AIR INSTALLATIONS COMPATIBLE USE ZONES STUDY
MARINE CORPS OUTLYING LANDING FIELD CAMP DAVIS

CAMP LEJEUNE, NORTH CAROLINA

AUGUST 2013

FINAL

AIR INSTALLATIONS COMPATIBLE USE ZONES STUDY

FOR

MARINE CORPS OUTLYING LANDING FIELD CAMP DAVIS NORTH CAROLINA

FINAL – AUGUST 2013

Prepared by

UNITED STATES DEPARTMENT OF THE NAVY
Naval Facilities Engineering Command, Mid-Atlantic
Norfolk, Virginia

This study was completed for the
United States Marine Corps
Marine Corps Base Camp Lejeune
Jacksonville, North Carolina
under
Naval Facilities Engineering Command – Atlantic
Contract #N62470-10-D-2024

TABLE OF CONTENTS

Executive Summary ES-1

ES.1 Purpose of an AICUZ Study ES-1
ES.2 MCOLF Camp Davis ES-2
ES.3 Aircraft Operations ES-2
ES.4 Aircraft Noise ES-2
ES.5 Airfield Safety ES-3
ES.6 Land Use Compatibility Analysis ES-4
ES.7 Land Use Tools and Recommendations ES-4
ES.8 Appendices ES-6
ES.8.1 Appendix A: Discussion of Noise and its Effect on the Environment ...ES-6
ES.8.2 Appendix B: Land Use Compatibility Recommendations ES-6
ES.8.3 Appendix C: Request for Approval of Outlying ES-6

1 Introduction 1-1

1.1 AICUZ Program 1-4
1.2 Purpose, Scope, and Authority 1-5
1.3 Responsibility for Compatible Land Uses 1-6
1.4 Previous AICUZ Efforts 1-7
1.5 Changes that Require an AICUZ Update 1-8
1.5.1 Changes in Aircraft Mix 1-8
1.5.2 Changes in Operations Level 1-8
1.5.3 Changes in Flight Tracks and Procedures 1-9

2 MCOLF Camp Davis 2-1

2.1 Location and History 2-1

2.2 Mission 2-3
2.3 Operational Areas 2-3
2.4 Local Economic Impacts 2-6

3 Aircraft Operations 3-1

3.1 Aircraft Types 3-1
3.1.1 Tilt-Rotor Aircraft 3-1
3.1.2 Rotary-Wing Aircraft 3-2
3.1.3 Fixed-Wing Aircraft 3-3
3.2 Local Airspace 3-4
3.3 Aircraft Operations 3-4
3.3.1 Typical Flight Operations 3-7
3.3.2 MCOLF Camp Davis Flight Operations 3-7
3.4 MCOLF Camp Davis Flight Tracks 3-9

4 Aircraft Noise 4-1

4.1 What is Sound/Noise? 4-1
4.2 Airfield Noise Sources 4-3
4.3 Noise Abatement and Complaints 4-3
4.3.1 Noise Abatement 4-3
4.3.2 Noise Complaints 4-4
4.4 2012 AICUZ Noise Contours 4-5
4.4.1 1978 AICUZ Noise Contours 4-5
4.4.2 2012 AICUZ Noise Contours 4-5
4.4.3 Comparison of 1978 and 2012 AICUZ Noise Contours for MCOLF Camp Davis 4-8

5 Airfield Safety 5-1

5.1 Accident Potential Zones 5-2
5.1.1 Aircraft Mishaps 5-2

5.1.2 APZ Requirements and Dimensions 5-2
5.1.3 MCOLF Camp Davis Clear Zones and APZs 5-4
5.2 Flight Safety 5-6
5.2.1 Imaginary Surfaces 5-6
5.2.2 Bird and Wildlife Aircraft Strike Hazards 5-8
5.2.3 Electromagnetic Interference (EMI) 5-8
5.2.4 Lighting 5-9
5.2.5 Smoke, Steam, and Dust 5-9

6 Land Use Compatibility Analysis 6-1

6.1 Land Use Compatibility Guidelines and Classifications 6-1
6.2 Planning Authorities 6-2
6.2.1 Onslow County 6-3
6.2.2 Town of Holly Ridge 6-5
6.3 Land Use Compatibility Analysis 6-6
6.3.1 Existing Land Use 6-7
6.3.2 Zoning and Future Land Use 6-9
6.4 Compatibility Concerns 6-11

7 Land Use Tools and Recommendations 7-1

7.1 Tools for Implementing AICUZ 7-2
7.1.1 Federal Tools 7-2
7.1.2 State and Local Government Level Tools 7-5
7.1.3 Tools for Private Citizens, Real Estate Professionals, and Businesses 7-8
7.2 Recommendations for AICUZ Implementation Strategy 7-8
7.2.1 MCOLF Camp Davis Recommendations 7-8
7.2.2 State and Local Government Recommendations 7-11
7.2.3 Recommendations for Private Citizens, Real Estate Professionals, and Businesses 7-12

8 References 8-1

APPENDICES

A DISCUSSION OF NOISE AND ITS EFFECT ON THE ENVIRONMENT

B LAND USE COMPATIBILITY RECOMMENDATIONS

C REQUEST FOR APPROVAL OF OUTLYING LANDING FIELD CLEARANCE CRITERIA FOR HELICOPTER/TILT-ROTOR AIRCRAFT

List of Tables

1 Introduction

1-1 Responsibility for Compatible Land Uses 1-7
1-2 MCOLF Camp Davis Aircraft Utilization between 1978 and 2010 1-9

2 MCOLF Camp Davis

2-1 MCOLF Camp Davis Runways 2-6

3 Aircraft Operations

3-1 Projected Annual Air Operations for MCOLF Camp Davis 3-8

4 Aircraft Noise

4-1 Noise Abatement Flight Procedures, MCOLF Camp Davis 4-4
4-2 Areas within Noise Zones (1978 and 2012), MCOLF Camp Davis 4-8

5 Airfield Safety

5-1 Airspace Imaginary Surfaces for Tilt-Rotor OLFs 5-6

6 Land Use Compatibility Analysis

6-1 Land-Use Classifications and Compatibility Guidelines 6-3
6-2 Existing Land Uses within Noise Zones, MCOLF Camp Davis 6-7
6-3 Existing Land Uses within APZs, MCOLF Camp Davis 6-7

This page intentionally left blank.

LIST OF FIGURES

Executive Summary

ES-1 Composite Coverage for Existing Land Uses and 2012 AICUZ Noise Contours and APZs, MCOLF Camp Davis, North Carolina ES-5

1 Introduction

1-1 Regional Location Map, MCOLF Camp Davis, North Carolina 1-3

2 MCOLF Camp Davis

2-1 Airfield Location and Vicinity Map, MCOLF Camp Davis, North Carolina 2-2
2-2 2d MAW Organization and Aviation Squadrons Located in the Vicinity of MCOLF Camp Davis, North Carolina 2-4
2-3 MCOLF Camp Davis Location and Runway Layout... 2-5

3 Aircraft Operations

3-1 Airspace and Airports in the Vicinity of MCOLF Camp Davis..................................... 3-5
3-2 Special Use Airspace in the Vicinity of MCOLF Camp Davis...................................... 3-6
3-3 Aircraft Arrival Flight Tracks MCOLF Camp Davis, North Carolina......................... 3-10
3-4 Aircraft Departure Flight Tracks MCOLF Camp Davis, North Carolina 3-11
3-5 Aircraft Landing Pattern Flight Tracks, MCOLF Camp Davis, North Carolina........... 3-12

4 Aircraft Noise

4-1 1978 AICUZ Noise Contours, Average Annual Day DNL, MCOLF Davis, North Carolina.. 4-6

4-2 2012 AICUZ Noise Contours, Average Annual Day DNL, MCOLF Davis, North Carolina 4-7
4-3 Estimate of Noise Propagation from Operations at MCOLF Camp Davis, North Carolina 4-9

5 Airfield Safety

5-1 Tilt-Rotor OLF Accident Potential Zones 5-4
5-2 2012 AICUZ Accident Potential Zones (APZs), MCOLF Camp Davis, North Carolina 5-5
5-3 Imaginary Surfaces for MCOLF Camp Davis 5-7

6 Land Use Compatibility Analysis

6-1 Composite Coverage for Existing Land Uses and 2012 AICUZ Noise Contours and APZs, MCOLF Camp Davis, North Carolina 6-8
6-2 Future Land Uses and 2012 AICUZ Noise Contours and APZs, MCOLF Camp Davis, North Carolina 6-10

ACRONYMS AND ABBREVIATIONS

AGL	above ground level
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
BASH	bird/wildlife aircraft strike hazard
BOC	Board of Commissioners
CAMA	Coastal Area Management Act
CAL	confined area landing
CP&LO	Community Plans and Liaison Officer
CY	calendar year
CZ	clear zone
dB	decibel
dBA	A-weighted decibel
DNL	day-night average sound level
DOD	(United States) Department of Defense
DZ	drop zone
EA	environmental assessment
EIS	environmental impact statement
EMI	electromagnetic interference
FAA	Federal Aviation Administration
FICUN	Federal Interagency Committee on Urban Noise
FPOD	flight path overlay district
GIS	geographic information system
GSA	Government Services Administration
GSRA	Greater Sandy Run Area
IFR	instrument flight rules
JLUS	Joint Land Use Studies
MAG	Marine Aircraft Group
MAW	Marine Aircraft Wing
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCO	Marine Corps Order
MCOLF	Marine Corps Outlying Landing Field
MEF	Marine Expeditionary Force
MSL	mean sea level
NAVFAC	Naval Facilities Engineering Command
Navy	United States Department of the Navy
NM	nautical mile
OEA	Office of Economic Adjustment
OLF	outlying landing field
OPNAVINST	Chief of Naval Operations Instruction
RNM	rotorcraft noise model

SUA	Special Use Airspace
TLZ	tactical landing zone
UFC	Unified Facilities Criteria
U.S.C.	United States Code
USMC	United States Marine Corps
VFR	visual flight rules

ES.1 Purpose of an AICUZ Study
ES.2 MCOLF Camp Davis
ES.3 Aircraft Operations
ES.4 Aircraft Noise
ES.5 Airfield Safety
ES.6 Land Use Compatibility Analysis
ES.7 Land Use Tools and Recommendations
ES.8 Appendices

Executive Summary

This Air Installations Compatible Use Zones (AICUZ) study has been prepared in accordance with Marine Corps instructions to protect the public's health, safety, and welfare and to prevent degrading the operational capability of Marine Corps Outlying Landing Field (MCOLF) Camp Davis. MCOLF Camp Davis is located in southwestern Onslow County just north of the town of Holly Ridge. This AICUZ study focuses on the noise areas and safety zones surrounding the two runways at the airfield. The Marine Corps encourages compatible development in the noise and safety zones and are committed to working with the surrounding communities to ensure a mutually safe environment while continuing to accomplish the mission of the installation.

ES.1 Purpose of an AICUZ Study

At the core of the AICUZ program are land use guidelines to promote compatible development near military installations. In the early 1970s, the Department of Defense (DOD) established the AICUZ program to balance the need for aircraft operations and community concerns over aircraft noise and accident potential. The DOD developed the AICUZ program in response to growing incompatible urban development around military airfields. Today, the AICUZ program is a vital tool used by the Marine Corps to educate and inform surrounding communities about their missions and associated areas of incompatible land use. This AICUZ study presents the 2012 AICUZ noise zones and accident potential zones (APZs) for aircraft operations at MCOLF Camp Davis. It identifies areas of current and possible future incompatible land uses, and recommends actions to promote compatible land use.

ES.2 MCOLF Camp Davis

MCOLF Camp Davis is located in eastern North Carolina on Marine Corps Base (MCB) Camp Lejeune. This airfield is about 17 miles southwest of the City of Jacksonville, North Carolina, and 1 mile north of the Town of Holly Ridge. MCOLF Camp Davis has two active runways, with most aircraft arriving from Marine Corps Air Station (MCAS) New River to conduct rotary-wing and tilt-rotor aircraft training.

ES.3 Aircraft Operations

Primary aircraft that operate at MCOLF Camp Davis include the AH-1W, CH-53E, MV-22, UH-1N and KC-130J.

MCOLF Camp Davis provides a local landing field for a variety of aircraft training missions. The field is currently used by the AH-1W "Super Cobra," CH-53E "Super Stallion," MV-22 "Osprey," UH-1N "Iroquois (Huey)," and, on occasion, the KC-130J "Hercules." The UH-1Y also has begun to use the airfield; however, operations data gathering was completed prior to its arrival. Typical operations include arrivals, departures, pattern operations (including touch-and-go), hovering, confined area landings (CAL), low approaches, and paradrop operations.

Aircraft generally follow designated flight tracks, which are specific routes over the ground that an aircraft follows while conducting an operation at the airfield. Flight tracks provide safety, consistency, and control of an airfield. Flight tracks may vary slightly from those depicted in this study due to aircraft performance, pilot technique, and weather conditions.

This AICUZ study contains noise contours and APZs based on projected operations for CY 2020.

AICUZ studies examine projected operations five to ten years in the future. This study used projected operations out to 2020. These results are designated as the 2012 AICUZ noise contours and APZs.

ES.4 Aircraft Noise

The primary source of noise at MCOLF Camp Davis is aircraft operations. Aircraft noise is represented using the day-night average sound level

(DNL) noise metric. The DNL is depicted as a noise contour that connects points of equal value using the DOD-approved noise models NOISEMAP and the Rotorcraft Noise Model (RNM). Operational data were collected from MCB Camp Lejeune range personnel and from pilots of aircraft that regularly use the airfield to model aircraft noise at MCOLF Camp Davis.

The AICUZ program designates three noise zones for use in land compatibility planning. Noise zones 1 through 3 are based on the DNL and provide associated land use control recommendations for each of the zones. These noise zones are the basis for identifying incompatible land uses around an airfield. This AICUZ study presents the 2012 AICUZ noise contours and the noise zones for MCOLF Camp Davis.

ES.5 Airfield Safety

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

The likelihood of an aircraft mishap occurring is remote. However, areas of accident potential have been identified for MCOLF Camp Davis based on historical data from aircraft mishaps to assist in land-use planning. The Marine Corps recommends that certain land uses that concentrate large numbers of people—apartments, churches, and schools—be located outside APZs.

Mishaps are more likely to occur along the flight path of an aircraft and increase in likelihood near the runways. In accordance with OPNAVINST 11010.36C/MCO 11010.16, all active runways are required to have a Clear Zone. The placement and dimensions of APZs depend upon the classification of the runway, the number of operations for a given runway flight track, and the shape of the flight track. The three APZs in order of diminishing accident potential with distance from the runway are the Clear Zone, APZ-I, and APZ-II. The MCB Camp Lejeune Commanding Officer submitted a request (Appendix C) to amend the Unified Facilities Criteria (UFC) 3-260-1, Airfield and Heliport Planning and Design, for airfield clearance criteria associated with Tilt-Rotor (MV-22) Aircraft Outlying Fields. The draft amendment was reviewed by the Naval Air Systems Command and endorsed by USMC leadership. Since UFC 3-260-1 applies to all Military Departments, incorporation of the draft amendment into the UFC is pending review by the Air Force and Army. The 2012 MCOLF

Camp Davis APZs were developed using the criteria identified in the draft UFC amendment (Appendix C).

The 2012 AICUZ map defines the minimum area needed to protect the health, safety, and welfare of populations near MCOLF Camp Davis.

ES.6 Land Use Compatibility Analysis

The noise zones and APZs form the 2012 composite AICUZ footprint for MCOLF Camp Davis (see Figure ES-1). The resulting "footprint" shows the minimum recommended acceptable area within which land use controls are needed to protect the health, safety, and welfare of those living or working nearby and to preserve the flying mission.

The DOD has developed land use compatibility recommendations for noise zones and APZs. The Marine Corps identifies these recommendations in their AICUZ instruction, Marine Corps Order (MCO) 11010.16, which is also identified as Chief of Naval Operations Instruction (OPNAVINST) 11010.36C. Certain land uses are incompatible with APZs and high noise zones, while other land uses may be considered entirely compatible or compatible under certain conditions or restrictions. This AICUZ study incorporates land use information and zoning regulations from the Town of Holly Ridge and Onslow County as the basis for identifying existing land uses as well as future land uses and zoning.

ES.7 Land Use Tools and Recommendations

Federal, state and local governments, as well as businesses, real estate developers, and private citizens, all play an important role in implementing this AICUZ study. The Marine Corps recommends incorporation of the AICUZ footprint into the zoning ordinances of both Onslow County and the Town of Holly Ridge to guide compatible development around the installation.

