2001a, and 2001b). Similarly, a 1994 study found that students exposed to aircraft noise of approximately 76 dBA scored 20% lower on recall ability tests than students exposed to ambient noise of 42-44 dBA (Hygge 1994). Similar studies involving the testing of attention, memory, and reading comprehension of school children located near airports showed that their tests exhibited reduced performance results compared to those of similar groups of children who were located in quieter environments (Evans, et al. 1998; Haines, et al. 1998). The Haines and Stansfeld study indicated that there may be some long-term effects associated with exposure, as one-year follow-up testing still demonstrated lowered scores for children in higher noise schools (Haines, et al. 2001a, and 2001b). In contrast, a 2002 study found that although children living near the old Munich airport scored lower in standardized reading and long-term memory tests than a control group, their performance on the same tests was equal to that of the control group once the airport was closed. (Hygge, et al. 2002).

Finally, although it is recognized that there are many factors that could contribute to learning deficits in school-aged children, there is increasing awareness that chronic exposure to high aircraft noise levels may impair learning. This awareness has led the World Health Organization and a North Atlantic Treaty Organization working group to conclude that daycare centers and schools should not be located near major sources of noise, such as highways, airports, and industrial sites (World Health Organization 2000; North Atlantic Treaty Organization 2000).

3.7.2 Health Effects

Physiological effects in children exposed to aircraft noise and the potential for health effects have also been the focus of limited investigation. Studies in the literature include examination of blood pressure levels, hormonal secretions, and hearing loss.

As a measure of stress response to aircraft noise, authors have looked at blood pressure readings to monitor children's health. Children who were chronically exposed to aircraft noise from a new airport near Munich, Germany, had modest (although significant) increases in blood pressure, significant increases in stress hormones, and a decline in quality of life (Evans, et al. 1998). Children attending noisy schools had statistically significant average systolic and diastolic blood pressure ($p < 0.03$). Systolic blood pressure means were 89.68 mm for children attending schools located in noisier environments compared to 86.77 mm for a control group. Similarly, diastolic blood pressure means for the noisier environment group were 47.84 mm and 45.16 for the control group (Cohen, et al. 1980).

Although the literature appears limited, studies focused on the wide range of potential effects of aircraft noise on school children have also investigated hormonal levels between groups of children exposed to aircraft noise compared to those in a control group. Specifically, two studies analyzed cortisol and urinary catecholamine levels in school children as measurements of stress response to aircraft noise (Haines, et al. 2001b and 2001c). In both instances, there were no differences between the aircraft-noise-exposed children and the control groups.

Other studies have reported hearing losses from exposure to aircraft noise. Noise-induced hearing loss was reportedly higher in children who attended a school located under a flight path near a Taiwan airport, as compared to children at another school far away (Chen, et al. 1997). Another study reported that hearing ability was reduced significantly in individuals who lived near an airport and were frequently exposed to aircraft noise (Chen and Chen 1993). In that study, noise exposure near the airport was reportedly uniform, with DNL greater than 75 dB and maximum noise levels of about 87 dB during overflights. Conversely, several other studies that were reviewed reported no difference in hearing ability between children exposed to high levels of airport noise and children located in quieter areas (Fisch 1977; Andrus, et al. 1975; Wu, et al. 1995).

3.8 Effects on Domestic Animals and Wildlife

Hearing is critical to an animal's ability to react, compete, reproduce, hunt, forage, and survive in its environment. While the existing literature does include studies on possible effects of jet aircraft noise and sonic booms on wildlife, there appears to have been little concerted effort in developing quantitative comparisons of aircraft noise effects on normal auditory characteristics. Behavioral effects have been relatively well described, but the larger ecological context issues, and the potential for drawing conclusions regarding effects on populations, has not been well developed.

The relationships between potential auditory/physiological effects and species interactions with their environments are not well understood. Mancini, et al. (1988), assert that the consequences that physiological effects may have on behavioral patterns is vital to understanding the long-term effects of noise on wildlife. Questions regarding the effects (if any) on predator-prey interactions, reproductive success, and intra-inter specific behavior patterns remain.

The following discussion provides an overview of the existing literature on noise effects (particularly jet aircraft noise) on animal species. The literature reviewed here involves those studies that have focused on the observations of the behavioral effects that jet aircraft and sonic booms have on animals.

A great deal of research was conducted in the 1960's and 1970's on the effects of aircraft noise on the public and the potential for adverse ecological impacts. These studies were largely completed in response to the increase in air travel and as a result of the introduction of supersonic jet aircraft. According to Mancini, et al. (1988), the foundation of information created from that focus does not necessarily correlate or provide information specific to the impacts to wildlife in areas overflowed by aircraft at supersonic speed or at low altitudes.

The abilities to hear sounds and noise and to communicate assist wildlife in maintaining group cohesiveness and survivorship. Social species communicate by transmitting calls of warning, introduction, and other types that are subsequently related to an individual's or group's responsiveness.

Animal species differ greatly in their responses to noise. Noise effects on domestic animals and wildlife are classified as primary, secondary, and tertiary. Primary effects are direct, physiological changes to the auditory system, and most likely include the masking of auditory signals. Masking is defined as the inability of an individual to hear important environmental signals that may arise from mates, predators, or prey. There is some potential that noise could disrupt a species' ability to communicate or could interfere with behavioral patterns (Mancini, et al. 1988). Although the effects are likely temporal, aircraft noise may cause masking of auditory signals within exposed faunal communities. Animals rely on hearing to avoid predators, obtain food, and communicate with, and attract, other members of their species. Aircraft noise may mask or interfere with these functions. Other primary effects, such as ear drum rupture or temporary and permanent hearing threshold shifts, are not as likely given the subsonic noise levels produced by aircraft overflights. Secondary effects may include non-auditory effects such as stress and hypertension; behavioral modifications; interference with mating or reproduction; and impaired ability to obtain adequate food, cover, or water. Tertiary effects are the direct result of primary and secondary effects, and include population decline and habitat loss. Most of the effects of noise are mild enough that they may never be detectable as variables of change in population size or population growth against the background of normal variation (Bowles 1995). Other environmental variables (e.g., predators, weather, changing prey base, ground-based disturbance) also influence secondary and tertiary effects, and confound the ability to identify the ultimate factor in limiting

productivity of a certain nest, area, or region (Smith, et al. 1988). Overall, the literature suggests that species differ in their response to various types, durations, and sources of noise (Manci, et al. 1988).

Many scientific studies have investigated the effects of aircraft noise on wildlife, and some have focused on wildlife “flight” due to noise. Apparently, animal responses to aircraft are influenced by many variables, including size, speed, proximity (both height above the ground and lateral distance), engine noise, color, flight profile, and radiated noise. The type of aircraft (e.g., fixed wing versus rotor-wing [helicopter]) and type of flight mission may also produce different levels of disturbance, with varying animal responses (Smith, et al. 1988). Consequently, it is difficult to generalize animal responses to noise disturbances across species.

One result of the 1988 Manci, et al., literature review was the conclusion that, while behavioral observation studies were relatively limited, a general behavioral reaction in animals from exposure to aircraft noise is the startle response. The intensity and duration of the startle response appears to be dependent on which species is exposed, whether there is a group or an individual, and whether there have been some previous exposures. Responses range from flight, trampling, stampeding, jumping, or running, to movement of the head in the apparent direction of the noise source. Manci, et al. (1988), reported that the literature indicated that avian species may be more sensitive to aircraft noise than mammals.

3.8.1 Domestic Animals

Although some studies report that the effects of aircraft noise on domestic animals is inconclusive, a majority of the literature reviewed indicates that domestic animals exhibit some behavioral responses to military overflights but generally seem to habituate to the disturbances over a period of time. Mammals in particular appear to react to noise at sound levels higher than 90 dB, with responses including the startle response, freezing (i.e., becoming temporarily stationary), and fleeing from the sound source. Many studies on domestic animals suggest that some species appear to acclimate to some forms of sound disturbance (Manci, et al. 1988). Some studies have reported such primary and secondary effects as reduced milk production and rate of milk release, increased glucose concentrations, decreased levels of hemoglobin, increased heart rate, and a reduction in thyroid activity. These latter effects appear to represent a small percentage of the findings occurring in the existing literature.

Some reviewers have indicated that earlier studies, and claims by farmers linking adverse effects of aircraft noise on livestock, did not necessarily provide clear-cut evidence of cause and effect (Cottreau 1978). In contrast, many studies conclude that there is no evidence that aircraft overflights affect feed intake, growth, or production rates in domestic animals.

Cattle

In response to concerns about overflight effects on pregnant cattle, milk production, and cattle safety, the U.S. Air Force prepared a handbook for environmental protection that summarizes the literature on the impacts of low-altitude flights on livestock (and poultry) and includes specific case studies conducted in numerous airspaces across the country. Adverse effects have been found in a few studies but have not been reproduced in other similar studies. One such study, conducted in 1983, suggested that 2 of 10 cows in late pregnancy aborted after showing rising estrogen and falling progesterone levels. These increased hormonal levels were reported as being linked to 59 aircraft overflights. The remaining eight cows showed no changes in their blood concentrations and calved normally (U.S. Air Force 1994b). A similar study reported abortions occurred in three out of five pregnant cattle after exposing them to flyovers by six different aircraft (U.S. Air Force 1994b). Another study suggested that feedlot cattle could stampede and injure themselves when exposed to low-level overflights (U.S. Air Force 1994b).

A majority of the studies reviewed suggests that there is little or no effect of aircraft noise on cattle. Studies presenting adverse effects to domestic animals have been limited. A number of studies (Parker and Bayley 1960; Casady and Lehmann 1967; Kovalcik and Sottnik 1971) investigated the effects of jet aircraft noise and sonic booms on the milk production of dairy cows. Through the compilation and examination of milk production data from areas exposed to jet aircraft noise and sonic boom events, it was determined that milk yields were not affected. This was particularly evident in those cows that had been previously exposed to jet aircraft noise.

A study examined the causes of 1,763 abortions in Wisconsin dairy cattle over a one-year time period and none were associated with aircraft disturbances (U.S. Air Force 1993). In 1987, Anderson contacted seven livestock operators for production data, and no effects of low-altitude and supersonic flights were noted. Three out of 43 cattle previously exposed to low-altitude flights showed a startle response to an F/A-18 aircraft flying overhead at 500 feet above ground level and 400 knots by running less than 10 meters. They resumed normal activity within one minute (U.S. Air Force 1994b). Beyer (1983) found that helicopters caused more reaction than other low-aircraft overflights, and that the helicopters at 30 to 60 feet overhead did not affect milk production and pregnancies of 44 cows and heifers in a 1964 study (U.S. Air Force 1994b).

Additionally, Beyer reported that five pregnant dairy cows in a pasture did not exhibit fright-flight tendencies or disturb their pregnancies after being overflown by 79 low-altitude helicopter flights and 4 low-altitude, subsonic jet aircraft flights (U.S. Air Force 1994b). A 1956 study found that the reactions of dairy and beef cattle to noise from low-altitude, subsonic aircraft were similar to those caused by paper blowing about, strange persons, or other moving objects (U.S. Air Force 1994b).

In a report to Congress, the U. S. Forest Service concluded that “evidence both from field studies of wild ungulates and laboratory studies of domestic stock indicate that the risks of damage are small (from aircraft approaches of 50 to 100 meters), as animals take care not to damage themselves (U.S. Forest Service 1992). If animals are overflown by aircraft at altitudes of 50 to 100 meters, there is no evidence that mothers and young are separated, that animals collide with obstructions (unless confined) or that they traverse dangerous ground at too high a rate.” These varied study results suggest that, although the confining of cattle could magnify animal response to aircraft overflight, there is no proven cause-and-effect link between startling cattle from aircraft overflights and abortion rates or lower milk production.

Horses

Horses have also been observed to react to overflights of jet aircraft. Several of the studies reviewed reported a varied response of horses to low-altitude aircraft overflights. Observations made in 1966 and 1968 noted that horses galloped in response to jet flyovers (U.S. Air Force 1993). Bowles (1995) cites Kruger and Erath as observing horses exhibiting intensive flight reactions, random movements, and biting/kicking behavior. However, no injuries or abortions occurred, and there was evidence that the mares adapted somewhat to the flyovers over the course of a month (U.S. Air Force 1994b). Although horses were observed noticing the overflights, it did not appear to affect either survivability or reproductive success. There was also some indication that habituation to these types of disturbances was occurring.

LeBlanc, et al. (1991), studied the effects of F-14 jet aircraft noise on pregnant mares. They specifically focused on any changes in pregnancy success, behavior, cardiac function, hormonal production, and rate of habituation. Their findings reported observations of “flight-fright” reactions, which caused increases in heart rates and serum cortisol concentrations. The mares, however, did habituate to the noise. Levels of anxiety and mass body movements were the highest after initial exposure, with intensities of responses decreasing thereafter. There were no differences in pregnancy success when compared to a control group.

Swine

Generally, the literature findings for swine appear to be similar to those reported for cows and horses. While there are some effects from aircraft noise reported in the literature, these effects are minor. Studies of continuous noise exposure (i.e., 6 hours, 72 hours of constant exposure) reported influences on short-term hormonal production and release. Additional constant exposure studies indicated the observation of stress reactions, hypertension, and electrolyte imbalances (Dufour 1980). A study by Bond, et al. (1963), demonstrated no adverse effects on the feeding efficiency, weight gain, ear physiology, or thyroid and adrenal gland condition of pigs subjected to observed aircraft noise. Observations of heart rate increase were recorded, noting that cessation of the noise resulted in the return to normal heart rates. Conception rates and offspring survivorship did not appear to be influenced by exposure to aircraft noise.

Similarly, simulated aircraft noise at levels of 100 dB to 135 dB had only minor effects on the rate of feed utilization, weight gain, food intake, or reproduction rates of boars and sows exposed, and there were no injuries or inner ear changes observed (Manci, et al. 1988; Gladwin, et al. 1988).

Domestic Fowl

According to a 1994 position paper by the U.S. Air Force on effects of low-altitude overflights (below 1,000 ft) on domestic fowl, overflight activity has negligible effects (U.S. Air Force 1994a). The paper did recognize that given certain circumstances, adverse effects can be serious. Some of the effects can be panic reactions, reduced productivity, and effects on marketability (e.g., bruising of the meat caused during “pile-up” situations).

The typical reaction of domestic fowl after exposure to sudden, intense noise is a short-term startle response. The reaction ceases as soon as the stimulus is ended, and within a few minutes all activity returns to normal. More severe responses are possible depending on the number of birds, the frequency of exposure, and environmental conditions. Large crowds of birds, and birds not previously exposed, are more likely to pile up in response to a noise stimulus (U.S. Air Force 1994a). According to studies and interviews with growers, it is typically the previously unexposed birds that incite panic crowding, and the tendency to do so is markedly reduced within five exposures to the stimulus (U.S. Air Force 1994a). This suggests that the birds habituate relatively quickly. Egg productivity was not adversely affected by infrequent noise bursts, even at exposure levels as high as 120 to 130 dBA.

Between 1956 and 1988, there were 100 recorded claims against the Navy for alleged damage to domestic fowl. The number of claims averaged three per year, with peak numbers of claims following publications of studies on the topic in the early 1960s (U.S. Air Force 1994a). Many of the claims were disproved or did not have sufficient supporting evidence. The claims were filed for the following alleged damages: 55% for panic reactions, 31% for decreased production, 6% for reduced hatchability, 6% for weight loss, and less than 1% for reduced fertility (U.S. Air Force 1994a).

Turkeys

The review of the existing literature suggests that there has not been a concerted or widespread effort to study the effects of aircraft noise on commercial turkeys. One study involving turkeys examined the differences between simulated versus actual overflight aircraft noise, turkey responses to the noise, weight gain, and evidence of habituation (Bowles, et al. 1990a). Findings from the study suggested that turkeys habituated to jet aircraft noise quickly, that there were no growth rate differences between the experimental and control groups, and that there were some behavioral differences that increased the difficulty in handling individuals within the experimental group.

Low-altitude overflights were shown to cause turkey flocks that were kept inside turkey houses to occasionally pile up and experience high mortality rates due to the aircraft noise and a variety of disturbances unrelated to aircraft (U.S. Air Force 1994a).

3.8.2 Wildlife

Studies on the effects of overflights and sonic booms on wildlife have been focused mostly on avian species and ungulates such as caribou and bighorn sheep. Few studies have been conducted on marine mammals, small terrestrial mammals, reptiles, amphibians, and carnivorous mammals. Generally, species that live entirely below the surface of the water have also been ignored due to the fact they do not experience the same level of sound as terrestrial species (National Park Service 1994). Wild ungulates appear to be much more sensitive to noise disturbance than domestic livestock (Manci, et al. 1988). This may be due to previous exposure to disturbances. One common factor appears to be that low-altitude flyovers seem to be more disruptive in terrain where there is little cover (Manci, et al. 1988).

3.8.2.1 MAMMALS

Terrestrial Mammals

Studies of terrestrial mammals have shown that noise levels of 120 dBA can damage mammals' ears, and levels at 95 dBA can cause temporary loss of hearing acuity. Noise from aircraft has affected other large carnivores by causing changes in home ranges, foraging patterns, and breeding behavior. One study recommended that aircraft not be allowed to fly at altitudes below 2,000 feet above ground level over important grizzly and polar bear habitat (Dufour 1980). Wolves have been frightened by low-altitude flights that were 25 to 1,000 feet off the ground. However, wolves have been found to adapt to aircraft overflights and noise as long as they were not being hunted from aircraft (Dufour 1980).