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\ES_Composite_11_17.mxd

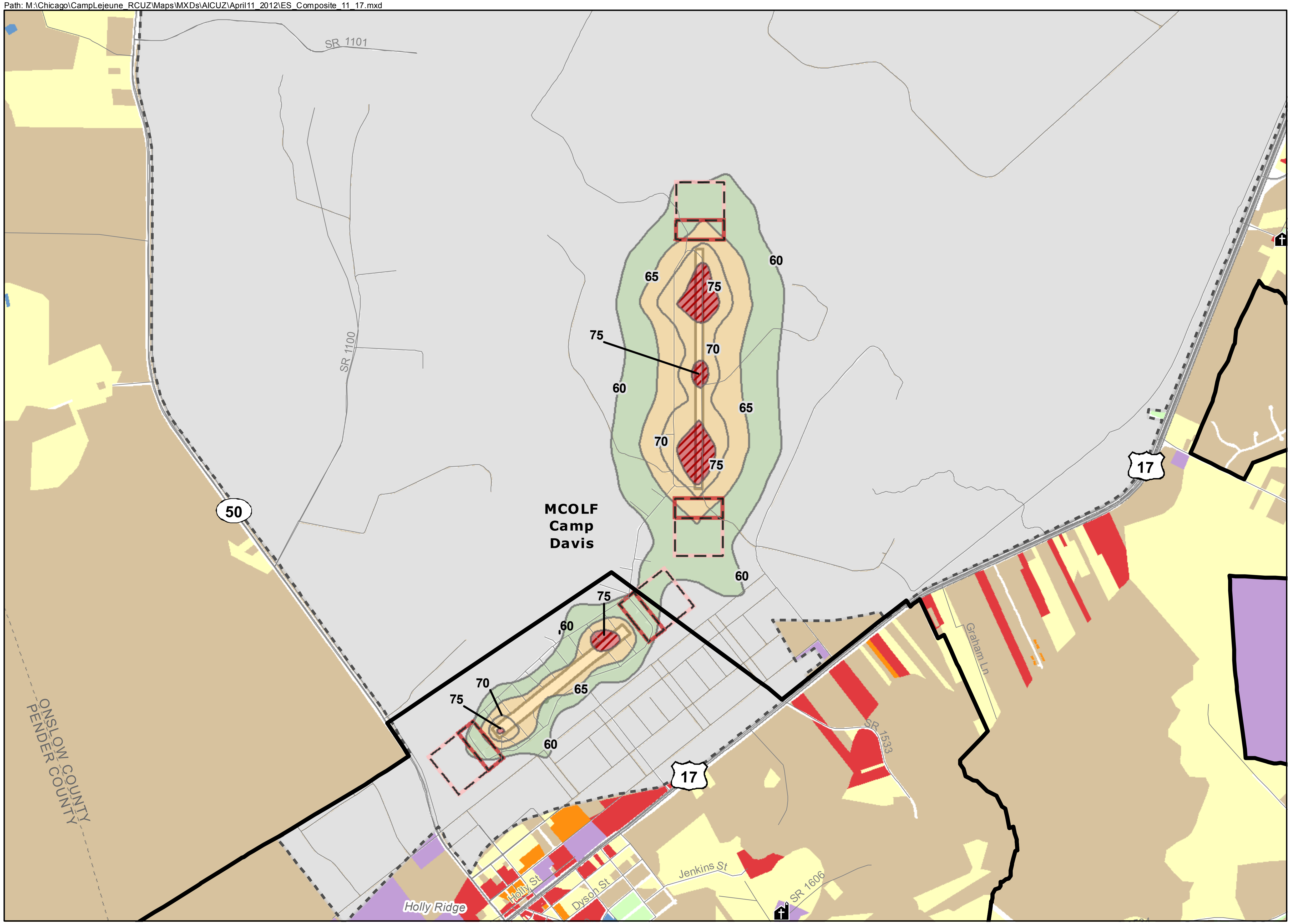


Figure ES-1
Composite Coverage for
Existing Land Uses and
2012 AICUZ Noise Contours
and APZs
MCOLF Camp Davis
North Carolina

Church
Runway
MCB Camp Lejeune
Holly Ridge Area for Planning and Regulation of Development
County Boundary

Accident Potential Zone
Clear Zone
APZ I

Noise Zones
Zone 1
Zone 2
Zone 3

Land Use
Military Reservation
Commercial
Industrial
Multi Family Residential
Single Family Residential
Office and Institutional
Recreation and Open Space
Undeveloped

0 0.25 0.5
Miles

Source:
ESRI, 2010; Onslow County, 2011

ES.8 APPENDICES

ES.8.1 Appendix A: Discussion of Noise and its Effect on the Environment

Appendix A provides detailed information on the basics of sound, sound measurements, and noise effects on humans and wildlife.

ES.8.2 Appendix B: Land Use Compatibility Recommendations

Appendix B presents comprehensive land use recommendations for noise zones 1 through 3 and for APZs as prescribed by OPNAVINST11010.36C/MCO 11010.16, “Air Installations Compatible Use Zones Program” (Navy 2008).

ES.8.3 Appendix C: Request for Approval of Outlying

Landing Field Clearance Criteria for Helicopter/Tilt-Rotor Aircraft

Appendix C presents a request for approval of outlying landing field clearance criteria for helicopter/tilt-rotor aircraft that was forwarded from the Commander, U.S. Marine Corps Bases, Atlantic to the Commander, Naval Facilities Engineering Command (NAVFAC) on 30 November 2010 recommending approval.

1 Introduction

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

Historically, the United States government established military bases in rural areas across the country. Increasing populations in many of these areas have brought development closer to these military installations. This growth is visible immediately outside many installation fence lines as well as throughout the surrounding areas. Communities construct new homes close to these installations to allow military and civilian personnel to live closer to their employer. Similarly, businesses locate near the installations to provide services to military personnel. Some of this development is incompatible with military operations and, over time, can result in adverse impacts on nearby residents and degrade the mission of the installation. As incompatible development encroaches upon a military airfield, more residents in the surrounding community experience the impacts associated with aircraft operations.

The Department of Defense (DOD) initiated the Air Installations Compatible Use Zones (AICUZ) program to help communities anticipate, identify, and promote compatible land uses and development near military installations. The goal of this program is to protect the health, safety, and welfare of those living or working near military air installations while protecting military operational capabilities. The AICUZ program recommends land uses that are compatible with noise levels, accident potential, and flight clearance requirements associated with military airfield operations. The objective is for local governments to incorporate the AICUZ recommendations into local land use planning and control programs to minimize incompatible development.

This AICUZ study has been prepared for Marine Corps Outlying Landing Field (MCOLF) Camp Davis, located in eastern North Carolina on Marine Corps Base (MCB) Camp Lejeune. The airfield is located approximately 17 miles southwest of the City of Jacksonville and 1 mile north of the Town of Holly Ridge (see Figure 1-1). MCOLF Camp Davis has two runways, with most aircraft originating from Marine Corps Air Station (MCAS) New River. The original AICUZ study for MCOLF Camp Davis was completed in 1978 as part of the overall AICUZ study for MCAS New River[1]. The latest MCAS New River AICUZ update was completed in September 2009, but that study did not include an update for MCOLF Camp Davis.

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

This goal is achieved by promoting compatible land - use patterns and activities near a military installation.

This document replaces the 1978 MCOLF Camp Davis AICUZ study. It has been developed to support the Marine Corps in its participation in the local community planning process. This study considers reasonably foreseeable changes in mission, aircraft, and projected operational levels that will occur within the next five to ten years. The Marine Corps has the responsibility to communicate, build relationships, collaborate, and provide input for those involved in local executive and legislative functions on land use planning, zoning, and similar matters that could affect installation operations or missions.

Section 1 of this study provides background information on the AICUZ program, and Section 2 describes MCOLF Camp Davis. Section 3 discusses current aircraft operations and airspace at MCOLF Camp Davis. Section 4 describes aircraft noise zones, and Section 5 discusses aircraft safety issues, including accident potential zones (APZs) and other land-use issues that could affect aircrew safety. Section 6 evaluates the compatibility of surrounding land uses and aircraft operations, and Section 7 provides tools and recommendations for promoting land uses that are compatible with the installation's activities and consistent with the goals of the AICUZ program.

[1] Naval Facilities Engineering Command - Southern Division 1978.

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\Regional Location Map_April2012.mxd

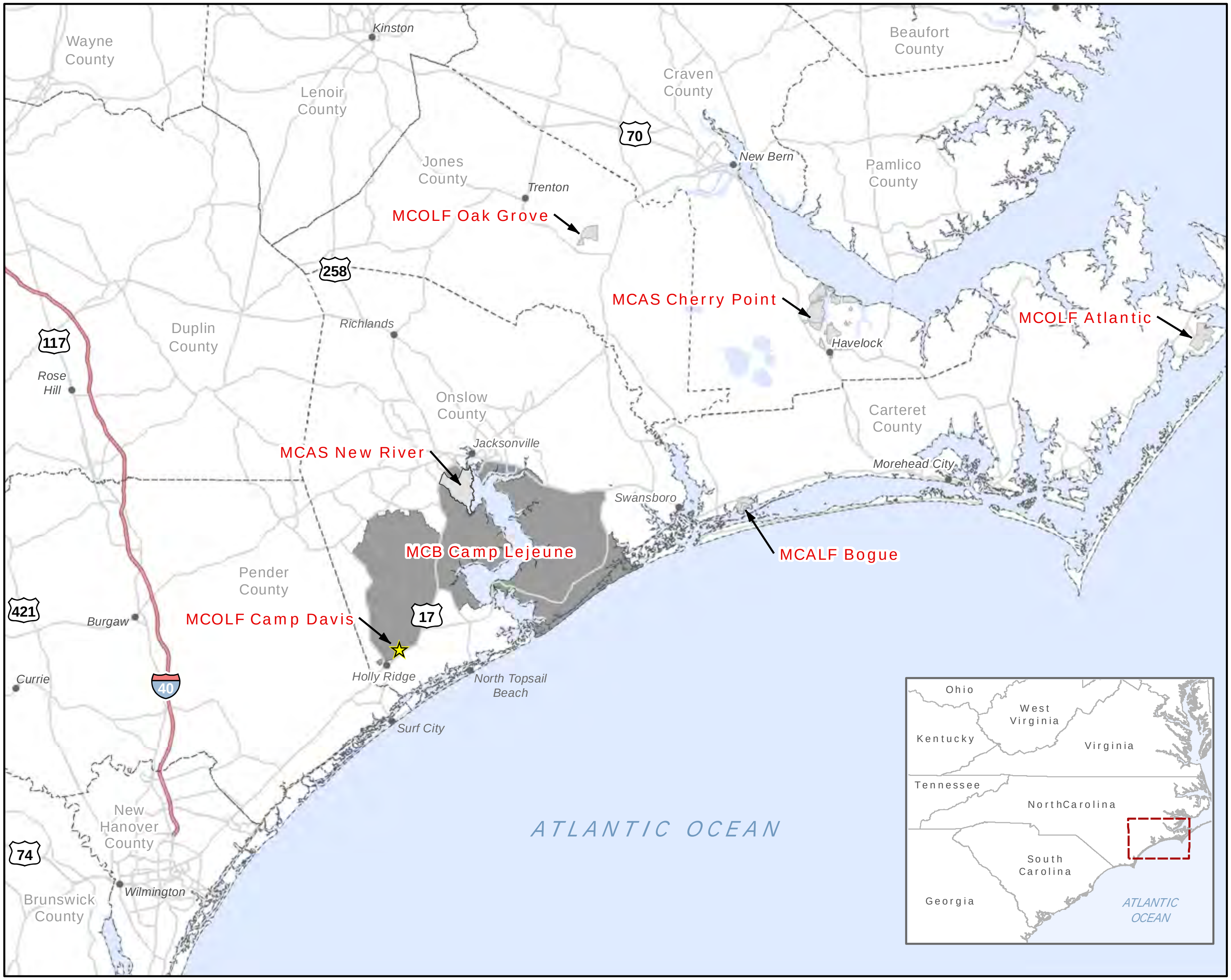


Figure 1-1
Regional Location Map
MCOLF Camp Davis
North Carolina

- MCOLF Camp Davis
- City / Town
- MCB Camp Lejeune
- Other Installation Areas
- Water Bodies
- County Boundaries

Source:
ESRI, 2010

0 5 10 20
Miles

1.1 AICUZ Program

In the 1970s, the DOD established the AICUZ program to balance the national need for military aircraft operations with local community concerns over aircraft noise and accident potential. The primary purpose of the AICUZ program is to achieve compatibility between air installations and neighboring communities by protecting the health, safety, and welfare of civilians and military personnel living near military airfields by encouraging land use that is compatible with aircraft operations. In addition, the program supports the following objectives:

- Protecting the health, safety, and welfare of persons living near military airfields by encouraging land use that is compatible with aircraft operations
- Protecting Navy and Marine Corps installation investments by safeguarding the installations' operational capabilities
- Reducing noise impacts caused by aircraft operations while meeting operational, training, and flight safety requirements, both on and in the vicinity of air installations
- Informing the public and seek cooperative efforts to minimize noise and aircraft accident potential impacts by promoting compatible development.

To meet these goals, the Navy and Marine Corps have identified the following components as requirements for a successful AICUZ program:

- Develop and periodically update a study and map for each air installation to quantify and depict aircraft noise zones and APZs
- Coordinate with federal, state, and local officials to encourage compatible land use development around each air installation
- Inform the local communities of the importance of maintaining the Marine Corps' ability to conduct aircraft operations

- Review operations and implement operational changes and noise abatement strategies to minimize noise impacts while ensuring mission requirements.

The DOD identifies noise zones and APZs as planning tools for local planning agencies. The Federal Aviation Administration (FAA) and the DOD also encourage local communities to restrict development or land uses that could endanger aircraft near the airfield. These hazards include lighting (direct or reflected) that would impair a pilot's vision; towers, tall structures, and vegetation that penetrate navigable airspace or are constructed near the airfield; uses that generate smoke, steam, or dust; uses that attract birds, especially waterfowl; and electromagnetic interference (EMI) with aircraft communication, navigation, or other electrical systems.

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

1.2 Purpose, Scope, and Authority

The purpose of the AICUZ program is to achieve compatibility between air installations and neighboring communities. To satisfy this purpose, the military installation collaborates with the community to discourage incompatible development of land adjacent to the installation. As developments "outside the fenceline" encroach upon the airfield, more people may experience the noise and accident potential associated with aircraft operations. The scope of an AICUZ study includes an analysis of the following:

- Aircraft noise zones for future-year forecasts
- Aircraft APZs for future-year forecasts
- Land use compatibility
- Historic, current, and future aircraft operations
- Noise reduction strategies
- Possible solutions to existing and potential incompatible land use problems.

AICUZ studies analyze community development trends and mission requirements at the airfield to develop a recommended strategy for the installation and surrounding communities to prevent incompatible development. The basis for implementing AICUZ guidelines lies in cooperation between the air installation commander and with local government.

The authority for the MCOLF Camp Davis AICUZ Program is derived from the following documents:

MCO 11010.16 is the current Marine Corps guidance document that governs the AICUZ program.

- DOD Instruction 4165.57, “Air Installations Compatible Use Zones” (May 2, 2011)
- OPNAVINST 11010.36C/MCO 11010.16, “Air Installations Compatible Use Zones Program” (October 9, 2008).

1.3 Responsibility for Compatible Land Uses

Military installations can make recommendations or advise local governments on land uses near an installation. Ultimately, the local government has the planning and zoning authority to preserve land - use compatibility near the installation.

Ensuring land use compatibility within the AICUZ is the responsibility of several entities, including the DOD, elected and appointed officials, local planning and zoning agencies, real estate agencies, residents, developers, and builders. Military installations share the responsibility for preserving land use compatibility near installation boundaries with local government agencies that have planning and zoning authority. Cooperative action by all parties is essential to prevent land use incompatibility and hazards for the neighboring community. Table 1-1 identifies some responsibilities for various community stakeholders living near an installation.

Table 1-1. Responsibility for Compatible Land Uses

Marine Corps	▪ Examine air mission for operation changes that could reduce impacts. ▪ Conduct noise and APZ studies and develop AICUZ maps. ▪ Examine local land uses and growth trends. ▪ Actively participate in the land-use planning process. ▪ Release an AICUZ study and update the study as required. ▪ Work with local governments and private citizens. ▪ Monitor operations and address noise concerns.
State and Local Government	▪ Incorporate AICUZ guidelines into a comprehensive development plan and zoning ordinance. ▪ Regulate height and obstruction concerns through an airport ordinance. ▪ Regulate acoustical treatment in new construction. ▪ Require fair disclosure in real estate for all buyers, renters, lessees, and developers.
Builders/Developers	▪ Develop properties in a manner that appropriately protects the health, safety, and welfare of the civilian population by constructing facilities that are compatible with aircraft operations (e.g., sound attenuation features, densities, and occupational noise considerations).
Real Estate Professionals	▪ Ensure potential buyers and renters receive and understand AICUZ information on affected properties.
Private Citizens	▪ Seek information and self-education on the established zones and the impacts they may have for individuals. ▪ Identify AICUZ considerations in all property transactions. ▪ Understand AICUZ effects before buying, renting, leasing, or developing property.

1.4 PREVIOUS AICUZ EFFORTS

An AICUZ study was prepared for MCOLF Camp Davis in 1978 as part of a larger study for MCAS New River.[2] Several updates to the MCAS New River AICUZ study have been completed since then, with the most recent update in June 2011. However, an update for MCOLF Camp Davis has not been completed since the original 1978 AICUZ study.

[2] *Ibid.*

1.5 CHANGES THAT REQUIRE AN AICUZ UPDATE

AICUZ studies should be updated when an installation has:

- Changes in the type of aircraft stationed at the installation.
- Significant changes in aircraft operations.
- Changes in flight paths or procedures.

AICUZ studies should be updated when an air installation has a significant change in aircraft operations (i.e., the number of takeoffs and landings), a change in the type of aircraft operating at the airfield, or changes in flight paths and procedures. These changes can result in a noise profile for an airfield that is different from earlier studies.

In accordance with OPNAVINST 11010.36C/MCO 11010.16, this AICUZ update has been prepared to reflect changes in airfield operations since the 1978 AICUZ study. It incorporates reasonable projections in mission changes for the next five to ten years. Since the 1978 MCOLF Camp Davis AICUZ study, the types and mix of aircraft that use this airfield have changed significantly. Furthermore, the technology and methodologies used to depict aircraft noise have become more precise.

1.5.1 Changes in Aircraft Mix

MCOLF Camp Davis is used primarily by aircraft from the Second Marine Aircraft Wing (2d MAW) originating from MCAS New River. Table 1-2 lists the aircraft using the airfield and compares their respective usage for 1978, 2010, and 2020. The table shows several important changes in the types of aircraft that use the airfield. The CH-46 was the primary user of the airfield in 1978, but it was recently replaced by the MV-22. The CH-53 was the primary user of the airfield in 2010, and it is expected to make up over 50% of the operations at MCOLF Camp Davis in the future.

1.5.2 Changes in Operations Level

At the time of the 1978 AICUZ study, flight operations at MCOLF Camp Davis averaged about 74 operations per day, or approximately 27,000 operations per year.[3] A review of 2010 flight operations data showed an estimated baseline of 22,904 operations per year. Using the 2010 operations estimate as a starting

[3] *Ibid.*

point, the Marine Corps estimated flight operations for the year 2020 to be 27,060[4]. This value incorporates future projections of the combinations of aircraft using the airfield, the individual aircraft operations, and available estimates of future mission requirements.

Table 1-2. MCOLF Camp Davis Aircraft Utilization between 1978 and 2010

Aircraft Type	1978	2010	2020 (projected)
CH-46	35%	1%	N/A
CH-53	20%	51%	54%
AH-1	14%	16%	17%
UH-1	31%	9%	9%
MV-22	0%	22%	19%
C-130 (and other aircraft)	0%	< 1%	< 1%

Sources: Naval Facilities Engineering Command - Southern Division 1978; Blue Ridge Research and Consulting 2011.