Wild ungulates (American bison, caribou, bighorn sheep) appear to be much more sensitive to noise disturbance than domestic livestock (Weisenberger, et al. 1996). Behavioral reactions may be related to the past history of disturbances by such things as humans and aircraft. Common reactions of reindeer kept in an enclosure exposed to aircraft noise disturbance were a slight startle response, raising of the head, pricking ears, and scenting of the air. Panic reactions and extensive changes in behavior of individual animals were not observed. Observations of caribou in Alaska exposed to fixed-wing aircraft and helicopters showed running and panic reactions occurred when overflights were at an altitude of 200 feet or less. The reactions decreased with increased altitude of overflights, and, with more than 500 feet in altitude, the panic reactions stopped. Also, smaller groups reacted less strongly than larger groups. One negative effect of the running and avoidance behavior is increased expenditure of energy. For a 90-kg animal, the calculated expenditure due to aircraft harassment is 64 kilocalories per minute when running and 20 kilocalories per minute when walking. When conditions are favorable, this expenditure can be counteracted with increased feeding; however, during harsh winter conditions, this may not be possible. Incidental observations of wolves and bears exposed to fixed-wing aircraft and helicopters in the northern regions suggested that wolves are less disturbed than wild ungulates, while grizzly bears showed the greatest response of any animal species observed.

It has been proven that low-altitude overflights do induce stress in animals. Increased heart rates, an indicator of excitement or stress, have been found in pronghorn antelope, elk, and bighorn sheep. As such reactions occur naturally as a response to predation, infrequent overflights may not, in and of themselves, be detrimental. However, flights at high frequencies over a long period of time may cause harmful effects. The consequences of this disturbance, while cumulative, is not additive. It may be that aircraft disturbance may not cause obvious and serious health effects, but coupled with a harsh winter, it may have an adverse impact. Research has shown that stress induced by other types of disturbances produces long-term decreases in metabolism and hormone balances in wild ungulates.

Behavioral responses can range from mild to severe. Mild responses include head raising, body shifting, or turning to orient toward the aircraft. Moderate disturbance may be nervous behaviors, such as trotting a short distance. Escape is the typical severe response.

Marine Mammals

The physiological composition of the ear in aquatic and marine mammals exhibits adaptation to the aqueous environment. These differences (relative to terrestrial species) manifest themselves in the auricle and middle ear (Manci, et al. 1988). Some mammals use echolocation to perceive objects in their surroundings and to determine the directions and locations of sound sources (Simmons 1983 in Manci, et al. 1988).

In 1980, the Acoustical Society of America held a workshop to assess the potential hazard of manmade noise associated with proposed Alaska Arctic (North Slope-Outer Continental Shelf) petroleum operations on marine wildlife and to prepare a research plan to secure the knowledge necessary for proper assessment of noise impacts (Acoustical Society of America, 1980). Since 1980 it appears that research on responses of aquatic mammals to aircraft noise and sonic booms has been limited. Research conducted on northern fur seals, sea lions, and ringed seals indicated that there are some differences in how various animal groups receive frequencies of sound. It was observed that these species exhibited varying intensities of a startle response to airborne noise, which was habituated over time. The rates of habituation appeared to vary with species, populations, and demographics (age, sex). Time of day of exposure was also a factor (Muyberg 1978 in Manci, et al. 1988).

Studies accomplished near the Channel Islands were conducted near the area where the space shuttle launches occur. It was found that there were some response differences between species relative to the loudness of sonic booms. Those booms that were between 80 and 89 dBA caused a greater intensity of startle reactions than lower-intensity booms at 72 to 79 dBA. However, the duration of the startle responses to louder sonic booms was shorter (Jehl and Cooper 1980 in Mancini, et al. 1988).

Jehl and Cooper (1980) indicated that low-flying helicopters, loud boat noises, and humans were the most disturbing to pinnipeds. According to the research, while the space launch and associated operational activity noises have not had a measurable effect on the pinniped population, it also suggests that there was a greater “disturbance level” exhibited during launch activities. There was a recommendation to continue observations for behavioral effects and to perform long-term population monitoring (Jehl and Cooper 1980).

The continued presence of single or multiple noise sources could cause marine mammals to leave a preferred habitat. However, it does not appear likely that overflights could cause migration from suitable habitats as aircraft noise over water is mobile and would not persist over any particular area. Aircraft noise, including supersonic noise, currently occurs in the overwater airspace of Eglin, Tyndall, and Langley AFBs from sorties predominantly involving jet aircraft. Survey results reported in Davis, et al. (2000), indicate that cetaceans (i.e., dolphins) occur under all of the Eglin and Tyndall marine airspace. The continuing presence of dolphins indicates that aircraft noise does not discourage use of the area and apparently does not harm the locally occurring population.

In a summary by the National Parks Service (1994) on the effects of noise on marine mammals, it was determined that gray whales and harbor porpoises showed no outward behavioral response to aircraft noise or overflights. Bottlenose dolphins showed no obvious reaction in a study involving helicopter overflights at 1,200 to 1,800 feet above the water. Neither did they show any reaction to survey aircraft unless the shadow of the aircraft passed over them, at which point there was some observed tendency to dive (Richardson, et al. 1995). Other anthropogenic noises in the marine environment from ships and pleasure craft may have more of an effect on marine mammals than aircraft noise (U.S. Air Force 2000). The noise effects on cetaceans appear to be somewhat attenuated by the air/water interface. The cetacean fauna along the coast of California have been subjected to sonic booms from military aircraft for many years without apparent adverse effects (Tetra Tech, Inc. 1997).

Manatees appear relatively unresponsive to human-generated noise to the point that they are often suspected of being deaf to oncoming boats [although their hearing is actually similar to that of pinnipeds (Bullock, et al. 1980)]. Little is known about the importance of acoustic communication to manatees, although they are known to produce at least ten different types of sounds and are thought to have sensitive hearing (Richardson, et al. 1995). Manatees continue to occupy canals near Miami International Airport, which suggests that they have become habituated to human disturbance and noise (Metro-Dade County 1995). Since manatees spend most of their time below the surface and do not startle readily, no effect of aircraft overflights on manatees would be expected (Bowles, et al. 1991b).

3.8.2.2 BIRDS

Auditory research conducted on birds indicates that they fall between the reptiles and the mammals relative to hearing sensitivity. According to Dooling (1978), within the range of one to five kHz, birds show a level of hearing sensitivity similar to that of the more sensitive mammals. In contrast to mammals, bird sensitivity falls off at a greater rate to increasing and decreasing frequencies. Passive observations and studies examining aircraft bird strikes indicate that birds nest and forage near airports. Aircraft noise in the vicinity of commercial airports apparently does not inhibit bird presence and use.

High-noise events (like a low-altitude aircraft overflight) may cause birds to engage in escape or avoidance behaviors, such as flushing from perches or nests (Ellis, et al. 1991). These activities impose an energy cost on the birds that, over the long term, may affect survival or growth. In addition, the birds may spend less time engaged in necessary activities like feeding, preening, or caring for their young because they spend time in noise-avoidance activity. However, the long-term significance of noise-related impacts is less clear. Several studies on nesting raptors have indicated that birds become habituated to aircraft overflights and that long-term reproductive success is not affected (Grubb and King 1991; Ellis, et al. 1991). Threshold noise levels for significant responses range from 62 dB for Pacific black brant (*Branta bernicla nigricans*) (Ward and Stehn 1990) to 85 dB for crested tern (*Sterna bergii*) (Brown 1990).

Songbirds were observed to become silent prior to the onset of a sonic boom event (F-111 jets), followed by “raucous discordant cries.” There was a return to normal singing within 10 seconds after the boom (Higgins 1974 in Mancini, et al. 1988). Ravens responded by emitting protestation calls, flapping their wings, and soaring.

Mancini, et al. (1988), reported a reduction in reproductive success in some small territorial passerines (i.e., perching birds or songbirds) after exposure to low-altitude overflights. However, it has been observed that passerines are not driven any great distance from a favored food source by a nonspecific disturbance, such as aircraft overflights (U.S. Forest Service 1992). Further study may be warranted.

A recent study, conducted cooperatively between the DoD and the USFWS, assessed the response of the red-cockaded woodpecker to a range of military training noise events, including artillery, small arms, helicopter, and maneuver noise (Pater, et al. 1999). The project findings show that the red-cockaded woodpecker successfully acclimates to military noise events. Depending on the noise level that ranged from innocuous to very loud, the birds responded by flushing from their nest cavities. When the noise source was closer and the noise level was higher, the number of flushes increased proportionately. In all cases, however, the birds returned to their nests within a relatively short period of time (usually within 12 minutes). Additionally, the noise exposure did not result in any mortality or statistically detectable changes in reproductive success (Pater, et al. 1999). Red-cockaded woodpeckers did not flush when artillery simulators were more than 122 meters away and SEL noise levels were 70 dBA.