Key:
N/A = Not applicable

1.5.3 Changes in Flight Tracks and Procedures

Data obtained during the course of this AICUZ study update shows substantial changes to flight tracks and associated procedures since the 1978 study. Descriptions of current flight tracks and associated operations are identified in detail in Section 3.3. Section 4.3 also discusses specific flight operation procedures associated with noise abatement.

[4] Blue Ridge Research and Consulting 2011.

This page intentionally left blank.

2

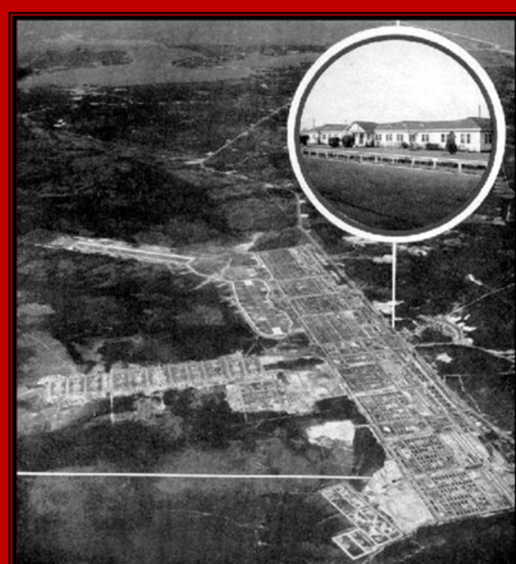
2.1 Location and History
2.2 Mission
2.3 Operational Areas
2.4 Local Economic Impacts

MCOLF Camp Davis

2.1 Location and History

MCOLF Camp Davis is located in the southeast corner of MCB Camp Lejeune in Onslow County, North Carolina. The airfield is north of the Town of Holly Ridge and approximately 15 miles southwest of MCAS New River (see Figure 2-1).

Camp Davis has been an important part of national defense for more than 60 years. The United States Army constructed Camp Davis in December 1940 as an anti-aircraft artillery training facility. The original facility consisted of more than 3,000 buildings on approximately 45,500 acres. Between 1942 and 1943, two runways were built for the Camp Davis Army Air Field. After World War II, Camp Davis was no longer needed for anti-aircraft training and was closed on February 17, 1946.


Camp Davis Army Airfield Circa 1940

The Navy leased a portion of the original Camp Davis anti-aircraft artillery training facility for testing early surface-to-air missiles from 1946 to 1948. After the Navy's lease expired, the land was declared surplus and was returned to the original landowners. In 1954, the Marine Corps leased approximately 955 acres of the former Army airfield to provide an outlying landing field (OLF) for aircraft based at MCAS New River. The Marine Corps

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\Airfield Location Map_April2012.mxd

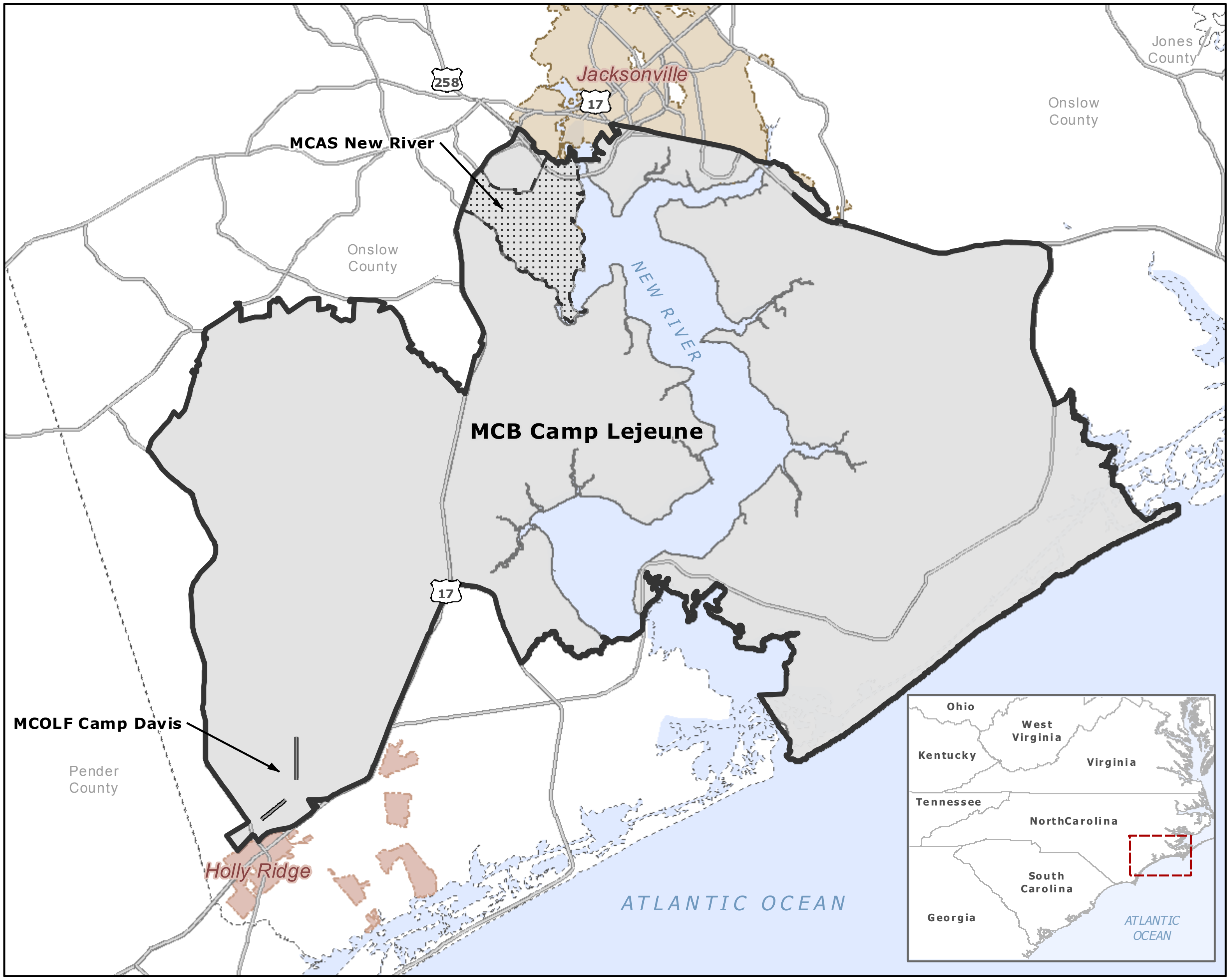


Figure 2-1
Airfield Location and Vicinity Map
MCOLF Camp Davis
North Carolina

Source:
ESRI, 2010; Onslow County, 2011.

subsequently purchased approximately 41,000 acres of land north of the Town of Holly Ridge and west of U.S. Highway 17 in 1992. The acquisition included the land associated with MCOLF Camp Davis and is referred to as the Greater Sandy Run Area (GSRA).

2.2 Mission

MCB Camp Lejeune operates and maintains MCOLF Camp Davis in support of aviation training operations for 2d MAW, which is headquartered out of MCAS Cherry Point. The 2d MAW comprises multiple units, including four Marine Aircraft Groups (MAGs). Each MAG is composed of fixed-wing, rotary-wing, or tilt-rotor aircraft. Each MAG is further divided into several Marine aviation squadrons. Figure 2-2 shows the 2d MAW organization and the two primary users of MCOLF Camp Davis, MAG-26 and MAG-29, which are stationed at MCAS New River.

MCOLF Camp Davis is used primarily by rotary-wing (helicopters) and tilt-rotor (MV-22) aircraft, with minor use by C-130 fixed-wing aircraft. Flight operations at MCOLF Camp Davis are various and include aircraft familiarization flights, air/ground tactical support missions, search-and-rescue training, and night-vision goggle/forward looking infrared training.

2.3 Operational Areas

MCOLF Camp Davis consists of two separate runways that are located northeast and southwest of each other (see Table 2-1). Tactical landing zones (TLZs) Phoenix and Swallow, drop zone (DZ) Duck, and TLZ/ DZ Pheasant are also located at or close to MCOLF Camp Davis.

The airfield is located in restricted airspace (R-5304A/B/C), which extends from the surface up to 17,999 feet mean sea level (MSL).Since the airfield does not have a manned control tower, MCOLF Camp Davis is classified as an uncontrolled airfield.

02:002958-0006-03TTO-Camp Davis MCOLF-B3540\2ndMarineAircraftWingFigure.ai-4/26/12-GRA

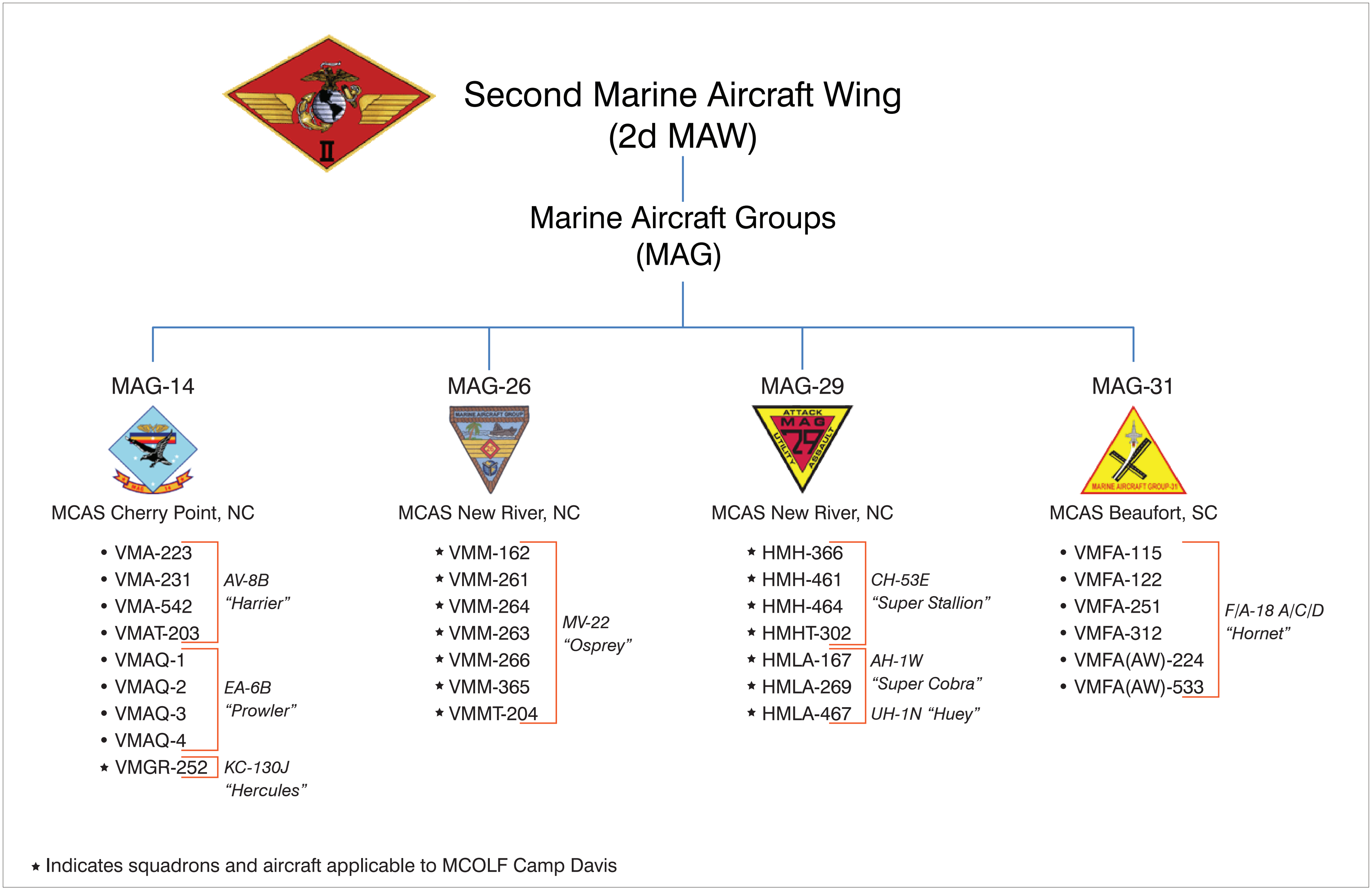


Figure 2-2 2d MAW Aviation Squadrons Located in the Vicinity of MCOLF Camp Davis, North Carolina

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\Camp Davis Location_April2012.mxd

Figure 2-3
MCOLF Camp Davis
Location and Runway Layout

Tactical Landing Zones (TLZ) and Drop Zones (DZ)
MCOLF Camp Davis Runway Centerlines
MCB Camp Lejeune
Town of Holly Ridge
County Boundary

Source:
ESRI, 2010; Onslow County, 2011

0 0.25 0.5 1
Miles

Table 2-1. MCOLF Camp Davis Runways

Runway	Length (feet)	Width (feet)
1/19	5,000	150
05/23	4,500	250

2.4 LOCAL ECONOMIC IMPACTS

Onslow County is home to an active duty, dependent, retiree, and civilian population of nearly 180,000[5]. In fiscal year (FY) 2010, direct economic impact from MCB Camp Lejeune totaled $3.6 billion (B) ($2.16B in total annual payroll). In FY 2011 total economic impact equaled $4.3B ($2.65B in total annual payroll). MCAS New River FY 2011 total economic impact equaled $533 million (M) ($402M in total annual payroll).. Specifically, the economic benefits are from the following sources:

- Employment opportunities and salaries
- Contracts with local businesses for services to support infrastructure
- Local revenues from sales to installation personnel and their families;
- Real estate income in terms of rent and sales of homes owned or occupied by military personnel, dependents, and DOD employees.

MCOLF Camp Davis, on its own, has minimal direct economic impact because it is an unmanned airfield without significant full-time operations staff. However, its use by MCAS New River, MCB Camp Lejeune, and other transient operators makes it a critical asset for local training of thousands of service members in the 2d MAW and II MEF. Hence, MCOLF Camp Davis does contribute indirectly to the local economy.

[5] U.S. Census Bureau 2010.

3

3.1 Aircraft Types
3.2 Local Airspace
3.3 Aircraft Operations
3.3 MCOLF Camp Davis Flight Tracks

Aircraft Operations

MCOLF Camp Davis is used primarily for rotary- and tilt-wing aircraft operations. On rare occasions, certain fixed-wing aircraft such as the C-130 may use the airfield. The aircraft that account for the majority of the operations at the airfield are described below.

3.1 AIRCRAFT TYPES

3.1.1 Tilt-Rotor Aircraft

MV-22 Osprey

The Osprey is a twin-engine, joint-service, multi-mission, tilt-rotor aircraft with vertical take-off and landing capability. It performs vertical take-off and landings like a helicopter while having the range and speed of a twin turboprop aircraft. As the replacement for the CH-46 "Sea Knight," the MV-22 is an assault transport for troops, equipment, and supplies and is capable of operating from ships or from expeditionary airfields ashore.

MV-22 "Osprey"

3.1.2 Rotary-Wing Aircraft

AH-1W Super Cobra

The AH-1W Super Cobra is a twin-engine, day/night marginal weather Marine Corps attack helicopter that provides en route escort for assault helicopters and their embarked forces. The primary mission of the AH-1W aircraft is as an armed tactical helicopter capable of close air support, target search and acquisition, reconnaissance, and troop helicopter support. A new variant, the AH-1Z, is currently being fielded in the Marine Corps inventory. Over the next five to ten years, all Super Cobras used at MCOLF Camp Davis will be AH-1Zs.

AH-1W "Super Cobra"

CH-53E Super Stallion

The Super Stallion is the largest helicopter in the U.S. military inventory. It is a heavy-lift aircraft used by the Marine Corps to transport personnel and equipment. With three engines and a maximum lift capacity of 30,000 pounds, the CH-53E is the only helicopter capable of lifting some of the weapon systems in the Marine Corps, including the M-198 Howitzer. It also can carry up to 55 combat-

CH-53E "Super Stallion"

loaded Marines. A future variant of this aircraft, the CH-53K, is currently in development and is expected to be introduced in the next decade.

UH-1N Iroquois (Huey)

UH-1N "Iroquois (Huey)"

The UH-1Ns are twin-engine helicopters that are widely used in transport, airborne battlefield command and control, troop insertion/extraction, fire support coordination, medical evacuation, search and rescue, reconnaissance, close air support, or utility roles in the Marine Corps. The UH-1N provides utility combat helicopter support to the landing force commander during ship-to-shore movement and in subsequent operations ashore. As with the Super Cobra, the Marine Corps UH-1N inventory is currently being upgraded with the new UH-1Y "Yankee" variant. In accordance with the FY 2012 Marine Aviation Plan, MAG-29 began to receive the UH-1Y variant in FY2011, and transition will be complete in FY2014.

3.1.3 Fixed-Wing Aircraft

KC-130J Hercules

KC-130J "Hercules"

The KC-130 is a four-engine, fixed-wing aircraft used by the Marine Corps for aerial in-flight refueling, cargo, and personnel transport. This aircraft can take off and land in a relatively short distance, making it a valuable asset for Marines ashore. With a takeoff distance as short as 3,127 feet (at 155,000 pounds gross weight), the KC-130J is capable of operating at shorter runways such as those at MCOLF Camp Davis.

3.2 LOCAL AIRSPACE

The use of airspace over MCOLF Camp Davis is dictated by the FAA's National Airspace System. This system is designed to ensure the safe, orderly, and efficient flow of commercial, private, and military aircraft. MCOLF Camp Davis is located in airspace assigned by the FAA to the Washington Air Route Traffic Control Center (ARTCC). "Washington Center" has delegated control of local special use airspace to MCAS Cherry Point Approach Control. Figure 3-1 depicts the location of MCOLF Camp Davis in relation to private and public airfields in the vicinity.

MCOLF Camp Davis is located under restricted airspace R-5304. This airspace extends vertically from the surface of the earth up to 17,999 feet MSL and horizontally over the southern half of the GSRA (see Figure 3-2). This airspace is subdivided into three separate levels. R-5304A is the lowest block of airspace and extends from the ground up to 6,999 feet MSL. The next level, R-5304B, extends from 7,000 feet to 9,999 feet MSL. The uppermost level is R-5304C, which extends from 10,000 feet to 17,999 feet MSL.

To allow civilian aircraft access to the Holly Ridge Air Park, an exclusion zone has been established in R-5304A. This zone limits the restricted airspace starting altitude to 1,500 feet AGL within 3 NM of the Holly Ridge Air Park. This exclusion zone allows civilian aircraft to operate at the air park without entering R-5304A.

3.3 AIRCRAFT OPERATIONS

The main noise source at MCOLF Camp Davis originates from local aircraft operations, including flight arrivals, departures, pattern-work, and low-level activities (i.e., hovering). Engine maintenance operations, also referred to as run-ups, are not conducted at MCOLF Camp Davis.

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\Airspace_April2012.mxd

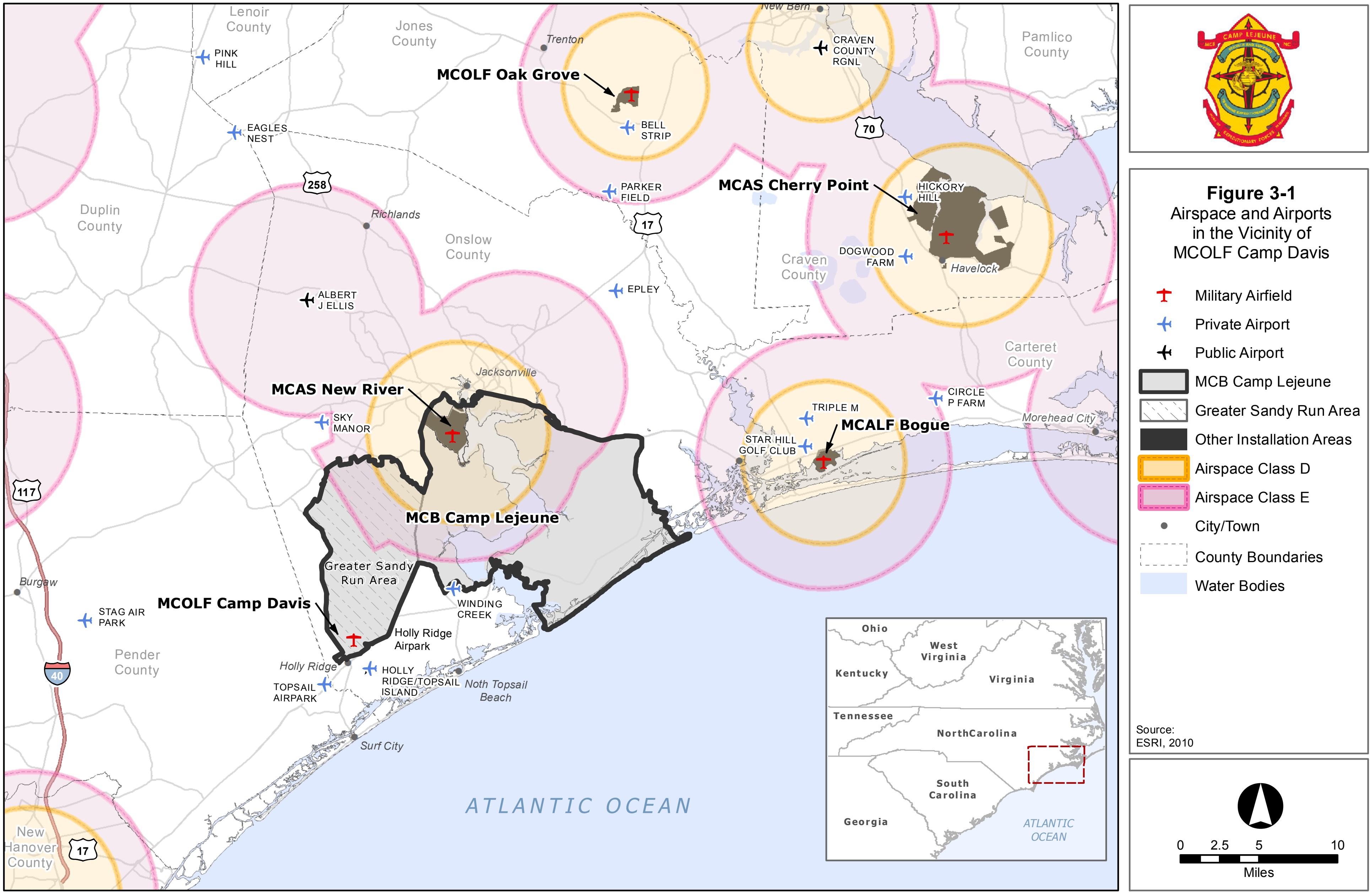


Figure 3-1
Airspace and Airports in the Vicinity of MCOLF Camp Davis

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\SpecialUseAreas.mxd

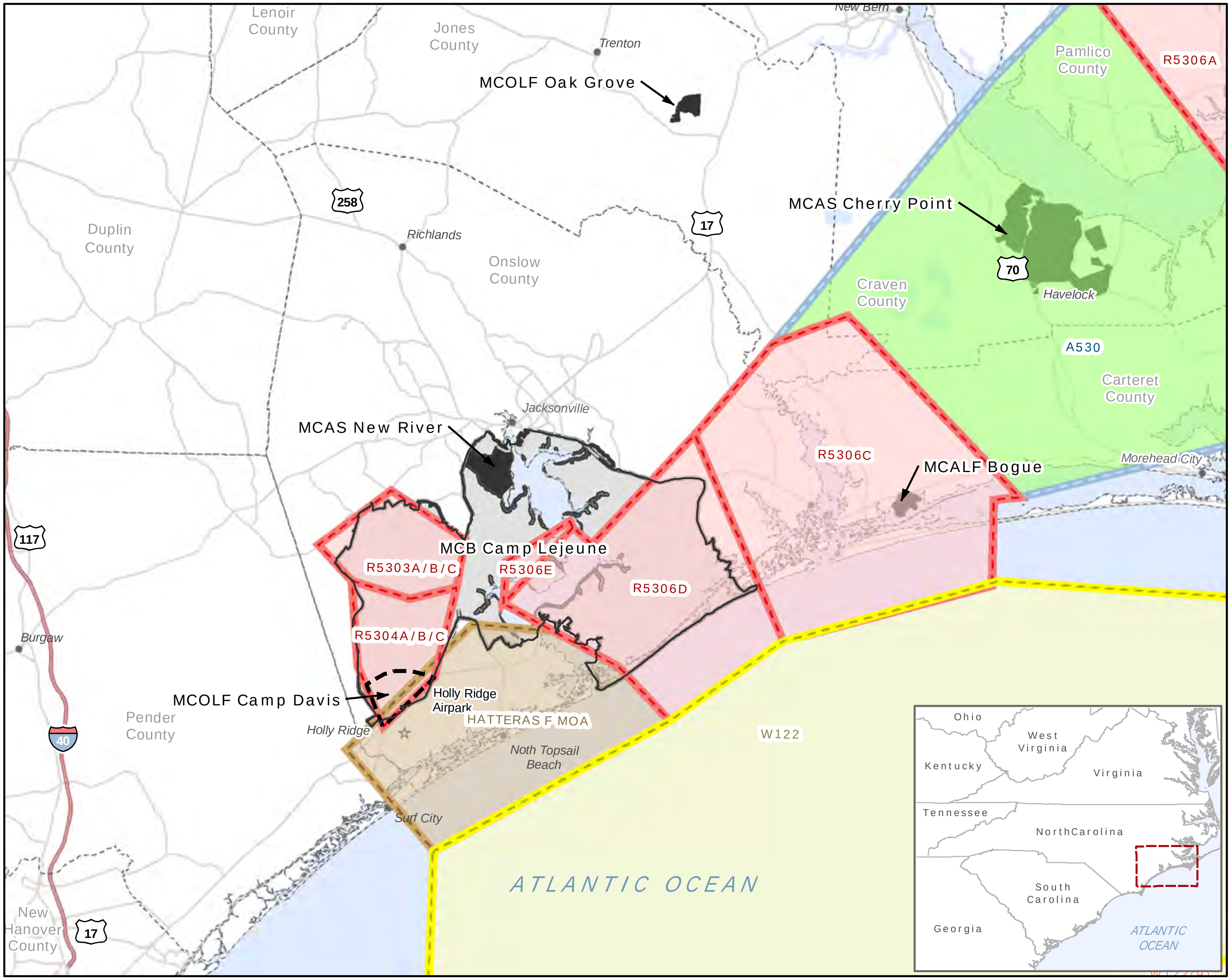


Figure 3-2
Special Use Airspace
in the Vicinity of
MCOLF Camp Davis

- R-5304A Exclusion Area
- Restricted Airspace
- Alert Area
- Military Operation Area (MOA)
- Warning Area
- ☆ Holly Ridge Air Park
- ● City/Town
- MCB Camp Lejeune
- Other Installation Areas
- County Boundaries
- Water Bodies

Source:
ESRI, 2010

0 2.5 5 10
Miles

3.3.1 Typical Flight Operations

Noise modeling requires an accurate count of projected flight operations for each aircraft. A *flight operation* refers to any single takeoff or landing. The takeoff and landing may be part of a training maneuver, such as an oval-shaped flight pattern, or may be associated with the initial arrival or final departure at the airfield. Four basic flight operations at MCOLF Camp Davis were modeled as part of the noise study analysis.

- **Departure.** A single operation event where an aircraft takes off from the runway environment is a departure. This departure could transition into another operation, such as a "touch-and-go," or leave the airfield for another destination. Departures may occur along the extended runway centerline or may transition into a repeated landing pattern.
- **Arrival.** An aircraft coming into the runway environment for a landing, hover, or touch-and-go is an arrival. Arrivals may occur straight in along the extended runway centerline or as part of a repeated landing pattern.
- **Touch-and-Go Pattern.** An aircraft that arrives, lands (or comes to a hover), and then immediately takes off again is considered a touch-and-go. The touch-and-go is counted as two operations: the arrival is counted as one operation, and the departure is counted as the second. This pattern is often repeated multiple times before the aircraft transitions to a departure and leaves the airfield.
- **Hovering.** Helicopters and tilt-rotor aircraft may conduct operations where the aircraft operates in a hover for an extended period without touching the ground.

3.3.2 MCOLF Camp Davis Flight Operations

MCOLF Camp Davis does not have an air traffic control tower, so there is limited data regarding historical operations. Pilots do provide verbal reports to MCB Camp Lejeune Range Control personnel, which are subsequently documented on paper. In order to establish an accurate operational baseline for the airfield, paper-based records for calendar year 2010 were obtained to estimate the number of flight operations. In CY 2010, 22,904 operations were estimated to have been conducted at MCOLF Camp Davis. This includes departures, arrivals, and touch-and-go pattern work for the AH-1W, CH-53E, MV-22, UH-1N, and C-130 aircraft.

To project future operations, the CY 2010 flight operations were evaluated and adjusted to account for anticipated future operations out to the year 2020. Projected cumulative operations counts were estimated to be 27,060, which is an increase of 18% over operations conducted in CY 2010 and approximately equivalent to the operations used in the 1978 study. The estimated 2020 operational tempo was then used to develop the MCOLF Camp Davis 2012 AICUZ noise contours (see Section 4, Aircraft Noise) and APZs (see Section 5, Airfield Safety).

Table 3-1 presents the total projected annual flight operations at MCOLF Camp Davis. Flight operations are classified by aircraft, operation type, and whether the operation occurs during acoustic day or night. Since MCOLF Camp Davis has two runways, the operational counts for each runway are also indicated.

Table 3-1: Projected Annual Air Operations for MCOLF Camp Davis

Aircraft Type	Operation Type[1]	Runway 01/19		Runway 05/23		Total
		Day 0700-2200	Night 2200-0700	Day 0700-2200	Night 2200-0700	
CH-53E	Departure	578	65	85	6	734
	Arrival	578	65	85	6	734
	Closed Patterns	10,394	1,170	1,530	113	13,207
	Total	**11,550**	**1,300**	**1,700**	**125**	**14,675**
AH-1W	Departure	235	51	44	6	336
	Arrival	235	51	44	6	336
	Closed Patterns	2,820	615	524	75	4,034
	Total	**3,290**	**717**	**612**	**87**	**4,706**
UH-1N	Departure	105	18	8	8	139
	Arrival	105	18	8	8	139
	Closed Patterns	1,679	280	120	120	2,199
	Total	**1,889**	**316**	**136**	**136**	**2,477**
MV-22	Departure	189	28	59	8	284
	Arrival	189	28	59	8	284
	Closed Patterns	3,024	448	944	128	4,544
	Total	**3,402**	**504**	**1,062**	**144**	**5,112**

Table 3-1: Projected Annual Air Operations for MCOLF Camp Davis

Aircraft Type	Operation Type[1]	Runway 01/19		Runway 05/23		Total
		Day 0700-2200	Night 2200-0700	Day 0700-2200	Night 2200-0700	
C-130	Departure	15	0	0	0	15
	Arrival	15	0	0	0	15
	Closed Patterns	60	0	0	0	60
	Total	**90**	**0**	**0**	**0**	**90**
Grand Total	Departure	1,122	162	196	28	1,508
	Arrival	1,122	162	196	28	1,508
	Closed Patterns	17,977	2,513	3,118	436	24,044
	Total	**20,221**	**2,837**	**3,510**	**492**	**27,060**

Source: Blue Ridge Research and Consulting 2011.

Notes:
[1] Closed patterns are considered touch-and-go or similar operations.

3.4 MCOLF Camp Davis Flight Tracks

Aircraft using the two runways at MCOLF Camp Davis follow specific paths over the ground during approaches, departures, and touch-and-go patterns. The dimensions of these paths, or flight tracks, vary among the different aircraft. To accurately model aircraft noise, flight tracks for each aircraft were obtained. Figures 3-3 through 3-5 depict all of the flight tracks analyzed in this study. It is important to note that during day-to-day operations, these flight tracks can vary slightly due to aircraft performance, pilot technique, and weather conditions.

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\Arrival Flight Tracks_April2012_v2.mxd

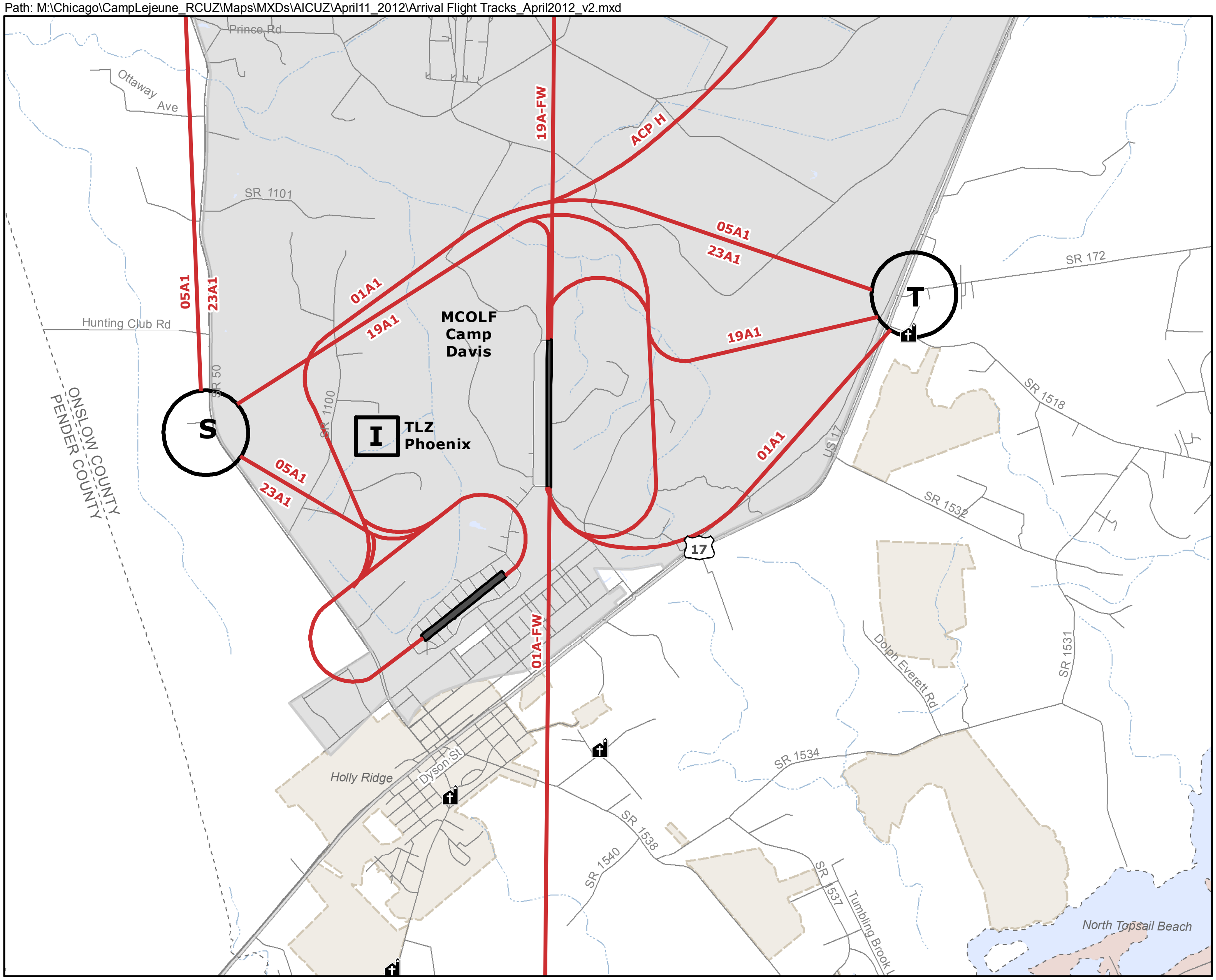


Figure 3-3
Aircraft Arrival
Flight Tracks
MCOLF Camp Davis
North Carolina

Church
Arrival Flight Track
Runway
MCB Camp Lejeune
Town of North Topsail Beach
Town of Holly Ridge
County Boundary

Source:
ESRI, 2010; Onslow County, 2011

0 0.25 0.5 1
Miles

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\Departure Flight Tracks_April2012_v2.mxd