Lynch and Speake (1978) studied the effects of both real and simulated sonic booms on the nesting and brooding eastern wild turkey (*Meleagris gallopavo silvestris*) in Alabama. Hens at four nest sites were subjected to between 8 and 11 combined real and simulated sonic booms. All tests elicited similar responses, including quick lifting of the head and apparent alertness for between 10 and 20 seconds. No apparent nest failure occurred as a result of the sonic booms.

Twenty-one brood groups were also subjected to simulated sonic booms. Reactions varied slightly between groups, but the largest percentage of groups reacted by standing motionless after the initial blast. Upon the sound of the boom, the hens and poults fled until reaching the edge of the woods (approximately 4 to 8 meters). Afterward, the poults resumed feeding activities while the hens remained alert for a short period of time (approximately 15 to 20 seconds). In no instances were poults abandoned, nor did they scatter and become lost. Every observation group returned to normal activities within a maximum of 30 seconds after a blast.

3.8.2.2.1 RAPTORS

In a literature review of raptor responses to aircraft noise, Mancini, et al. (1988), found that most raptors did not show a negative response to overflights. When negative responses were observed they were predominantly associated with rotor-winged aircraft or jet aircraft that were repeatedly passing within 0.5 mile of a nest.

Ellis, et al. (1991), performed a study to estimate the effects of low-level military jet aircraft and mid- to high-altitude sonic booms (both actual and simulated) on nesting peregrine falcons and seven other raptors (common black-hawk, Harris’ hawk, zone-tailed hawk, red-tailed hawk, golden eagle, prairie falcon, bald eagle). They observed responses to test stimuli, determined nest success for the year of the testing, and evaluated site occupancy the following year. Both long- and short-term effects were noted in the study. The results reported the successful fledging of young in 34 of 38 nest sites (all eight species) subjected to low-level flight and/or simulated sonic booms. Twenty-two of the test sites were revisited in the following year, and observations of pairs or lone birds were made at all but one nest.

Nesting attempts were underway at 19 of 20 sites that were observed long enough to be certain of breeding activity. Reoccupancy and productivity rates were within or above expected values for self-sustaining populations.

Short-term behavior responses were also noted. Overflights at a distance of 150 m or less produced few significant responses and no severe responses. Typical responses consisted of crouching or, very rarely, flushing from the perch site. Significant responses were most evident before egg laying and after young were “well grown.” Incubating or brooding adults never burst from the nest, thus preventing egg breaking or knocking chicks out of the nest. Jet passes and sonic booms often caused noticeable alarm; however, significant negative responses were rare and did not appear to limit productivity or reoccupancy. Due to the locations of some of the nests, some birds may have been habituated to aircraft noise. There were some test sites located at distances far from zones of frequent military aircraft usage, and the test stimuli were often closer, louder, and more frequent than would be likely for a normal training situation.

Manci, et al. (1988), noted that a female northern harrier was observed hunting on a bombing range in Mississippi during bombing exercises. The harrier was apparently unfazed by the exercises, even when a bomb exploded within 200 feet. In a similar case of habituation/non-disturbance, a study on the Florida snail-kite stated the greatest reaction to overflights (approximately 98 dBA) was “watching the aircraft fly by.” No detrimental impacts to distribution, breeding success, or behavior were noted.

Bald Eagle

A study by Grubb and King (1991) on the reactions of the bald eagle to human disturbances showed that terrestrial disturbances elicited the greatest response, followed by aquatic (i.e., boats) and aerial disturbances. The disturbance regime of the area where the study occurred was predominantly characterized by aircraft noise. The study found that pedestrians consistently caused responses that were greater in both frequency and duration. Helicopters elicited the highest level of aircraft-related responses. Aircraft disturbances, although the most common form of disturbance, resulted in the lowest levels of response. This low response level may have been due to habituation; however, flights less than 170 meters away caused reactions similar to other disturbance types. Ellis, et al. (1991), showed that eagles typically respond to the proximity of a disturbance, such as a pedestrian or aircraft within 100 meters, rather than the noise level. Fleischner and Weisberg (1986) stated that reactions of bald eagles to commercial jet flights, although minor (e.g., looking), were twice as likely to occur when the jets passed at a distance of 0.5 mile or less. They also noted that helicopters were four times more likely to cause a reaction than a commercial jet and 20 times more likely to cause a reaction than a propeller plane.

The USFWS advised Cannon AFB that flights at or below 2,000 feet AGL from October 1 through March 1 could result in adverse impacts to wintering bald eagles (U.S. Fish and Wildlife Service 1998). However, Fraser, et al. (1985), suggested that raptors habituate to overflights rapidly, sometimes tolerating aircraft approaches of 65 feet or less.

Osprey

A study by Trimper, et al. (1998), in Goose Bay, Labrador, Canada, focused on the reactions of nesting osprey to military overflights by CF-18 Hornets. Reactions varied from increased alertness and focused observation of planes to adjustments in incubation posture. No overt reactions (e.g., startle response, rapid nest departure) were observed as a result of an overflight. Young nestlings crouched as a result of any disturbance until they grew to 1 to 2 weeks prior to fledging. Helicopters, human presence, float planes, and other ospreys elicited the strongest reactions from nesting ospreys. These responses included flushing, agitation, and aggressive displays. Adult osprey showed high nest occupancy rates during incubation regardless of external influences.

The osprey observed occasionally stared in the direction of the flight before it was audible to the observers. The birds may have been habituated to the noise of the flights; however, overflights were strictly controlled during the experimental period. Strong reactions to float planes and helicopter may have been due to the slower flight and therefore longer duration of visual stimuli rather than noise-related stimuli.

Red-tailed Hawk

Anderson, et al. (1989), conducted a study that investigated the effects of low-level helicopter overflights on 35 red-tailed hawk nests. Some of the nests had not been flown over prior to the study. The hawks that were naïve (i.e., not previously exposed) to helicopter flights exhibited stronger avoidance behavior (nine of 17 birds flushed from their nests) than those that had experienced prior overflights. The overflights did not appear to affect nesting success in either study group. These findings were consistent with the belief that red-tailed hawks habituate to low-level air traffic, even during the nesting period.

3.8.2.2.2 MIGRATORY WATERFOWL

A study of caged American black ducks was conducted by Fleming, et al. in 1996. It was determined that noise had negligible energetic and physiologic effects on adult waterfowl. Measurements included body weight, behavior, heart rate, and enzymatic activity. Experiments also showed that adult ducks exposed to high noise events acclimated rapidly and showed no effects.

The study also investigated the reproductive success of captive ducks, which indicated that duckling growth and survival rates at Piney Island, North Carolina, were lower than those at a background location. In contrast, observations of several other reproductive indices (i.e., pair formation, nesting, egg production, and hatching success) showed no difference between Piney Island and the background location. Potential effects on wild duck populations may vary, as wild ducks at Piney Island have presumably acclimated to aircraft overflights. It was not demonstrated that noise was the cause of adverse impacts. A variety of other factors, such as weather conditions, drinking water and food availability and variability, disease, and natural variability in reproduction, could explain the observed effects. Fleming noted that drinking water conditions (particularly at Piney Island) deteriorated during the study, which could have affected the growth of young ducks. Further research would be necessary to determine the cause of any reproductive effects.

Another study by Conomy, et al. (1998) exposed previously unexposed ducks to 71 noise events per day that equaled or exceeded 80 dBA. It was determined that the proportion of time black ducks reacted to aircraft activity and noise decreased from 38 percent to 6 percent in 17 days and remained stable at 5.8 percent thereafter. In the same study, the wood duck did not appear to habituate to aircraft disturbance. This supports the notion that animal response to aircraft noise is species-specific. Because a startle response to aircraft noise can result in flushing from nests, migrants and animals living in areas with high concentrations of predators would be the most vulnerable to experiencing effects of lowered birth rates and recruitment over time. Species that are subjected to infrequent overflights do not appear to habituate to overflight disturbance as readily.

Black brant studied in the Alaska Peninsula were exposed to jets and propeller aircraft, helicopters, gunshots, people, boats, and various raptors. Jets accounted for 65% of all the disturbances. Humans, eagles, and boats caused a greater percentage of brant to take flight. There was markedly greater reaction to Bell-206-B helicopter flights than fixed wing, single-engine aircraft (Ward, et al. 1986).

The presence of humans and low-flying helicopters in the Mackenzie Valley North Slope area did not appear to affect the population density of Lapland longspurs, but the experimental group was shown to have reduced hatching and fledging success and higher nest abandonment. Human presence appeared to have a greater impact on the incubating behavior of the black brant, common eider, and Arctic tern than fixed-wing aircraft (Gunn and Livingston 1974).

Gunn and Livingston (1974) found that waterfowl and seabirds in the Mackenzie Valley and North Slope of Alaska and Canada became acclimated to float plane disturbance over the course of three days. Additionally, it was observed that potential predators (bald eagle) caused a number of birds to leave their nests. Non-breeding birds were observed to be more reactive than breeding birds. Waterfowl were affected by helicopter flights, while snow geese were disturbed by Cessna 185 flights. The geese flushed when the planes were under 1,000 feet, compared to higher flight elevations. An overall reduction in flock sizes was observed. It was recommended that aircraft flights be reduced in the vicinity of premigratory staging areas.

Manci, et al. 1988 reported that waterfowl were particularly disturbed by aircraft noise. The most sensitive appeared to be snow geese. Canada geese and snow geese were thought to be more sensitive than other animals such as turkey vultures, coyotes, and raptors (Edwards, et al. 1979).

3.8.2.2.3 WADING AND SHORE BIRDS

Black, et al. (1984), studied the effects of low-altitude (less than 500 feet AGL) military training flights with sound levels from 55 to 100 dBA on wading bird colonies (i.e., great egret, snowy egret, tricolored heron, and little blue heron). The training flights involved three or four aircraft, which occurred once or twice per day. This study concluded that the reproductive activity—including nest success, nestling survival, and nestling chronology—was independent of F-16 overflights. Dependent variables were more strongly related to ecological factors, including location and physical characteristics of the colony and climatology. Another study on the effects of circling fixed-wing aircraft and helicopter overflights on wading bird colonies found that at altitudes of 195 to 390 feet, there was no reaction in nearly 75 percent of the 220 observations. Ninety percent displayed no reaction or merely looked toward the direction of the noise source. Another 6 percent stood up, 3 percent walked from the nest, and 2 percent flushed (but were without active nests) and returned within 5 minutes (Kushlan 1978). Apparently, non-nesting wading birds had a slightly higher incidence of reacting to overflights than nesting birds. Seagulls observed roosting near a colony of wading birds in another study remained at their roosts when subsonic aircraft flew overhead (Burger 1981). Colony distribution appeared to be most directly correlated to available wetland community types and was found to be distributed randomly with respect to military training routes. These results suggest that wading bird species presence was most closely linked to habitat availability and that they were not affected by low-level military overflights (U.S. Air Force 2000).

Burger (1986) studied the response of migrating shorebirds to human disturbance and found that shorebirds did not fly in response to aircraft overflights, but did flush in response to more localized intrusions (i.e., humans and dogs on the beach). Burger (1981) studied the effects of noise from JFK Airport in New York on herring gulls that nested less than 1 kilometer from the airport. Noise levels over the nesting colony were 85 to 100 dBA on approach and 94 to 105 dBA on takeoff. Generally, there did not appear to be any prominent adverse effects of subsonic aircraft on nesting, although some birds flushed when the Concorde flew overhead and, when they returned, engaged in aggressive behavior. Groups of gulls tended to loaf in the area of the nesting colony, and these birds remained at the roost when the Concorde flew overhead. Up to 208 of the loafing gulls flew when supersonic aircraft flew overhead. These birds would circle around and immediately land in the loafing flock (U.S. Air Force 2000).

In 1970, sonic booms were potentially linked to a mass hatch failure of Sooty Terns on the Dry Tortugas (Austin, et al. 1970). The cause of the failure was not certain, but it was conjectured that sonic booms from military aircraft or an overgrowth of vegetation were factors. In the previous season, Sooties were observed to react to sonic booms by rising in a “panic flight,” circling over the island, then usually settling down on their eggs again. Hatching that year was normal. Following the 1969 hatch failure, excess vegetation was cleared and measures were taken to reduce supersonic activity. The 1970 hatch appeared to proceed normally. A colony of Noddies on the same island hatched successfully in 1969, the year of the Sooty hatch failure.

Subsequent laboratory tests of exposure of eggs to sonic booms and other impulsive noises (Bowles, et al. 1991a; Bowles, et al. 1994; Cottreau 1972; Cogger and Zegarra 1980) failed to show adverse effects on hatching of eggs. A structural analysis (Ting, et al. 2002) showed that, even under extraordinary circumstances, sonic booms would not damage an avian egg.

Burger (1981) observed no effects of subsonic aircraft on herring gulls in the vicinity of JFK International Airport. The Concorde aircraft did cause more nesting gulls to leave their nests (especially in areas of higher density of nests), causing the breakage of eggs and the scavenging of eggs by intruder prey. Clutch sizes were observed to be smaller in areas of higher-density nesting (presumably due to the greater tendency for panic flight) than in areas where there were fewer nests.

3.8.3 Fish, Reptiles, and Amphibians

The effects of overflight noise on fish, reptiles, and amphibians have been poorly studied, but conclusions regarding their expected responses have involved speculation based upon known physiologies and behavioral traits of these taxa (Gladwin, et al. 1988). Although fish do startle in response to low-flying aircraft noise, and probably to the shadows of aircraft, they have been found to habituate to the sound and overflights. Reptiles and amphibians that respond to low frequencies and those that respond to ground vibration, such as spadefoots (genus *Scaphiopus*), may be affected by noise. Limited information is available on the effects of short-duration noise events on reptiles. Dufour (1980) and Mancini, et al. (1988), summarized a few studies of reptile responses to noise. Some reptile species tested under laboratory conditions experienced at least temporary threshold shifts or hearing loss after exposure to 95 dB for several minutes. Crocodylians in general have the most highly developed hearing of all reptiles. Crocodile ears have lids that can be closed when the animal goes under water. These lids can reduce the noise intensity by 10 to 12 dB (Wever and Vernon 1957). On Homestead Air Reserve Station, Florida, two crocodylians (the American Alligator and the Spectacled Caiman) reside in wetlands and canals along the base runway suggesting that they can coexist with existing noise levels of an active runway including DNLs of 85 dB.

3.8.4 Summary

Some physiological/behavioral responses such as increased hormonal production, increased heart rate, and reduction in milk production have been described in a small percentage of studies. A majority of the studies focusing on these types of effects have reported short-term or no effects.

The relationships between physiological effects and how species interact with their environments have not been thoroughly studied. Therefore, the larger ecological context issues regarding physiological effects of jet aircraft noise (if any) and resulting behavioral pattern changes are not well understood.

Animal species exhibit a wide variety of responses to noise. It is therefore difficult to generalize animal responses to noise disturbances or to draw inferences across species, as reactions to jet aircraft noise appear to be species-specific. Consequently, some animal species may be more sensitive than other species and/or may exhibit different forms or intensities of behavioral responses. For instance, wood ducks appear to be more sensitive and more resistant to acclimation to jet aircraft noise than Canada geese in one study. Similarly, wild ungulates seem to be more easily disturbed than domestic animals.

The literature does suggest that common responses include the “startle” or “fright” response and, ultimately, habituation. It has been reported that the intensities and durations of the startle response decrease with the numbers and frequencies of exposures, suggesting no long-term adverse effects. The majority of the literature suggests that domestic animal species (cows, horses, chickens) and wildlife species exhibit adaptation, acclimation, and habituation after repeated exposure to jet aircraft noise and sonic booms.

Animal responses to aircraft noise appear to be somewhat dependent on, or influenced by, the size, shape, speed, proximity (vertical and horizontal), engine noise, color, and flight profile of planes. Helicopters also appear to induce greater intensities and durations of disturbance behavior as compared to fixed-wing aircraft. Some studies showed that animals that had been previously exposed to jet aircraft noise exhibited greater degrees of alarm and disturbance to other objects creating noise, such as boats, people, and objects blowing across the landscape. Other factors influencing response to jet aircraft noise may include wind direction, speed, and local air turbulence; landscape structures (i.e., amount and type of vegetative cover); and, in the case of bird species, whether the animals are in the incubation/nesting phase.

3.9 Property Values

Property within a noise zone (or Accident Potential Zone) may be affected by the availability of federally guaranteed loans. According to U.S. Department of Housing and Urban Development (HUD), Federal Housing Administration (FHA), and Veterans Administration (VA) guidance, sites are acceptable for program assistance, subsidy, or insurance for housing in noise zones of less than 65 dB DNL, and sites are conditionally acceptable with special approvals and noise attenuation in the 65 to 75 dB DNL noise zone and the greater than 75 dB DNL noise zone. HUD's position is that noise is not the only determining factor for site acceptability, and properties should not be rejected only because of airport influences if there is evidence of acceptability within the market and if use of the dwelling is expected to continue. Similar to the Navy's and Air Force's Air Installation Compatible Use Zone Program, HUD, FHA, and VA recommend sound attenuation for housing in the higher noise zones and written disclosures to all prospective buyers or lessees of property within a noise zone (or Accident Potential Zone).