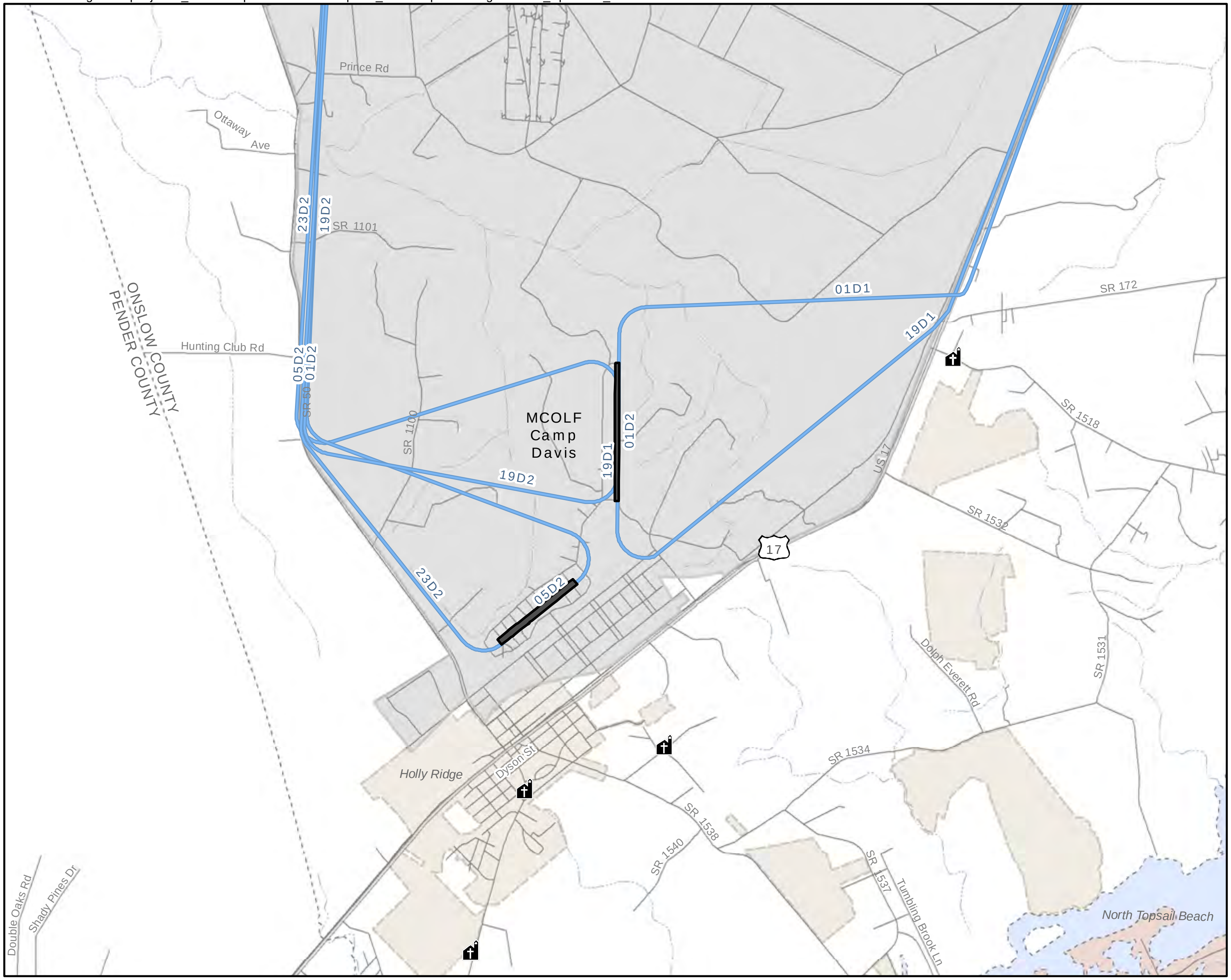


Figure 3-4
Aircraft Departure
Flight Tracks
MCOLF Camp Davis
North Carolina

Church
Departure Flight Track
Runway
MCB Camp Lejeune
Town of North Topsail Beach
Town of Holly Ridge
County Boundary

Source:
ESRI, 2010; Onslow County, 2011

0 0.25 0.5 1
Miles

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\Closed Pattern Flight Tracks_April2012.mxd

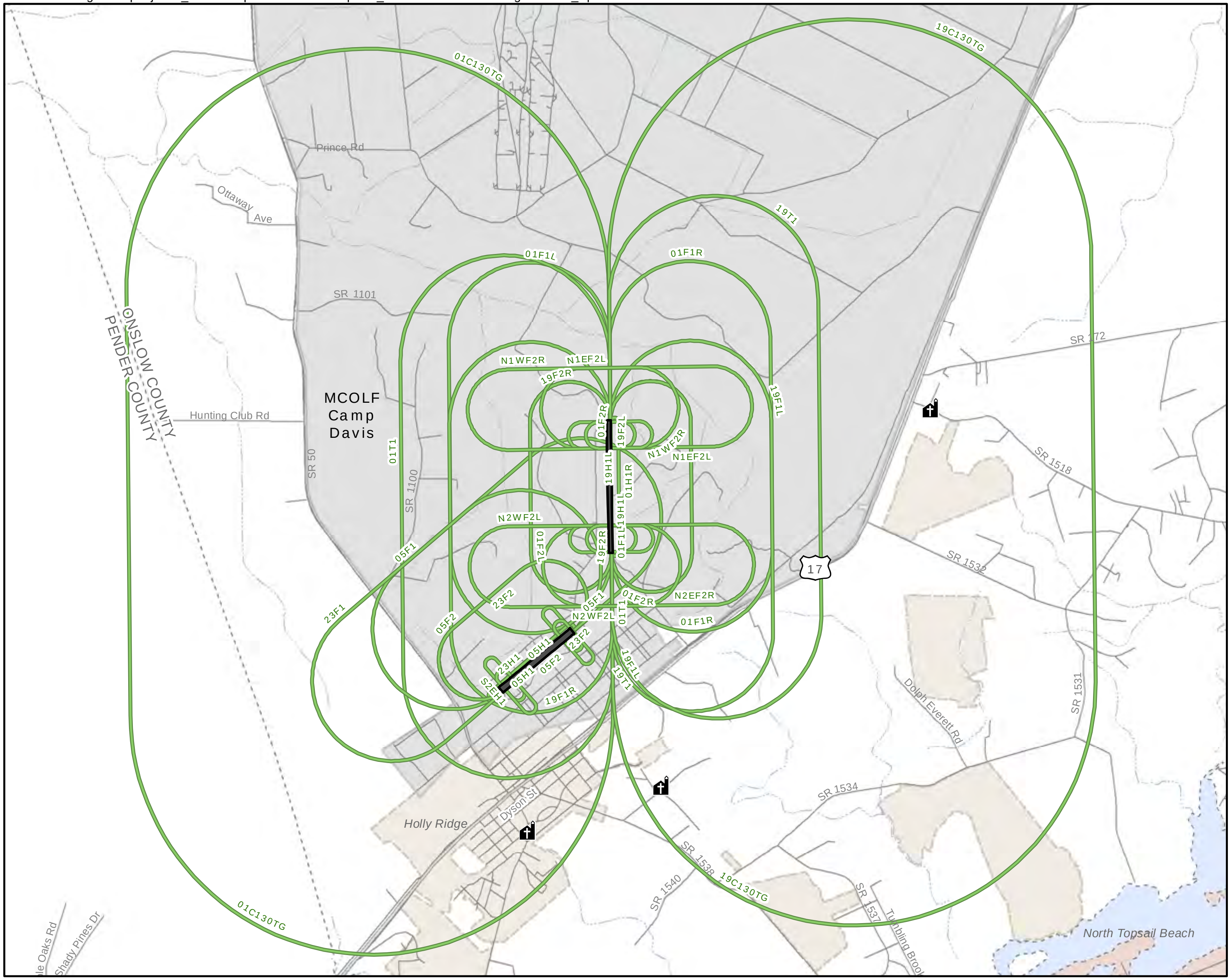


Figure 3-5

Aircraft Landing Pattern
Flight Tracks
MCOLF Camp Davis
North Carolina

- Church
- Closed Pattern Flight Track
- Runway
- MCB Camp Lejeune
- Town of North Topsail Beach
- Town of Holly Ridge
- County Boundary

Source:
ESRI, 2010; Onslow County, 2011

0 0.25 0.5 1
Miles

4

Aircraft Noise

4.1 What is Sound/Noise?
4.2 Airfield Noise Sources
4.3 Noise Abatement and Complaints
4.4 2012 AICUZ Noise Contours

The impact of aircraft noise is a critical factor in planning future land uses near air facilities. MCB Camp Lejeune has defined certain areas in the vicinity of MCOLF Camp Davis as noise zones under the AICUZ program. This section discusses noise associated with aircraft operations at MCOLF Camp Davis, including average noise levels, noise complaints, noise abatement/flight procedures, and the 2012 AICUZ noise contours.

4.1 What is Sound/Noise?

Sound results from vibrations in the air, and “noise” can be defined as unwanted sound. Potential sources of noise include roadway traffic, railway activities, and aircraft operations. Whether sound becomes noise depends on the listener, but sound typically becomes noise when it interferes with normal activities. Appendix A of this document contains a detailed explanation of noise and noise exposure issues.

In this study, all noise levels are measured in A-weighted decibels (dBA). This metric adjusts sound pressure levels to the range of human hearing with intensity greater than the ambient or background sound pressure. Normal speech has a noise level of approximately 60 dBA. For reference, the threshold of hearing is zero dBA, and the threshold of pain is 140 dBA.

The noise exposure from aircraft operations is measured using the day-night average sound level (DNL) metric. The DNL, 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. DNL is an average of the sound levels at specific location over a 24-hour period.

Common Measurements of Noise/Sound

Decibels (dB): A unit of measurement used to represent sound intensity.

A-Weighted Decibels (dBA): The relative loudness of sounds 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.

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

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

A feature of DNL is that it adds an additional 10 dB "penalty" to events occurring between 10:00 p.m. and 7:00 a.m. This 10 dB increase reflects the added intrusiveness of sounds that occur during normal sleeping hours. This is because people are more sensitive to noise during those hours and because ambient sound levels at night are typically lower.

By combining factors most noticeable about noise annoyance—maximum noise levels, duration, and the quantity of flight events over a 24-hour period—the DNL provides a single measure of overall noise impact. Scientific studies and social surveys on community annoyance from noise have found DNL to be the best measure of that annoyance.[6,7,8]

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 DNL of 65 dBA could result from a small number of loud events or a large number of quieter events.

The AICUZ study shows DNL noise contour values in 5 dBA increments. DNL increments of 60 dBA, 65 dBA, 70 dBA, 75 dBA, and 80 dBA are graphical depictions of ranges of noise exposure plotted on maps. These noise contours are then grouped into three categories known as noise zones:

- **Noise Zone 1:** Less than 65 dBA DNL; low or no noise impact.
- **Noise Zone 2:** 65 to 74 dBA DNL; moderate impact, where some land use controls are required.
- **Noise Zone 3:** 75 dBA DNL and greater; most severely affected area and requires the greatest degree of land use control.

[6] Federal Interagency Committee on Noise 1992.
[7] U.S. Environmental Protection Agency April 1982.
[8] American National Standards Institute 1990.

4.2 Airfield Noise Sources

The main sources of noise at MCOLF Camp Davis are aircraft flight operations. The Marine Corps used computer models to develop noise contours based on the following information:

- Type of operation (arrival, departure, and pattern)
- Number of operations per day, with special consideration given to operations at night
- Time of operation
- Flight track location and dimensions
- Aircraft power settings, speeds, altitudes, rotor blade pitch angle and/or nacelle angle
- Terrain and surface type
- Environmental data (temperature and humidity).

4.3 Noise Abatement and Complaints

MCB Camp Lejeune takes precautions to reduce noise impacts on sensitive areas located near the airfield. However, with the training requirements and high level of activity at MCOLF Camp Davis, MCB Camp Lejeune and MCAS New River have received noise complaints. Local noise abatement and noise complaint procedures for MCOLF Camp Davis are discussed below.

4.3.1 Noise Abatement

MCB Camp Lejeune and the squadrons using MCOLF Camp Davis actively pursue noise-reduction measures. The Marine Corps conducts noise-abatement procedures to the best of its ability, commensurate with safety and operational training requirements. Table 4-1 summarizes local noise abatement procedures for MCOLF Camp Davis.

Table 4-1: Noise Abatement Flight Procedures, MCOLF Camp Davis

MCOLF Camp Davis
Noise Abatement ▪ Pilots shall avoid overflight of residences and livestock containment areas in the vicinity of MCOLF Camp Davis and shall adhere to rules of the road (right side) along U.S. Highway 17 when transitioning between MCAS New River and MCOLF Camp Davis. Avoid overflight of Dixon Middle/High Schools by one-half mile horizontal and 1,000 feet vertically. ▪ Pilots entering or departing MCOLF Camp Davis shall remain north and west of U.S. Highway 17 when within a three nautical mile (nm)-radius of MCOLF Camp Davis to avoid civilian air traffic conflicts and for noise abatement over the Town of Holly Ridge.

Source: Camp Lejeune Base Order 3570.1C (2 May 2011).

4.3.2 Noise Complaints

Noise complaints are related to the intensity and frequency of the events as well as the individual sensitivity of the person hearing the noise. Individual sensitivity and response to noise levels varies from person to person. Complaints from outside the areas depicted by noise contours can and do occur. Often this is due to a single event that is unusual, such as when an aircraft flies over an area not commonly overflown. Factors influencing sensitivity include:

- The activity an individual was engaged in at the time of the noise event
- The individual's general sensitivity to noise
- The time of day or night
- The length of time an individual is exposed to a noise
- The predictability of noise
- Weather conditions.

Both MCB Camp Lejeune and MCAS New River receive occasional noise complaints due to operations at MCOLF Camp Davis. MCB Camp Lejeune is responsible for recording and investigating these complaints to determine if any corrective actions are appropriate.

4.4 2012 AICUZ Noise Contours

Noise contour maps provide a military installation, local planning organizations, and the public with a graphical representation of potential noise-related impacts.

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

Noise contours, when overlaid with local land uses, create a useful tool to help the Marine Corps, local planning organizations, and the public locate and address any incompatible land uses and can assist in planning for future development. The AICUZ process calls for modeling and analyzing existing conditions and any future aircraft operational changes that can reasonably be predicted. Using the operational counts and flight tracks described in Section 3, the MCOLF Camp Davis 2012 AICUZ noise contours were developed using DOD-approved computer-based models.

The noise contours in this study are the 2012 AICUZ noise contours. They represent current and potential operations projected out to CY 2020. Aircraft operations are projected into the future to help ensure that the future operational capability of the air installation is considered. As a planning document, this AICUZ study forecasts aircraft operations approximately 10 years into the future to assess the airfield's impact on the local community.

4.4.1 1978 AICUZ Noise Contours

As mentioned previously, the last time that aircraft noise was modeled for MCOLF Camp Davis was in 1978. To provide the installation and the community with a historical context of where noise contours were located, Figure 4-1 depicts the 1978 AICUZ noise contours. As the figure illustrates, the historic noise contours remained within the confines of what is now MCB Camp Lejeune property. In 1978, only the noise contours between 65 and 75 DNL were modeled.

4.4.2 2012 AICUZ Noise Contours

As in 1978, the 2012 noise contours remain on MCB Camp Lejeune property (see Figure 4-2). Projected runway use data illustrated an increase in the use of the northern runway with a corresponding decrease in operations at the southern runway closest to the Town of Holly Ridge. The 2012 noise contours depict this change in operations with larger contours surrounding the northern

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\1978 Noise Contours_041212.mxd

Figure 4-1
1978 AICUZ Noise Contours
Average Annual Day DNL
MCOLF Camp Davis
North Carolina

Church
Runway
MCB Camp Lejeune
Town of Holly Ridge
1978 Noise Contour
65 DNL
70 DNL

Source:
ESRI, 2010; Onslow County, 2011

0 0.25 0.5 0.75
Miles

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\2012 Noise Contours_April2012.mxd

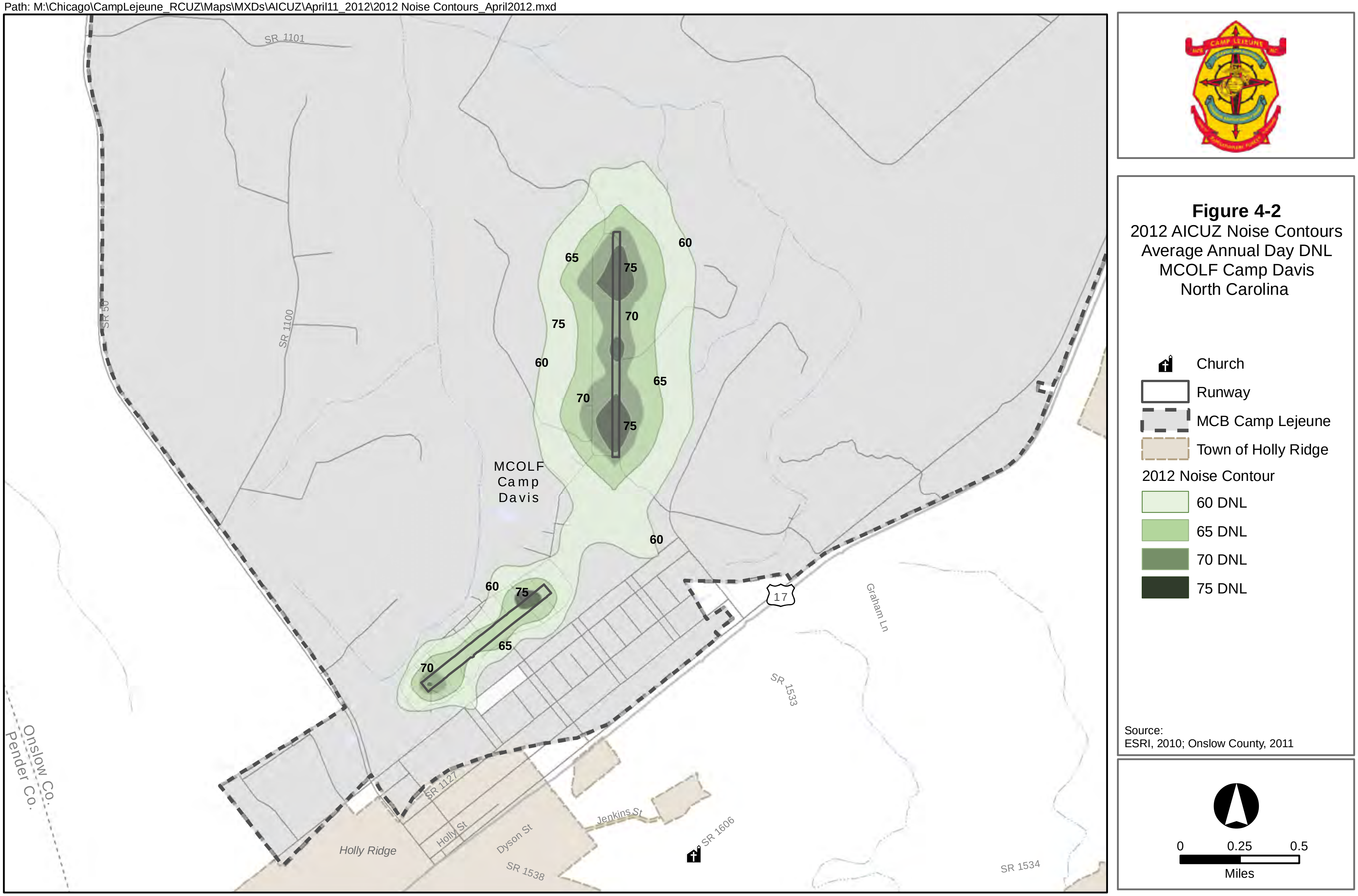


Figure 4-2
2012 AICUZ Noise Contours
Average Annual Day DNL
MCOLF Camp Davis
North Carolina

Source:
ESRI, 2010; Onslow County, 2011

runway and smaller contours on the southern runway. The noise contours remain on government property in a designated military training area.