Newman and Beattie (1985) reviewed the literature to assess the effect of aircraft noise on property values. One paper by Nelson (1978), reviewed by Newman and Beattie, suggested a 1.8 to 2.3 percent decrease in property value per decibel at three separate airports, while at another period of time, they found only a 0.8 percent devaluation per decibel change in DNL. However, Nelson also noted a decline in noise depreciation over time which he theorized could be due to either noise sensitive people being replaced by less sensitive people or the increase in commercial value of the property near airports; both ideas were supported by Crowley (1978). Ultimately, Newman and Beattie summarized that while an effect of noise was observed, noise is only one of the many factors that is part of a decision to move close to, or away from, an airport, but which is sometimes considered an advantage due to increased opportunities for employment or ready access to the airport itself. With all the issues associated with determining property values, their reviews found that decreases in property values usually range from 0.5 to 2 percent per decibel increase of cumulative noise exposure.

More recently Fidell, et al. (1996) studied the influences of aircraft noise on actual sale prices of residential properties in the vicinity of two military facilities and found that equations developed for one area to predict residential sale prices in areas unaffected by aircraft noise worked equally well when applied to predicting sale prices of homes in areas with aircraft noise in excess of 65 dB DNL. Thus, the model worked equally well in predicting sale prices in areas with and without aircraft noise exposure. This indicates that aircraft noise had no meaningful effect on residential property values. In some cases, the average sale prices of noise exposed properties were somewhat higher than those elsewhere in the same area. In the vicinity of Davis-Monthan AFB in Tucson, AZ, Fidell found the homes near the AFB were much older, smaller and in poorer condition than homes elsewhere. These factors caused the equations developed for predicting sale prices in areas further away from the base to be inapplicable with those nearer the AFB. However, again Fidell found that, similar to other researchers, differences in sale prices between homes with and without aircraft noise were frequently due to factors other than noise itself.

3.10 Noise Effects on Terrain

It has been suggested that noise levels associated with low-flying aircraft may affect the terrain under the flight path by disturbing fragile soil or snow, especially in mountainous areas, causing landslides or avalanches. There are no known instances of such effects, and it is considered improbable that such effects would result from routine, subsonic aircraft operations.

3.11 Noise Effects on Historical and Archaeological Sites

Because of the potential for increased fragility of structural components of historical buildings and other historical sites, aircraft noise may affect such sites more severely than newer, modern structures. Particularly in older structures, seemingly insignificant surface cracks initiated by vibrations from aircraft noise may lead to greater damage from natural forces (Hanson, et al. 1991). There are few scientific studies of such effects to provide guidance for their assessment.

One study involved the measurements of sound levels and structural vibration levels in a superbly restored plantation house, originally built in 1795, and now situated approximately 1,500 feet from the centerline at the departure end of Runway 19L at Washington Dulles International Airport. These measurements were made in connection with the proposed scheduled operation of the Concorde airplane at Dulles (Wesler 1977). There was special concern for the building's windows, since roughly half of the 324 panes were original. No instances of structural damage were found. Interestingly, despite the high levels of noise during Concorde takeoffs, the induced structural vibration levels were actually less than those induced by touring groups and vacuum cleaning.

As noted above for the noise effects of noise-induced vibrations of conventional structures, assessments of noise exposure levels for normally compatible land uses should also be protective of historic and archaeological sites.

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APPENDIX B

MCAS BEAUFORT

LAND USE COMPATIBILITY RECOMMENDATIONS

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Land Use Compatibility Recommendations								
Land Use		Accident Potential Areas ¹			Noise Levels			
SLUCM No.	Name	Clear Zone	APZ I	APZ II	65 to 70 DNL	70 to 75 DNL	75 to 80 DNL	80 to 85 DNL
10	Residential							
11	Household units	NA	NA	NA	N ²⁶	N ²⁶	N	N
11.11	Single units; detached	N	N	Y ²	N ²⁶	N ²⁶	N	N
11.12	Single units; semidetached	N	N	N	N ²⁶	N ²⁶	N	N
11.13	Single units; attached row	N	N	N	N ²⁶	N ²⁶	N	N
11.21	Two units; side-by-side	N	N	N	N ²⁶	N ²⁶	N	N
11.22	Two units; one above the other	N	N	N	N ²⁶	N ²⁶	N	N
11.31	Apartments; walk up	N	N	N	N ²⁶	N ²⁶	N	N
11.32	Apartments; elevator	N	N	N	N ²⁶	N ²⁶	N	N
12	Group quarters	N	N	N	N ²⁶	N ²⁶	N	N
13	Residential hotels	N	N	N	N ²⁶	N ²⁶	N	N
14	Mobile home parks or courts	N	N	N	N	N	N	N
15	Transient lodgings	N	N	N	N ²⁶	N ²⁶	N ²⁶	N
16	Other residential	N	N	N	N ²⁶	N ²⁶	N	N
20	Manufacturing ³							
21	Food and kindred products; manufacturing	N	N	Y ⁴	Y	Y ²⁷	Y ²²	Y ²⁹
22	Textile mill products; manufacturing	N	N	Y ⁴	Y	Y ²⁷	Y ²⁸	Y ²⁹
23	Apparel and other finished products made from fabrics, leather, and similar materials; manufacturing	N	N	N	Y	Y ²⁷	Y ²⁸	Y ²⁹
24	Lumber and wood products (except furniture); manufacturing	N	Y ⁵	Y ⁵	Y	Y ²⁷	Y ²⁸	Y ²⁹
25	Furniture and fixtures; manufacturing	N	Y ⁵	Y ⁵	Y	Y ²⁷	Y ²⁸	Y ²⁹
26	Paper and allied products; manufacturing	N	Y ⁵	Y ⁵	Y	Y ²⁷	Y ²⁸	Y ²⁹
27	Printing, publishing, and allied industries	N	Y ⁵	Y ⁵	Y	Y ²⁷	Y ²⁸	Y ²⁹
28	Chemicals and allied products; manufacturing	N	N	N	Y	Y ²⁷	Y ²⁸	Y ²⁹

Land Use Compatibility Recommendations								
Land Use		Accident Potential Areas ¹			Noise Levels			
SLUCM No.	Name	Clear Zone	APZ I	APZ II	65 to 70 DNL	70 to 75 DNL	75 to 80 DNL	80 to 85 DNL
29	Petroleum refining and related industries	N	N	N	Y	Y ²⁷	Y ²⁸	Y ²⁹
30	Manufacturing (cont'd) ³							Y ²⁹
31	Rubber and misc. plastic products; manufacturing	N	N	N	Y	Y ²⁷	Y ²⁸	Y ²⁹
32	Stone, clay, and glass products; manufacturing	N	N	Y ⁵	Y	Y ²⁷	Y ²⁸	Y ²⁹
33	Primary metal products; manufacturing	N	N	Y ⁵	Y	Y ²⁷	Y ²⁸	Y ²⁹
34	Fabricated metal products; manufacturing	N	N	Y ⁵	Y	Y ²⁷	Y ²⁸	Y ²⁹
35	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks; manufacturing	N	N	N	Y	25	30	N
39	Miscellaneous manufacturing	N	Y ⁶	Y ⁶	Y	Y ²⁷	Y ²⁸	Y ²⁹
40	Transportation, communication and utilities ^{3,6}					Y ²⁷		
41	Railroad, rapid rail transit, and street railway transportation	N	Y ^{3,7}	Y ³	Y	Y ²⁷	Y ²⁸	Y ²⁹
42	Motor vehicle transportation	N	Y ^{3,7}	Y ³	Y	Y ²⁷	Y ²⁸	Y ²⁹
43	Aircraft transportation	N	Y ^{3,7}	Y ³	Y	Y ²⁷	Y ²⁸	Y ²⁹
44	Marine craft transportation	N	Y ^{3,7}	Y ³	Y	Y ²⁷	Y ²⁸	Y ²⁹
45	Highway and street right-of-way	N	Y ^{3,7}	Y ³	Y	Y ²⁷	Y ²⁸	Y ²⁹
46	Automobile parking	N	Y ^{3,7}	Y ³	Y	Y ²⁷	Y ²⁸	Y ²⁹
47	Communication	N	Y ^{3,7}	Y ³	Y	25,30	30,30	N
48	Utilities	N	Y ^{3,7}	Y ³	Y	Y ²⁷	Y ²⁸	Y ²⁹
485	Solid waste disposal (landfills, incineration, etc.)	N	N	N	NA	NA	NA	NA
49	Other transportation, communication, and utilities	N	Y ^{3,7}	Y ³	Y	25,30	30,30	N
50	Trade							
51	Wholesale trade	N	Y ⁵	Y ⁵	Y	Y ²⁷	Y ²⁸	Y ²⁹
52	Retail trade – building materials, hardware, and farm equipment	N	Y ⁸	Y ⁸	Y	Y ²⁷	Y ²⁸	Y ²⁹