4.4.3 Comparison of 1978 and 2012 AICUZ Noise Contours for MCOLF Camp Davis

The 2012 AICUZ noise contours for MCOLF Camp Davis have changed compared with the 1978 contours. In 1978, the larger noise contour was located around Runway 05/23, which is the runway closest to the Town of Holly Ridge. The updated 2012 AICUZ noise contours depicted in Figure 4-2 illustrate that the larger noise contour now is around Runway 01/19, which is located further north. Table 4-2 provides a comparison of the amount of land acreage that is located inside the noise zones of both the 1978 and 2012 studies.

Table 4-2: Areas within Noise Zones (1978 and 2012), MCOLF Camp Davis

Noise Zone	TOTAL LAND AREA (IN ACRES)	
	1978 AICUZ Noise Zones	2012 AICUZ Noise Zones
60-65 DNL	-	392.27
65-70 DNL	341.65	179.23
70-75 DNL	48.31	85.53
>75 DNL	-	39.11
TOTAL AREA	**389.96**	**696.14**

The difference between the contours is due to a number of factors. First, the proportion of aircraft using the northern runway has increased as compared with the southern runway. Secondly, the Marine Corps has acquired new types of aircraft with different noise signatures. Finally, noise-modeling techniques have also changed, and the modeling applications used today are more precise.

It is important to note that noise from operations at MCOLF Camp Davis does not necessarily stop at the installation boundary or at the edges of the noise contours. Depending on weather, specific aircraft flight profiles, and local geography, aircraft noise can travel beyond the source. Figure 4-3 illustrates how sound from operations at MCOLF Camp Davis disperses and decreases in loudness beyond the 2012 AICUZ contours.

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\Noise_Gradient.mxd

Figure 4-3
Estimate of Noise Propagation from Operations at MCOLF Camp Davis North Carolina

MCB Camp Lejeune
2012 Noise Contour
<10 dBA DNL
<30 dBA DNL
< 50 dBA DNL
>50 dBA DNL

Source:
ESRI, 2010; Onslow County, 2011

0 1 2
Miles

This page intentionally left blank.

5 Airfield Safety

5.1 Accident Potential Zones
5.2 Flight Safety

The Marine Corps has identified airfield safety issues that necessitate the development of compatible land uses to ensure the health and safety of the community while allowing the installation to continue its operations. These issues include accident potential and hazards within the airfield vicinity that obstruct or interfere with aircraft approaches and departures, pilot vision, communications, or aircraft electronics.

While the likelihood of an aircraft mishap occurring is remote, the Marine Corps has identified areas of accident potential at MCOLF Camp Davis to assist in land use planning. These accident potential zones (APZs) are areas where a mishap is most likely to occur if one were to occur. APZs are not predictors of accidents (see Section 5.1.2 for a discussion of APZ requirements and dimensions).

In addition, the FAA and the military have also defined flight safety zones (imaginary surfaces) below aircraft arrival and departure flight tracks and surrounding the airfield. For the safety of the aircraft, the heights of structures and vegetation should be restricted in these zones. The flight safety zones are designed to maximize the safety of aircraft using an airfield while minimizing the potential harm if a mishap does occur. Other hazards to flight safety that should be avoided near the airfield include the following:

- Uses that would attract birds, especially waterfowl
- Lighting (direct or reflected) that would impair pilot vision
- Uses that would generate smoke, steam, or dust
- Electromagnetic interference with aircraft communication, navigation, or other electrical systems.

5.1 ACCIDENT POTENTIAL ZONES

5.1.1 Aircraft Mishaps

Recognizing the need to identify areas of accident potential, the military conducted a tri-service study in the 1970s of historic accident and operations data throughout the military. The study showed that most aircraft mishaps occur on or near the runway or along the runway centerline. The likelihood decreased with distance from the airfield.

There are three classes of aircraft mishaps. The most severe is a Class "A" mishap. A Class "A" mishap is an accident in which the total cost of damage to property or aircraft exceeds $2 million, an aircraft is destroyed or missing, or any fatality or permanent total disability results from the incident. Class "B" mishaps result in damages exceeding $500,000 but are less than $2 million and/or involve permanent partial disability and/or hospitalization of five or more personnel. A Class "C" mishap is the least severe—property damage cost is between $50,000 and $200,000 and/or involves injury that results in a loss of five workdays. Since 1980, there have been zero Class A mishaps at MCOLF Camp Davis.

5.1.2 APZ Requirements and Dimensions

In accordance with OPNAVINST 11010.36C/MCO 11010.16, all active runways are required to have a CZ. The placement and dimensions of APZs depend upon the classification of the runway, the number of operations for a given runway flight track, and the shape of the flight track. MCOLF Camp Davis comprises two tilt-rotor OLF runways.

Because helicopters and the MV-22 tilt-rotor aircraft are the primary users of MCOLF Camp Davis, the installation determined that APZ requirements for rotary-wing airfields and tilt-rotor runways were the most relevant to this study. The MCB Camp Lejeune Commanding Officer submitted a request (Appendix C) to amend the Unified Facilities Criteria (UFC) 3-260-1, Airfield and Heliport Planning and Design, for airfield clearance criteria associated with Tilt-Rotor (MV-22) Aircraft Outlying Fields. The draft amendment was reviewed by the Naval Air Systems Command and endorsed by USMC leadership. Since UFC 3-260-1 applies to all Military Departments, incorporation of the draft amendment into the UFC is pending review by the Air Force and Army. The 2012 MCOLF Camp Davis APZs were developed using the criteria identified in the draft UFC amendment (Appendix C). This is also consistent with the MCOLF Oak Grove AICUZ study dated June 2011.

The components of these zones for tilt-rotor aircraft operating at an OLF are identified in Figure 5-1 and are defined as follows:

- Clear Zone (CZ). This is the area immediately beyond the runway/helipad threshold. This zone has the greatest potential for aircraft accidents because this is where the pilots are transitioning to forward flight or completing the landing phase close to the ground. The CZ should remain undeveloped and clear of obstructions to flight. The CZ measures 1,000 feet wide and extends 400 feet immediately beyond the end of the primary surface. The primary surface itself extends 200 feet beyond the end of each runway. A CZ is required for all active runways and should remain undeveloped.
- APZ-I. This is the area immediately beyond the CZ that still has a measurable, but lower, potential for accidents relative to the CZ. This zone for tilt-rotor aircraft is 1,000 feet wide and extends 800 feet beyond the CZ.
- APZ-II. This is an area beyond APZ I (or CZ if APZ-I is not required) that has the lowest measurable potential for mishaps relative to the APZ-I and the CZ. This zone is not required for MCOLF Camp Davis.

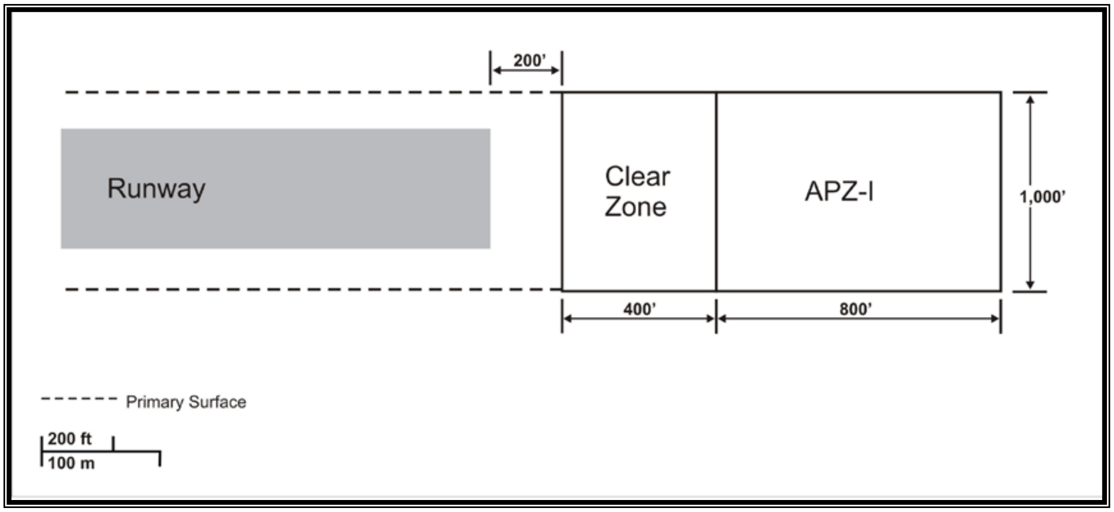


Figure 5-1: Tilt-Rotor OLF Accident Potential Zones

Very few land uses are compatible with military aircraft operations within the CZ. For this reason, the Marine Corps typically acquires sufficient real property interests in land within this zone to ensure incompatible development does not occur. Within APZ-I, a variety of land uses are compatible; however, people-intensive uses (e.g., schools, apartments) should be restricted because of the greater risk in these areas. When development results in threats to the mission of the installation, and when local communities are unwilling or unable to take the necessary steps to promote land use compatibility via their own land use and zoning authority, the Marine Corps may consider land acquisition or restrictive easements.

5.1.3 MCOLF Camp Davis Clear Zones and APZs

Figure 5-2 depicts the 2012 CZs and APZs for MCOLF Camp Davis. The CZ consists of 37 acres, and APZ-I is 73 acres in size. All of this acreage is contained within MCB Camp Lejeune property. There are no associated incompatible land uses in the surrounding community. APZs were not evaluated in the 1978 AICUZ study, so there are no available data to compare for changes in the size of these zones.

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\2012 APZs_041212.mxd

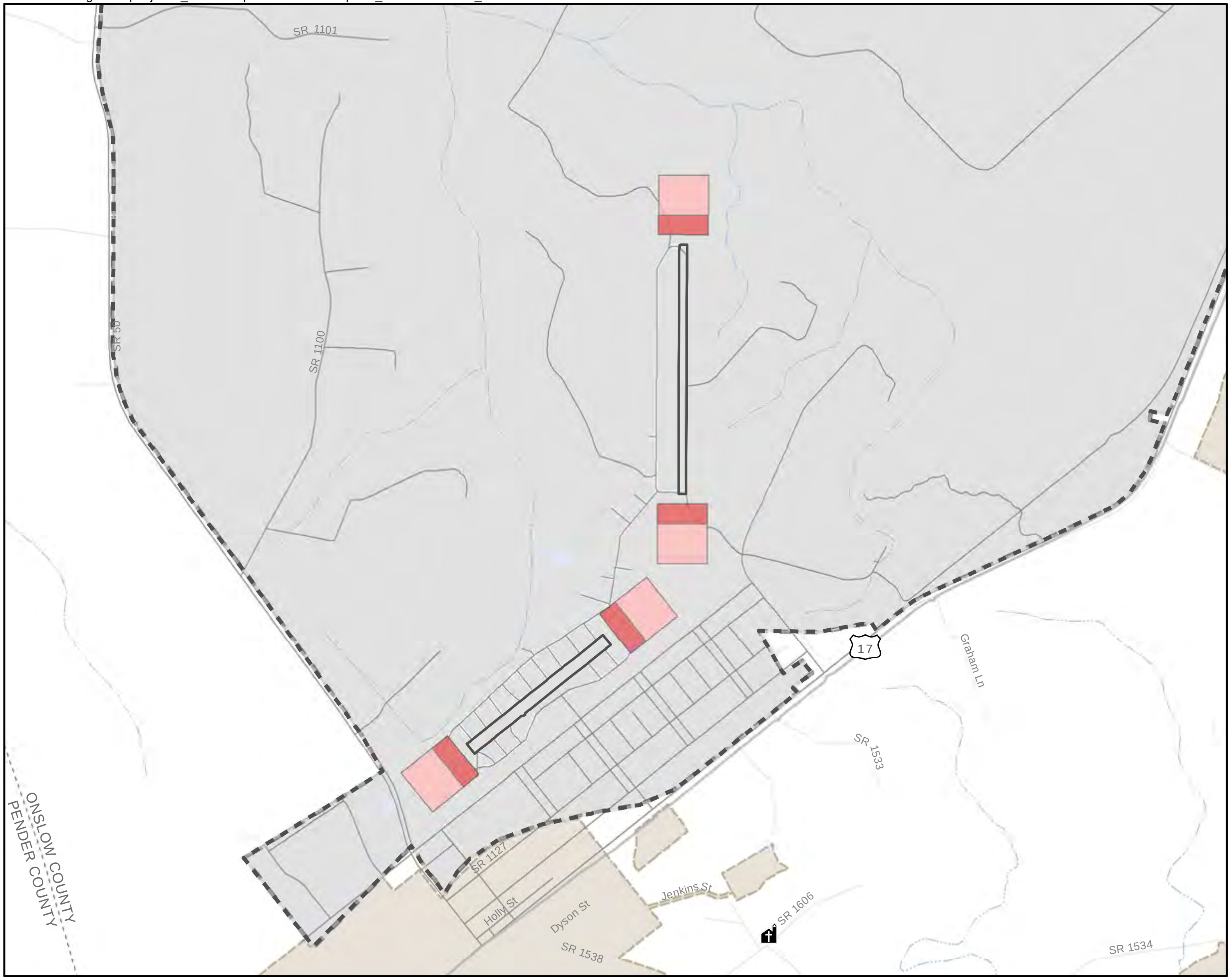


Figure 5-2
2012 AICUZ Accident Potential Zones (APZs)
MCOLF Camp Davis
North Carolina

Church
Runway
MCB Camp Lejeune
Town of Holly Ridge
Accident Potential Zone
Clear Zone
APZ I
County Boundary

Source:
ESRI, 2010; Onslow County, 2011

0 0.25 0.5
Miles

5.2 FLIGHT SAFETY

5.2.1 Imaginary Surfaces

Typically, the closer the aircraft is to the airfield, the closer it is to the ground. The closer the aircraft is to the ground, the higher the likelihood that a building, tower, or tree will become a hazard to flight. Imaginary flight surfaces define the required airspace that must remain free of obstructions to ensure safety of flight near an airfield. These obstructions may include natural features such as trees and manmade features such as buildings, towers, and other vertical objects. Table 5-1 describes the imaginary surfaces for tilt-rotor OLF runways.

Table 5-1: Airspace Imaginary Surfaces for Tilt-Rotor OLFs

Planes and Surfaces	Geographical Dimensions
Primary Surface	An area surrounding the runway that is 1,000 feet wide and centered on the runway centerline. The area extends 200 feet beyond the end of the runway.
Clear Zone	Extends 400 feet beyond the end of the primary surface and is 1,000 feet wide.
Accident Potential Zone I	Extends 800 feet beyond the end of the clear zone and is 1,000 feet wide.
Approach/Departure Surface	A trapezoidal shape that begins at the end of the primary surface at ground level and extends 8,000 feet at a 20:1 slope (horizontal to vertical) to an altitude of 400 feet above the runway elevation. The width at the primary surface is 1,000 feet and gradually increases to a maximum width of 3,400 feet.
Horizontal Surface	An oval-shaped surface located at 150 feet above the runway elevation. The oval shape is constructed by creating an arc that is 4,600 feet away from the entire length of the runway centerline.
Transitional Surface	This surface starts at the lateral edges of the primary surface and extends outwards and upward at a 2:1 slope to an elevation of 150 feet above the runway elevation. The transitional surface extends along the length of the runway until it reaches the approach/departure surface.

Figure 5-3 depicts the 2012 imaginary surfaces for MCOLF Camp Davis. This figure shows that some of the 2012 imaginary surfaces for MCOLF Camp Davis extend beyond the installation boundary. The FAA monitors and documents height obstructions that may affect navigable airspace. There are three height obstructions currently documented by the FAA that either are within the imaginary surfaces or are located close to the airfield.