Land Use Compatibility Recommendations								
Land Use		Accident Potential Areas ¹			Noise Levels			
SLUCM No.	Name	Clear Zone	APZ I	APZ II	65 to 70 DNL	70 to 75 DNL	75 to 80 DNL	80 to 85 DNL
53	Retail trade – shopping centers	N	N ⁹	Y ⁹	Y	25	30	N
54	Retail trade – food	N	N	Y ¹⁰	Y	25	30	N
55	Retail trade – automotive, marine craft, aircraft, and accessories	N	Y ⁸	Y ⁸	Y	25	30	N
56	Retail trade – apparel and accessories	N	N	Y ¹¹	Y	25	30	N
57	Retail trade – furniture, home furnishings, and equipment	N	N	Y ¹¹	Y	25	30	N
58	Retail trade – eating and drinking establishments	N	N	N	Y	25	30	N
59	Other retail trade	N	N	Y ⁹	Y	25	30	N
60	Services ¹²							
61	Finance, insurance, and real estate services	N	N	Y ¹³	Y	25	30	N
62	Personal services	N	N	Y ¹⁴	Y	25	30	N
62.4	Cemeteries	N	Y ¹⁵	Y ¹⁵	Y	Y ²⁷	Y ²⁸	Y ^{29,24}
63	Business services	N	N	Y ¹⁶	Y	25	30	N
63.7	Warehousing and storage	N	Y ¹⁷	Y ¹⁷	Y	Y ²⁷	Y ²⁸	Y ²⁹
64	Repair services	N	Y ¹⁸	Y ¹⁸	Y	Y ²⁷	Y ²⁸	Y ²⁹
65	Professional services	N	N	Y ⁹	Y	25	30	N
65.1	Hospitals, other medical facilities	N	N	N	25	30	N	N
65.16	Nursing homes	N	N	N	N ²⁶	N ²⁶	N	N
66	Contract construction services	N	Y ¹⁸	Y ¹⁸	Y	25	30	N
67	Governmental services	N	N	Y ¹⁰	Y ²⁶	25	30	N
68	Educational services	N	N	N	25	30	N	N
69	Miscellaneous services	N	N	Y ⁹	Y	25	30	N
70	Cultural, entertainment and recreational							
71	Cultural activities (including churches)	N	N	N	25	30	N	N

MCAS Beaufort

Land Use Compatibility Recommendations								
Land Use		Accident Potential Areas ¹			Noise Levels			
SLUCM No.	Name	Clear Zone	APZ I	APZ II	65 to 70 DNL	70 to 75 DNL	75 to 80 DNL	80 to 85 DNL
71.2	Nature exhibits	N	Y ¹⁹	Y ¹⁹	Y ²⁶	N	N	N
72	Public assembly	N	N	N	Y	N	N	N
72.1	Auditoriums, concert halls	N	N	N	25	30	N	N
72.11	Outdoor music shells, amphitheaters	N	N	N	N	N	N	N
72.2	Outdoor sports arenas, spectator sports	N	N	N	Y ³¹	Y ³¹	N	N
73	Amusements (including fairgrounds, miniature golf, driving ranges, amusement parks)	N	N	Y	Y	Y	N	N
74	Recreational activities (including golf courses, riding stables, water recreation)	N	Y ^{18,19}	Y ^{18,19}	Y ²⁶	25	30	N
75	Resorts and group camps	N	N	N	Y ²⁶	Y ²⁶	N	N
76	Parks	N	Y ^{18,19}	Y ^{18,19}	Y ²⁶	Y ²⁶	N	N
79	Other cultural, entertainment and recreation	N	Y ^{18,19}	Y ^{18,19}	Y ²⁶	Y ²⁶	N	N
80	Resource production and extraction							
81	Agriculture (except livestock)	Y ⁶	Y ²⁰	Y ²⁰	Y ³²	Y ³³	Y ³⁴	Y ^{34,35}
81.5, 81.7	Livestock farming and animal breeding	N	Y ^{20,21}	Y ^{20,21}	Y ³²	Y ³³	N	N
82	Agricultural related activities	N	Y ^{20,22}	Y ^{20,22}	Y ³²	Y ³³	Y ³⁴	Y ^{34,35}
83	Forestry activities and related services ²³	N	Y ²²	Y ²²	Y ³²	Y ³³	Y ³⁴	Y ^{34,35}
84	Fishing activities and related services ²⁴	N ²⁴	Y ²²	Y ²²	Y	Y	Y	Y
85	Mining activities and related services	N	Y ²²	Y ²²	Y	Y	Y	Y
89	Other resource production and extraction	N	Y ²²	Y ²²	Y	Y	Y	Y
90	Other							
91	Undeveloped land	Y	Y	Y	NA	NA	NA	NA
93	Water areas	N ²⁵	N ²⁵	N ²⁵	NA	NA	NA	NA

Source: U.S. Department of the Navy 2008.

Land Use Compatibility Recommendations								
Land Use		Accident Potential Areas ¹			Noise Levels			
SLUCM No.	Name	Clear Zone	APZ I	APZ II	65 to 70 DNL	70 to 75 DNL	75 to 80 DNL	80 to 85 DNL
<p>Notes:</p> <ol style="list-style-type: none"> 1. A "Yes" or a "No" designation for compatible land use is to be used only for general comparison. Within each, uses exist where further evaluation may be needed in each category as to whether it is clearly compatible, normally compatible, or not compatible due to the variation of densities of people and structures. In order to assist installations and local governments, general suggestions as to floor/area ratios (FAR) are provided in OPNAVINST 11010.36C as a guide to density in some categories. In general, land use restrictions that limit commercial, services, or industrial buildings or structure occupants to 25 per acre in APZ I and 50 per acre in APZ II are the range of occupancy levels considered to be low density. Outside events should normally be limited to assemblies of not more than 25 people per acre in APZ I, and maximum assemblies of 50 people per acre in APZ II. 2. The suggested maximum density for detached single-family housing is 1 to 2 dwelling units per acre (Du/Ac). In a Planned Unit Development (PUD) of single-family detached units where clustered housing development results in large open areas, this density could possibly be increased, provided the amount of surface area covered by structures does not exceed 20% of the PUD total area. PUD encourages clustered development that leaves large open areas. 3. Other factors to be considered: Labor intensity, structural coverage, explosive characteristics, air pollution, electronic interference with aircraft, height of structures, and potential glare. 4. Maximum FAR of 0.56. 5. Maximum FAR of 0.28 in APZ I and 0.56 in APZ II. 6. No structures (except airfield lighting), buildings or aboveground utility/communications lines should normally be located in clear zone areas on or off the installation. The clear zone is subject to severe restrictions. See NAVFAC P-80.3 or Tri-Service Manual AFM 32-1123(I); TM 5-803-7, NAVFAC P-971 "Airfield and Heliport Planning & Design" dated 17 November 2008 for specific design details. 7. No passenger terminals and no major aboveground transmission lines in APZ I. 8. Maximum FAR of 0.14 in APZ I and 0.28 in APZ II. 9. Maximum FAR of 0.22. 10. Maximum FAR of 0.24. 11. Maximum FAR of 0.28. 12. Low intensity office uses only. Accessory uses such as meeting places, auditoriums, etc., are not recommended. 13. Maximum FAR of 0.22 for "General Office/Office Park." 14. Office uses only. Maximum FAR of 0.22. 15. No chapels are allowed within APZ I or APZ II. 16. Maximum FAR of 0.22 in APZ II. 17. Maximum FAR of 1.0 in APZ I and 2.0 in APZ II. 18. Maximum FAR of 0.11 in APZ I and 0.22 in APZ II. 19. Facilities must be low intensity and provide no tot lots, etc. Facilities such as clubhouses, meeting places, auditoriums, large classes, etc., are not recommended. 20. Includes livestock grazing but excludes feedlots and intensive animal husbandry. Activities that attract concentrations of birds creating a hazard to aircraft operations should be excluded. 21. Includes feedlots and intensive animal husbandry. 22. Maximum FAR of 0.28 in APZ I and 0.56 in APZ II. No activity that produces smoke or glare or involves explosives. 23. Lumber and timber products removed due to establishment, expansion, or maintenance of clear zones will be disposed of in accordance with appropriate DoD Natural Resources Instructions. 24. Controlled hunting and fishing may be permitted for the purpose of wildlife management. 25. Naturally occurring water features (e.g., rivers, lakes, streams, wetlands) are compatible. 26. <ol style="list-style-type: none"> a. Although local conditions regarding the need for housing may require residential use in these zones, residential use is discouraged in DNL 65-69 and strongly discouraged in DNL 70-74. The absence of viable alternative development options should be determined and an evaluation should be conducted prior to approvals indicating that a demonstrated community need for the residential use would not be met if development were prohibited in these zones. b. Where the community determines that residential uses must be allowed, measures to achieve outdoor to indoor noise level reduction (NLR) of at least 25 dB (DNL 65-69) and 30 dB (DNL 70-74) should be incorporated into building codes and be considered in individual approvals; for transient housing a NLR of at least 35 dB should be incorporated in DNL 75-79. c. Normal permanent construction can be expected to provide an NLR of 20 dB; thus, the reduction requirements are often stated as 5, 10, or 15 dB over standard construction and normally assume mechanical ventilation, upgraded Sound Transmission Class (STC) ratings in windows and doors and closed windows year round. Additional consideration should be given to modifying NLR levels based on peak noise levels or vibrations. d. NLR criteria will not eliminate outdoor noise problems. However, building location and site planning, design, and use of berms and barriers can help mitigate outdoor exposure, particularly from ground level sources. Measures that reduce noise at a site should be used wherever practical in preference to measures which only protect interior spaces. 27. Measures to achieve an NLR of 25 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or 								

MCAS Beaufort

Land Use Compatibility Recommendations								
Land Use		Accident Potential Areas ¹			Noise Levels			
SLUCM No.	Name	Clear Zone	APZ I	APZ II	65 to 70 DNL	70 to 75 DNL	75 to 80 DNL	80 to 85 DNL
<p>where the normal noise level is low.</p> <p>28. Measures to achieve an NLR of 30 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.</p> <p>29. Measures to achieve an NLR of 35 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.</p> <p>30. If the project or proposed development is noise sensitive, use indicated NLR; if not, land use is compatible without NLR.</p> <p>31. Land use compatible, provided special sound reinforcement systems are installed.</p> <p>32. Residential buildings require an NLR of 25.</p> <p>33. Residential buildings require an NLR of 30.</p> <p>34. Residential buildings not permitted.</p> <p>35. Land use not recommended, but if the community decides use is necessary, hearing protection devices should be worn by personnel.</p> <p>Key: Y (Yes) = Land use and related structures compatible without restrictions. N (No) = Land use and related structures are not compatible and should be prohibited. Y^x (Yes with restrictions) = The land use and related structures are generally compatible. However, see notes indicated by superscript. N^x (No with restrictions) = The land use and related structures are generally incompatible. However, see notes indicated by superscript. SLUCM = Standard Land Use Coding Manual. NLR (Noise Level Reduction) = Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure. DNL = Day-night average sound level. NA = Not Applicable (no data available for that category). 25, 30, or 35 = Land use and related structures generally compatible; measures to achieve NLR of 25, 30, or 35 must be incorporated into design and construction of structure.</p>								

APPENDIX C

MCAS BEAUFORT

ONLINE NOISE REPORT FORM

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Aircraft Noise Complaint Report

Aircraft Noise Complaint Report

Today's Date:		Time:		Caller's Name:	
Phone Number:			Residential Community:		
Caller's Address:				Email Address:	
Time and Date of Incident:			Type of Aircraft:		
Aircraft Markings (color, size, etc.):			Aircraft Flight Path (i.e. climbing, diving, etc.):		
Approximate Altitude:		Direction of Flight:		What Sounds Heard (engine noise, sonic boom, etc.):	
Any Additional Information Caller Would Like to Give (please be detailed):					

Under the **AUTHORITY** 10 U.S.C. 5013, Secretary of the Navy; 10 U.S.C. 5041, Headquarters, Marine Corp; and E.O. 9397 (SSN), this for is **FOR OFFICIAL USE ONLY** for the **PURPOSE** To maintain a record of correspondence received and responses made. In addition to those disclosures generally permitted under 5 U.S.C. 552a(b) of the Privacy Act, these records or information contained therein may specifically be disclosed outside the DoD as a **ROUTINE USE** pursuant to 5 U.S.C. 552a(b)(3) as follows The DoD 'Blanket Routine Uses' that appear at the beginning of the Navy's compilation of systems notices apply to this system. **DISCLOSURE** is **Voluntary**, however, not disclosing may result in your request not being processed.

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APPENDIX D

BEAUFORT COUNTY, SOUTH CAROLINA

AICUZ DISCLOSURE STATEMENT FORM AND

NOTIFICATION

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**AIR INSTALLATION COMPATIBLE USE ZONES (AICUZ)
DISCLOSURE FORM**

The property at _____ (address/location) is located in proximity to the Marine Corps Air Station Beaufort. It has been determined that persons on the premises will be exposed to accident potentials and/or significant noise levels as a result of the airport operations. Certain noise zones and accident potential zones (APZs) have been established.

The above property is located within the following zones of the Air Installation Compatible Use Zones (AICUZ) of MCAS Beaufort:

- | | |
|--|---------------------|
| <input type="checkbox"/> Noise Zone 1 | less than 65 DNL |
| <input type="checkbox"/> Noise Zone 2 a | 65 to 75 DNL |
| <input type="checkbox"/> Noise Zone 2 b | 70 to 75 DNL |
| <input type="checkbox"/> Noise Zone 3 | greater than 75 DNL |
| <input type="checkbox"/> Accident Potential Zone 1 | |
| <input type="checkbox"/> Accident Potential Zone 2 | |
| <input type="checkbox"/> Not located in an Accident Potential Zone | |

Certain restrictions have been placed on the development and use of property within these areas. Before purchasing the above property, you should consult the local zoning ordinance administrator to determine the restrictions that have been placed on the subject property.

CERTIFICATION

As the owner of the subject property, I hereby certify that I have informed _____, as a prospective purchaser, that the subject property is located in an Air Installation Compatible Use Zones District.

Dated this _____ day of _____, _____

Witness _____ Owner _____

As a prospective purchaser of the subject property, I hereby certify that I have been informed that the subject property is in an Air Installation Compatible Use Zones District, and I have consulted the local zoning ordinance administrator to determine the restrictions which have been placed on the subject property.

Dated this _____ day of _____, _____

Witness _____ Purchaser _____

NOTE: All prospective renters signing a commercial or residential lease shall be notified by the property owner through a written provision contained in the lease agreement if the leased property is located within the Airport overlay district.

**THIS FORM NEEDS TO BE FILED WITH THE DEED OR PLAT AT THE
BEAUFORT COUNTY REGISTER OF DEEDS OFFICE**

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Sec. 4. Notification. 

(a)

At all real estate closings involving a property in an accident potential zone or noise zone, the buyer, seller and witnesses shall sign the following form, which shall be filed with the deed and/or plat at the Beaufort County Register of Deeds Office (RMC Office).

Airport Overlay Disclosure Form

The property at _____ (address/location) is located in proximity to the Marine Corps Air Station Beaufort. Beaufort County has determined that persons on the premises will be exposed to accident potentials and/or significant noise levels as a result of the airport operations. The County has established certain noise zones and accident potential zones (APZs) within its Zoning and Development Standards Ordinance (ZDSO).

The above property is located in Noise Zone _____ and in Accident Potential Zone _____.

The County has placed certain restrictions on the development and use of property within these areas. Before purchasing the above property, you should consult the Beaufort County Zoning and Development Administrator to determine the restrictions that have been placed on the subject property.

CERTIFICATION

As the owner of the subject property, I hereby certify that I have informed _____, as a prospective purchaser, that the subject property is located in an Airport Overlay district.

Dated this _____ day of _____, _____.

Witness _____ Owner _____

As a prospective purchaser of the subject property, I hereby certify that I have been informed that the subject property is in an Airport Overlay district, and I have consulted the Beaufort County Zoning and Development Administrator to determine the restrictions which have been placed on the subject property.

Dated this _____ day of _____, _____.

Witness _____ Purchaser _____

(b)

All prospective renters signing a commercial or residential lease shall be notified by the property owner through a written provision contained in the lease agreement if the leased property is located within the AO District.

(c)

All subdivision plats, planned unit development plats, townhouse plats and /or condominium documents shall contain the following disclosure statement:

Airport Overlay Disclosure Statement

This property lies within an Airport Overlay District, which applies to property in proximity to the Marine Corps Air Station Beaufort. Beaufort County has determined that persons on the premises will be exposed to accident potentials and/or significant noise levels as a result of the airport operations. Purchasers are required to sign a Disclosure Form per Appendix A1 of the Beaufort County Zoning and Development Standards Ordinance and file the form with the deed and/or plat at the Beaufort County Register of Deeds Office. All or a portion of this property lies within:

Accident Potential Zone: _____

Noise Zone: _____ DNL (Day-Night Average Sound Level): _____

(d)

In the case of new construction, a signed Airport Overlay Disclosure Statement shall accompany the building permit application.

(Ord. No. 2006/27, § 4, 12-11-2006)