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\2012 Imaginary Surfaces_041212.mxd

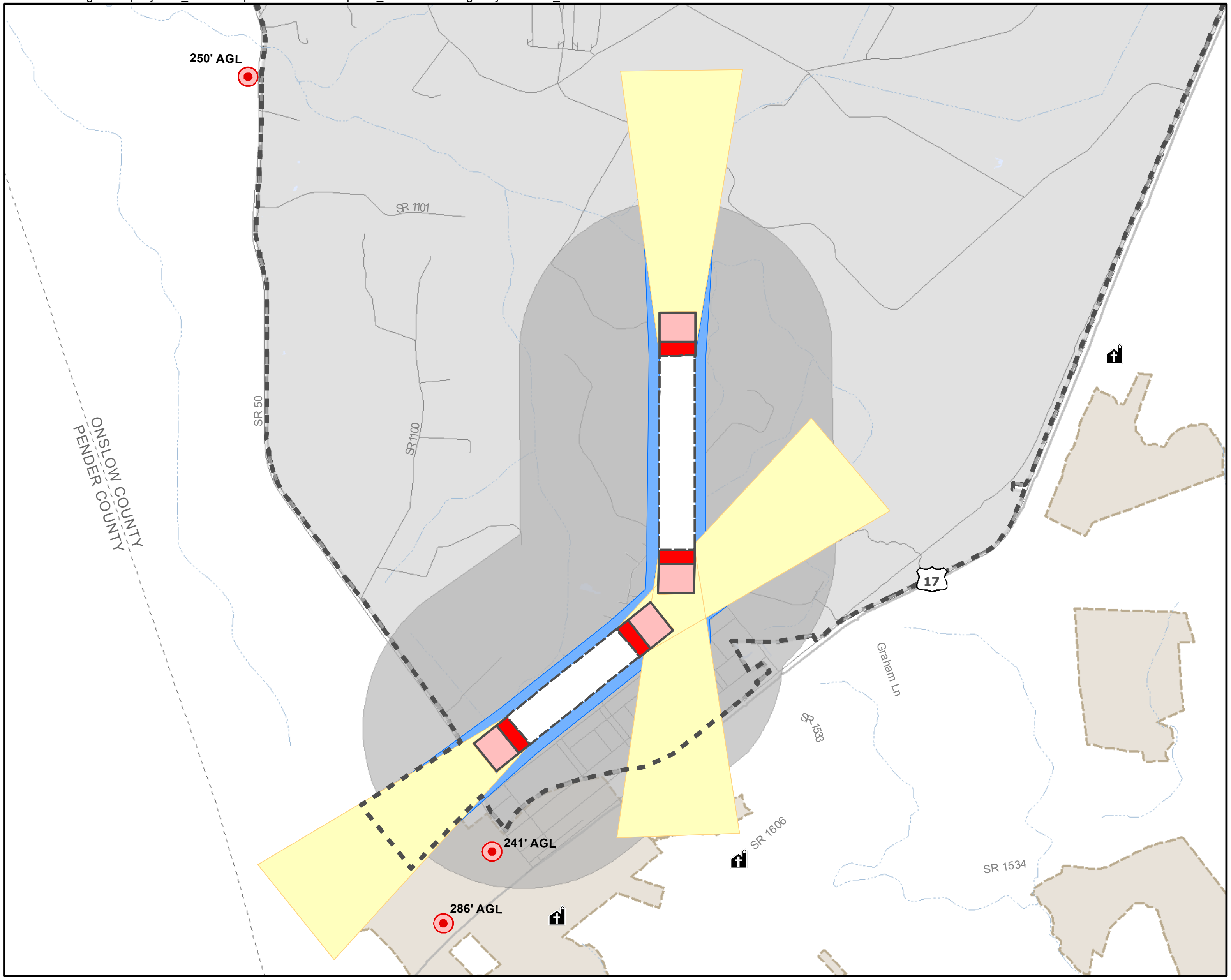
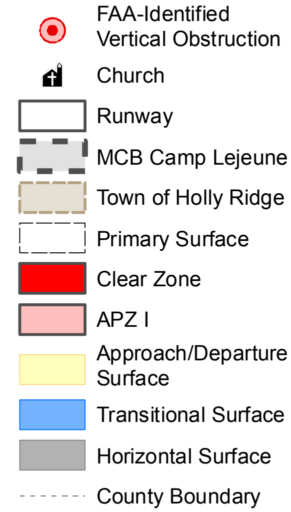


Figure 5-3
Imaginary Surfaces for MCOLF Camp Davis



Source:
ESRI, 2010; Onslow County, 2011;
FAA, 12/15/2011.

5.2.2 Bird and Wildlife Aircraft Strike Hazards

Wildlife represents a significant hazard for flight operations. Birds, in particular, are drawn to the open, grassy areas, wetlands, and warm pavement of the airfield. Seventy-eight percent of bird strikes occur below 1,000 feet AGL and 90% occur below 3,000 feet AGL (Federal Aviation Administration 2007). Because of the speed of the aircraft, collisions with wildlife can happen with considerable force. Although most bird and wildlife strikes do not result in crashes, they can cause structural and mechanical damage to aircraft and require extensive inspections and potential repairs.

To reduce bird/wildlife aircraft strike hazards (BASH), the FAA recommends a minimum distance of 10,000 feet between the airfield serving turbine-powered aircraft and land uses that attract birds and other wildlife (Federal Aviation Administration 2007). These land uses include waste disposal operations, wastewater management facilities, wetlands, storm water ponds, golf courses, and agricultural activities.

5.2.3 Electromagnetic Interference (EMI)

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. American National Standards Institute (ANSI) defines EMI as any electromagnetic disturbance that causes, or is capable of causing, undesired responses or degradation of performance in electrical or electronic equipment. It can be induced intentionally, as in forms of electronic warfare, or unintentionally, as a result of spurious emissions and responses, such as high-tension line leakage.

As the demand for alternative energy sources increases, the implementation of wind turbines and wind farms is resulting in a new source of EMI that can affect air- and ground-based radar systems. As the blades of a wind turbine spin, they can cause interference and “clutter” with radar systems (The MITRE Corporation 2008). Since the military uses a variety of radar systems on a day-to-day basis, the adverse effects of wind farms on military systems can degrade the capabilities of an installation (U.S. Department of Defense 2006).

5.2.4 Lighting

Bright lights in the airfield vicinity can impair a pilot's vision. 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 until their night vision returns. This is particularly dangerous at night when the flash can diminish the eye's adaptation to darkness. Partial recovery is usually achieved in minutes, but full adaptation typically requires 40 to 45 minutes.

5.2.5 Smoke, Steam, and Dust

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

This page intentionally left blank.

6

6.1 Land-Use Compatibility Guidelines and Classifications
6.2 Planning Authorities
6.3 Land-Use Compatibility Analysis
6.4 Compatibility Concerns

Land Use Compatibility Analysis

The APZs and noise zones comprise the composite AICUZ map for an air installation. The AICUZ map defines the minimum recommended area within which land use controls are needed to protect the health, safety, and welfare of those living near a military airfield and to preserve the military flying mission. The AICUZ map is the fundamental tool necessary for the AICUZ planning process.

The information presented in this chapter is intended for consideration by MCB Camp Lejeune, government entities at the local and state level, surrounding communities, or other interested groups. The purpose of this AICUZ study is to encourage cooperative land use planning between the Marine Corps and the external stakeholders surrounding MCOLF Camp Davis. The goals are to ensure that future growth and development are compatible with the operational missions while seeking ways to lessen the operational impacts on adjacent land. Although ultimate control over land use and development surrounding the installation is the responsibility of local governments, the Marine Corps encourages local governments to work with MCB Camp Lejeune to plan for compatible development.

6.1 Land Use Compatibility Guidelines and Classifications

The Navy and Marine Corps have jointly published land use compatibility recommendations for APZs and noise zones. Table 6.1 provides a summary of more frequent land uses and their associated compatibilities. Appendix B of this study provides a complete table of these recommendations.

Certain land uses are incompatible with noise zones and APZs, while other land uses may be considered compatible or compatible under certain conditions. Noise-sensitive land uses, such as churches and schools, should be avoided in high-noise zones. Uses that may result in a high density of people congregating in a smaller area, such as apartment complexes and shopping centers, should not be placed in APZs.

6.2 Planning Authorities

Military installations can make recommendations or advise local government and agencies on land use outside the fence, but development of the land is dictated by local land use planning, ordinances, and regulations.

The development and control of land outside of the installation fence are beyond the direct authority of the Marine Corps. Local government controls development of these lands through land use ordinances, regulations, and planning studies. MCOLF Camp Davis is located within the boundaries of MCB Camp Lejeune in Onslow County, North Carolina. A portion of the airfield also lies within the extraterritorial jurisdiction of the Town of Holly Ridge. Therefore, both Onslow County and the Town of Holly Ridge are the land use authorities for off-installation property lying within their respective jurisdictions near the airfield.

By legislative action, the State of North Carolina also has a role in land use planning as it applies to military installations. Both Sections 153A-323(b) and 160A-364 of the North Carolina General Statutes require that Onslow County and the Town of Holly Ridge provide written notice of any proposed changes to zoning or land uses within five miles of the installation perimeter to the MCB Camp Lejeune Commanding General at least ten days prior to the public hearing date. If the installation provides comments or analysis on the proposed ordinance or amendment, the local governing body must consider these comments before making a final determination.

Table 6-1. Land-Use Classifications and Compatibility Guidelines

	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	55-64	65-69	70-74	75-79	>80			
Single-Unit Residential (detached)									(1)
Multi-Family Residential, (apartment, transient lodging)									
Public Assembly									
Schools and Hospitals			(2)	(2)					
Manufacturing (e.g., petrol/chem.; textile)									
Retail Trade			(2)	(2)					
Parks				(2)				(4)	(4)
Business Services				(2)	(2)			(3)	(3)
Agriculture, Forestry, and Mining									

Source: Adapted from OPNAVINST 11010.36C/MCO 11010.16 (Navy 2008)

Notes:
This generalized land use table provides an overview of recommended land uses. To determine specific land use compatibility, see Appendix B.
(1) Maximum density of 1 to 2 dwellings per acre.
(2) Land use and related structures generally compatible; however, measures to achieve NLR 25 or 30 must be incorporated into design and construction of the structures.
(3) Maximum floor area ratio that limits people density may apply.
(4) Facilities must be low intensity.

Key:

	Compatible
	Incompatible

6.2.1 Onslow County

Onslow County has been conducting land-use planning since 1975. Its first land- use planning document was completed in 1981 in response to a substantial increase in personnel at MCB Camp Lejeune. This increase in installation population had a significant impact on the county's economy and land use trends. The initial plan laid out a basic framework for how the county should develop in light of mounting development pressures.

In 1991, the county adopted its first Coastal Area Management Act (CAMA) Land Use Plan in order to comply with North Carolina's CAMA regulations. While this plan expanded upon the efforts of the 1981 plan, CAMA plans at that time were primarily focused on the protection of environmentally sensitive areas. This CAMA plan was updated in 1997 and again focused primarily on regulating development in areas of environmental concern in the county.

Onslow County adopted its initial comprehensive planning document, "Agenda for Change: Operation Onslow" in 1995. The plan addressed a broad range of county issues and concerns that included land use, law enforcement, and education. It also identified strategic policies and assigned implementation tasks for each policy outlined in the document.

In 2003, the county adopted the "Citizen's Comprehensive Plan for Onslow County." This plan was developed with the help of four citizen committees, focusing on the following areas of concern: land use and housing, environmental protection and use, transportation and major facilities, and economy and culture. This was Onslow County's first true land use planning tool and was the foundation for establishing county-wide zoning. The Onslow County Board of Commissioners (BOC) adopted their first Zoning Ordinance regulations and Official Zoning Map in December 2003.

Onslow County also completed a Joint Land Use Study (JLUS) in 2003. The JLUS program is sponsored and administered by the Office of Economic Adjustment (OEA). The Onslow County JLUS was the outcome of a land use planning partnership between MCB Camp Lejeune, MCAS New River, and the surrounding communities. The study identified existing and future land use conflicts and provided recommendations to achieve land use compatibility. In 2005, the Onslow County BOC appointed a JLUS Implementation Committee, which developed a report, "Recommended Measures to Implement Joint Land Use Study Recommendations Selected by the Board of Commissioners, August 2006."

The Onslow County BOC implemented one of the JLUS recommendations in 2006 by amending their zoning ordinance to incorporate a military flight path overlay district (FPOD). The purpose of the FPOD is to ensure the compatibility of air operations associated with MCB Camp Lejeune and MCAS New River with land uses on properties near these bases. The FPOD section of the zoning ordinance establishes prohibited land uses as well as height limitations of 100 feet AGL for structures underlying the zoned FPOD.

In October 2009, the county completed its most recent CAMA Core Land Use Plan, which was certified by the North Carolina Coastal Resources Commission in 2010. This plan serves as an update to the county's 1997 CAMA Land Use Plan and incorporates the goals, policies, and implementing actions from the 2003 Citizen's Comprehensive Plan and the JLUS recommendations selected for implementation by the Onslow County BOC into a single planning document. Today, the 2009 CAMA Land Use Plan is the county's sole comprehensive land use planning document. The Onslow County CAMA Land Use Plan also includes the participating municipalities of Holly Ridge and Richlands.

The Onslow County zoning and subdivision ordinances currently require that officially adopted plans—including the CAMA Land Use Plan, Onslow County Citizens Comprehensive Plan, Joint Land Use Study, Transportation Plans, and other official plans adopted by the Onslow County BOC—be considered when making land use recommendations and decisions. These documents can be found on the Onslow County Planning and Development Department website (http://www.onslowcountync.gov/Planning/).

FPOD – Flight Path Overlay District

Established in 2006, this zoning amendment was a collaborative effort between the Marine Corps and Onslow County to mitigate potential future land-use incompatibilities related to aviation activities around MCB Camp Lejeune and MCAS New River.

For the purpose of this study, GIS data displaying current land use and zoning was used to identify current and potential land use incompatibilities. Onslow County data were obtained directly from the county's GIS homepage[9].

6.2.2 Town of Holly Ridge

The Town of Holly Ridge was incorporated in 1941, which coincides with the construction of Camp Davis. The establishment of Camp Davis caused the population of Holly Ridge to explode from 28 in 1940 to 110,000 in 1943. However, the end of World War II and the closure and relocation of military activities at Camp Davis resulted in a significant decrease in population.

[9] http://maps.onslowcountync.gov/download/index.cfm

According to the town's website, the population is approximately 1,180 people today.

As noted above, the Town of Holly Ridge participated in the development of the Onslow County 2009 CAMA Land Use Plan. The plan provides the demographic and natural systems profile of the town, as well as an analysis of existing land use and desired future development. All policies and implementing actions included in the plan also apply to Holly Ridge.

The town also has zoning and subdivision ordinances that govern land use and development within the town's municipal boundary and extraterritorial planning jurisdiction. A review of the Holly Ridge zoning ordinance showed no reference to the Onslow County FPOD.[10] GIS data for Holly Ridge were obtained via Onslow County's GIS homepage (see Section 6.2.1 above).

6.3 Land Use Compatibility Analysis

This section addresses land use compatibility within aircraft noise zones and APZs by examining existing and future land uses near MCOLF Camp Davis (see Sections 6.1 and 6.2 for a description of the land use compatibility criteria used in this AICUZ study). The analysis was based on Marine Corps land use compatibility recommendations (see Appendix B). Land use patterns and zoning in the immediate vicinity of MCOLF Camp Davis, along with the land use compatibility assessment, are discussed below.

For the 2012 AICUZ study, there are no current or projected land use incompatibilities related to noise zones or APZs.

All noise contours and APZs remain on MCB Camp Lejeune property.

Using GIS tools, analysts calculated the land area encompassed by the noise contours and APZs and classified those areas as compatible or incompatible based upon current and future land uses according to the Onslow County and USMC GIS data files. Since all noise zones and APZs for the 2012 AICUZ study remain within the MCB Camp Lejeune boundary, no land use incompatibilities with MCOLF Camp Davis were identified. The remainder of this section illustrates existing and future land use in association with the 2012

[10] http://townofhollyridge.com/Ordinances/article_7_zoning.html

AICUZ noise zones and APZs to further sustain compatible land development in the future.

6.3.1 Existing Land Use

The term "land use" refers to the management of land and the extent to which land has been modified.

Land use is a term used to describe the management of land and the extent to which it has been modified. Existing land use describes how land has been developed. This may or may not align with local zoning. Land use is usually a key guiding component of the comprehensive plans, which are the primary policy documents for local land use and development.

Figure 6-1 is the 2012 MCOLF Camp Davis Composite AICUZ Map. It depicts current land use as it relates to the 2012 noise zones and APZs. Since the 2012 noise zones and APZs for MCOLF Camp Davis remain within the MCB Camp Lejeune boundary, existing land uses are military airfield surfaces, military operational facilities, and roads. Tables 6-2 and 6-3 provide measurements of the land use areas that fall underneath those areas.

Table 6-2. Existing Land Uses within Noise Zones, MCOLF Camp Davis

Land Use	Noise Zone 1 60-65 DNL (acres)	Noise Zone 2 65 – 74 DNL (acres)	Noise Zone 3 75+ DNL (acres)	Total
Military Airfield Pavements	3.83	25.63	13.51	**42.97**
Military Land Operational Facilities	374.13	227.54	23.36	**627.03**
Military Roads/Streets	14.32	11.58	0.26	**26.17**
Total	**392.28**	**264.75**	**39.13**	**696.16**

Notes: Figures may not sum exactly due to rounding. All acreage is located on U.S. government property at MCB Camp Lejeune and is 100% compatible (see Figure 6-1).

Table 6-3. Existing Land Uses within APZs, MCOLF Camp Davis

Land Use	Clear Zone (acres)	APZ I (acres)	Total
Military Airfield Pavements	3.36	73.40	**76.77**
Military Land Operational Facilities	30.86	0.06	**30.91**
Military Roads/Streets	2.49	0.00	**2.49**
Total	**36.71**	**73.46**	**110.17**

Note: Figures may not sum exactly due to rounding. All acreage is located on U.S. Government property and is 100% compatible (see Figure 6-2).

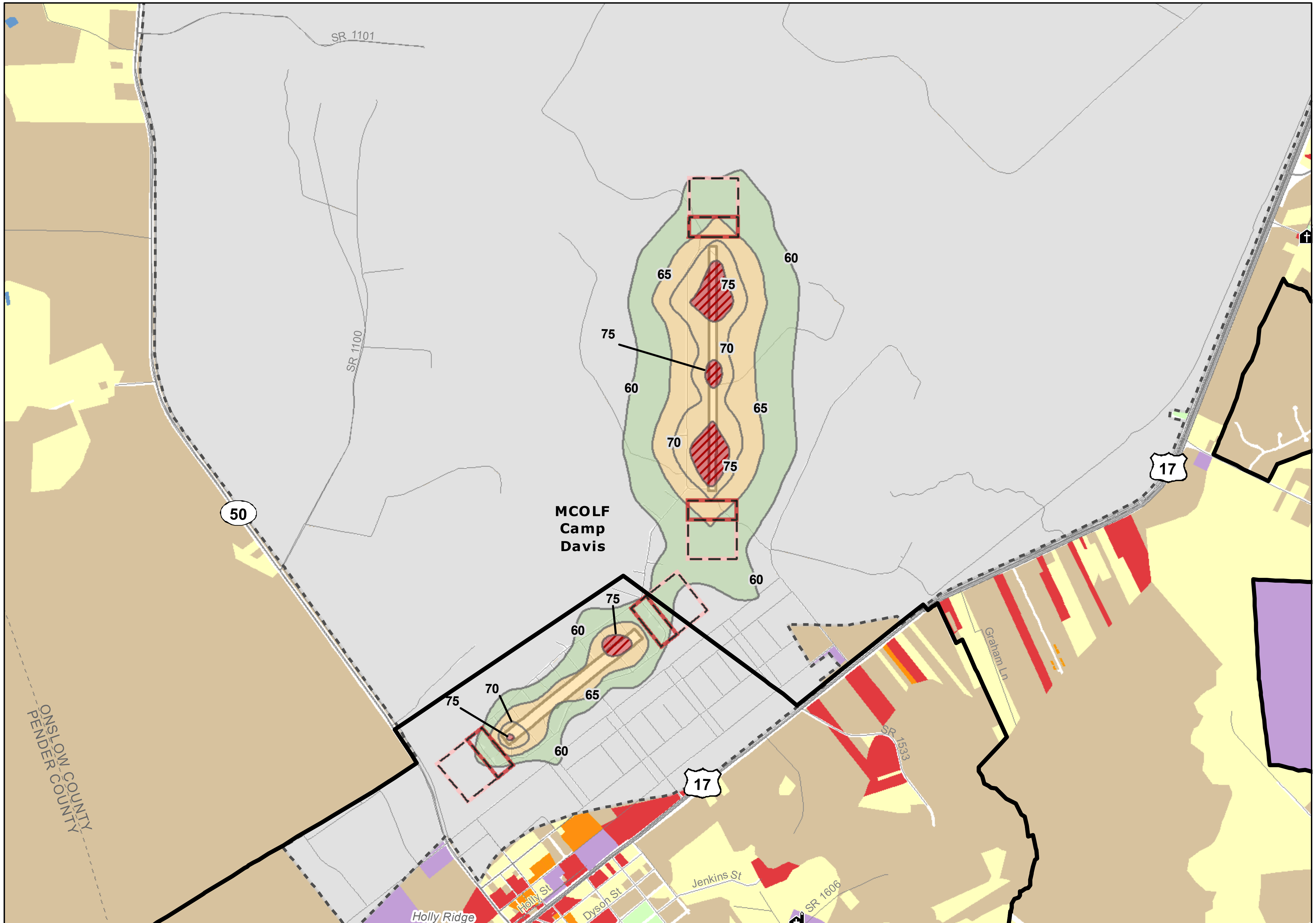


Figure 6-1
Composite Coverage for Existing Land Uses and 2012 AICUZ Noise Contours and APZs
MCOLF Camp Davis
North Carolina

- Church
- Runway
- MCB Camp Lejeune
- Holly Ridge Area for Planning and Regulation of Development
- County Boundary

Accident Potential Zone
- Clear Zone
- APZ I

Noise Zones
- Zone 1
- Zone 2
- Zone 3

Land Use
- Military Reservation
- Commercial
- Industrial
- Multi Family Residential
- Single Family Residential
- Office and Institutional
- Recreation and Open Space
- Undeveloped

0 0.25 0.5
Miles

Source:
ESRI, 2010; Onslow County, 2011

6.3.2 Zoning and Future Land Use

The nearest civilian land uses, which are outside of the 2012 AICUZ noise zones and APZs, are low- to medium-intensity development and include a mix of residential and commercial uses as well as vacant land. Eighty-six percent of the land in Holly Ridge is classified as vacant (Onslow County 2010).

Zoning is the system used by local government to control the physical development of land and the type of uses that may be applied to each individual property.

Zoning is a term used in urban planning for an integrated set of land use regulations. Local governments use zoning to control the physical development of land and the type of uses that may be applied to each individual property. Zoning codes provide the regulatory framework to direct future land development, influence how the various uses interact with each other, and prevent land use incompatibility. Zoning addresses not only the possible future use of property, but also the scale and intensity of the use.

Future development of land is traditionally outlined in local land use plans and regulations that are developed and adopted by local authorities. Long-range comprehensive planning documents include future land use maps that identify the land use type and intensity that should be allowed in specific areas. These comprehensive plans are guides, whereas the zoning ordinances are the legal foundation for future development. To implement a recommended change from a comprehensive plan, local government must enact appropriate amendments to local regulations in order for the proposed changes to become enforceable. GIS data for zoning in Onslow County and Holly Ridge were obtained from the Onslow County Information Technology Services Department website. This zoning information was used to develop the 2012 AICUZ figure depicting future land use (see Figure 6-2).

Figure 6-2 depicts future land uses near MCOLF Camp Davis, based upon current zoning for properties. Although the noise zones and APZs do not extend off the base property, additional development along Highway 17 and State Road 50 at the southwest corner of MCB Camp Lejeune could expose residents to elevated noise levels associated with MCOLF Camp Davis. These noise levels would be less than 60 DNL and outside of Noise Zone 1, but individual operations or peaks in training may result in an increase in noise complaints in the community.

Path: M:\Chicago\CampLejeune_RCUZ\Maps\MXDs\AICUZ\April11_2012\2012 APZs and Contours with Zoning_11_17v2.mxd

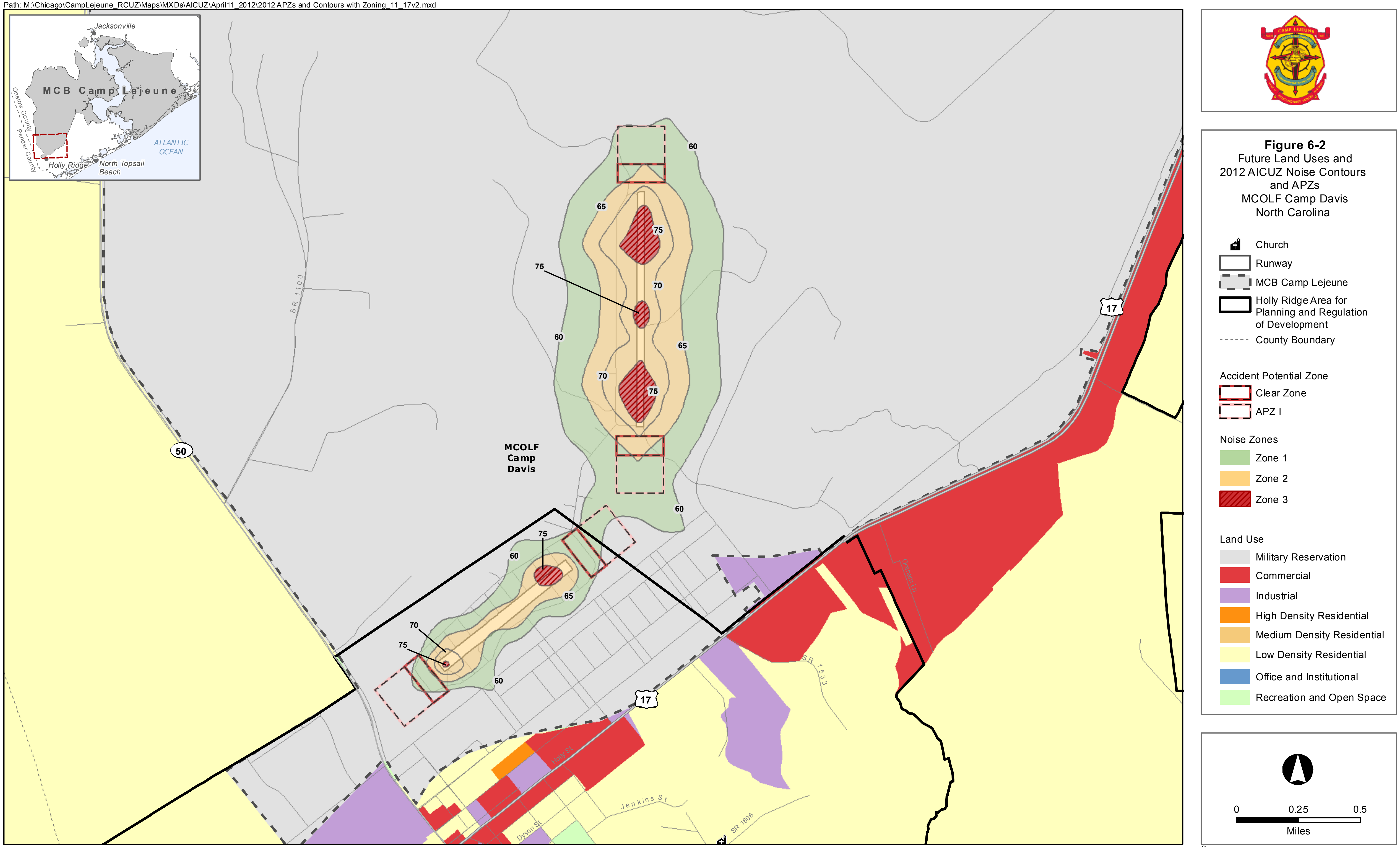


Figure 6-2
Future Land Uses and
2012 AICUZ Noise Contours
and APZs
MCOLF Camp Davis
North Carolina

Source:
ESRI, 2010; Onslow County, 2011

6.4 COMPATIBILITY CONCERNS

The Marine Corps examined existing and future land use patterns near MCOLF Camp Davis to identify compatibility issues. Since the 2012 AICUZ noise zones and APZs are located on MCB Camp Lejeune property, there are no current or future land use compatibility concerns at this time. If the Marine Corps increases operations at MCOLF Camp Davis, appropriate steps should be taken to update this AICUZ and re-evaluate land use compatibility.

Construction of tall structures that may be considered height obstructions in the imaginary surfaces of MCOLF Camp Davis (see Figure 5-3) could also be a future concern. The construction of tall buildings and towers that exceed the height of the imaginary surfaces can present a danger to aircraft and adversely affect operations at the airfield. However, there are no known proposals in the area that can be considered a concern at this time.

This page intentionally left blank.

7 Land Use Tools and Recommendations

7.1 Tools for Implementing AICUZ
7.2 Recommendations for AICUZ Implementation Strategy

The goal of the AICUZ program— to protect the health, safety, and welfare of those living near military airfields while preserving the DOD mission —can most effectively be accomplished by active participation of all interested parties, including the Marine Corps, local governments, private citizens, developers, real estate professionals, and others. This chapter describes the tools, resources, and recommendations that can be used as an AICUZ implementation strategy to manage existing and future development within and around the MCOLF Camp Davis 2012 AICUZ zones. This strategy, if implemented, will continue to support MCB Camp Lejeune and its 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."

Although control over land use and development in the vicinity of MCOLF Camp Davis is the responsibility of the local governments, the Marine Corps is responsible for implementing programs in support of the local effort. At the installation level, the Installation Commander is responsible for ensuring an operational training environment. A robust AICUZ program is an important tool for the Installation Commander to ensure that viable training and operational environment continue. Pursuant to OPNAVINST 11010.36C/MCO 11010.16, the Installation Commander at MCB Camp Lejeune is committed to and shall:

- Implement an AICUZ Program for MCOLF Camp Davis
- Work with state and local planning officials to implement the objectives of the AICUZ study

- Designate a Community Plans and Liaison Officer (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
- Notify the chain-of-command in the AICUZ program office whenever local conditions merit update or review of the AICUZ study.

The MCB Camp Lejeune Installation Commander has fostered strong community relations through a robust outreach program and active participation in a number of committees and organizations. The Marine Corps actively participates in the following state and local committees:

- Airport Planning Committee
- Chamber of Commerce Steering Committee
- Committee of 100
- Government Affairs Committee
- Jacksonville (NC) Metropolitan Planning Organization
- Military/Community Cooperative Planning Group
- North Carolina Airport Association Region 1
- North Carolina Advisory Committee on Military Affairs
- Onslow BIGHT Conservation Forum

7.1 TOOLS FOR IMPLEMENTING AICUZ

7.1.1 Federal Tools

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. The intent is to limit encroachment or use of the property that would be incompatible with the mission or that would 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 to limit encroachment on the mission of a military installation and/or to preserve habitat off the installation. The DOD can share the real estate acquisition costs for projects that support the purchase of land for conservation or other restrictive easements for such property. The eligible entity negotiates with and acquires the real estate interest for encroachment partnering projects from 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.

Environmental Review

Environmental review deals with assessment of projects that may have some potential impact on land use and the public's interest. For example, the National Environmental Policy Act (NEPA) mandates full disclosure of the environmental effects resulting from proposed federal actions, approvals, or funding. Impacts of the action are generally documented in an environmental impact statement (EIS) or an environmental assessment (EA). The environmental review process can serve as a means to incorporate the elements of the AICUZ in the planning review process.

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

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

Because of the Intergovernmental Cooperation Act of 1968, the United States Office of Management and Budget 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.

Government Services Administration (GSA) Federal Management Circular 75-2

Circular 75-2 allows the air installation to extend its land use recommendations to federally funded projects in the vicinity. Specifically, it requires agencies sponsoring federally funded projects to ensure they are compatible with land use plans of MCOLF Camp Davis.

Adjustment of Operational Procedures

Adjustments to operational procedures can be made only after careful consideration of all options and only if the changes do not compromise the installation's mission.

The Marine Corps can adjust local operational procedures and initiate facility improvements to reduce the extent of exposure to noise (noise abatement) and mishaps. The options available to military authorities vary between installations due to specific local conditions, local air operations, and local mission requirements. Only after careful consideration of all options should changes in operational procedures be made. No changes that compromise flight safety or the mission should be instituted.

Public Law 111-383, National Defense Authorization Act of 2011

The Secretary of Defense established the DoD Siting Clearinghouse in 2010 to provide a timely, transparent, and repeatable process that can evaluate potential impacts and explore mitigation options, while preserving the DoD mission. In January 2011, Congress codified the DoD initiative with specific direction in § 358 of the Ike Skelton National Defense Authorization Act For 2011, Public Law 111-383. This legislation changed the nature of how DoD communicates with external stakeholders, and significantly raised the bar in terms of when and how DoD may object to project proposals.

The Deputy Secretary of Defense, acting as the Clearinghouse Senior Officer, chartered a Board of Directors that includes representatives from each Service, the Joint Staff, Homeland Defense, and Office of the Secretary of Defense. The Clearinghouse's formal review process applies to projects filed with the Secretary of Transportation, under § 44718 of Title 49, U.S. Code (FAA Obstruction Evaluation process), as well as other projects proposed for construction within military training routes or special use airspace, whether on private, State, or Federal property (such as Bureau of Land Management lands).

However, the Clearinghouse also provides informal reviews, when requested. This means that a developer of a renewable energy development or other energy project, a landowner, or a State, Indian tribal, or local official may request a preliminary determination in advance of the filing of an application with the Secretary of Transportation under 49 U.S.C. § 44718.

7.1.2 State and Local Government Level Tools

Local Government Comprehensive Plans and Planning

Comprehensive plans should include specific language and maps regarding the AICUZ program and coordination with NAS Meridian regarding land-use decisions.

Local land use planning and zoning regulations control the development of private and public lands outside of the installation boundary. This falls upon the Town of Holly Ridge for lands located within its extraterritorial jurisdiction and Onslow County for all unincorporated lands. Enforcement of current zoning ordinances and modifications of these ordinances can encourage compatible land use around MCOLF Camp Davis and enhance AICUZ implementation.

Joint Land Use Study (JLUS) Planning Initiative

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

The JLUS program facilitates cooperative planning initiatives between the installation and the surrounding cities/counties. It is community-controlled and community-directed and produced by and for the local jurisdictions. A JLUS is partially funded with DOD planning assistance grants through the Office of Economic Adjustment (OEA) for state and local governments. However, since a JLUS is a partnership between the military installation and local governments, non-federal funds must be committed to the project. The goal of the JLUS is to promote compatible community growth that supports military training and operational missions. The JLUS program aids in the understanding and introduction of the AICUZ technical data into local planning and outreach programs. 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 encroachment. Onslow County completed its most recent JLUS study in February 2003.

Capital Improvements Programs

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

Capital improvements projects such as potable water lines, sewage transmission lines, road paving and/or improvements, new right-of-way acquisitions, 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. Local government agencies and organizations can develop capital improvement programs that avoid extending capital improvements into or near high-noise zones or APZs.

Special Planning Districts

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

Special Planning Districts 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 districts' regulations supersede the underlying zoning and may be either more or less restrictive. Local governments and commissions have the power to create Special Planning Districts, such as "military influence areas" or "airport overlay zones/districts" where local governments can either enact restrictions on land development or require notification for proposed development within the special planning area. Special Planning Districts can help mitigate the negative effects of certain projects or land use activities, such as to prevent the development of buildings and towers within the airfield imaginary surfaces that could present a hazard to flight. In the case of MCOLF Camp Davis, Onslow County has adopted an FPOD to encourage compatible land use around all of MCB Camp Lejeune and MCAS New River property.

Real Estate Disclosure

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.

Real estate disclosures allow prospective buyers, lessees, or renters of property near military operation areas 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 location of APZs, subsequently reducing frustration and anti-airport criticism by those who were not adequately informed before purchasing properties within impacted areas.

In May 2010, the North Carolina Real Estate Commission revised its disclosure procedures to include "military nuisance" as an element that requires full disclosure on real estate transactions. Real estate agents, as of July 2010, are required by law to inform potential buyers that property is impacted by its proximity to a military base. The updated real estate disclosure forms require the seller to disclose any commercial, industrial, or military noise affecting the property. Public release of this AICUZ study and the 2012 AICUZ maps are important tools in informing realtors and potential buyers and sellers of real estate about the expected impacts of aviation operations at MCOLF Camp Davis.

Public Land Acquisition Programs

Public land acquisition programs can be used to purchase land to support the AICUZ Program. Land acquisitions 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.

Building Codes

The local building codes can be used to ensure the noise attenuation measures of the AICUZ program. 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. Using proper sound insulation construction techniques and materials can minimize the impacts of aircraft noise and reduce interference with regular indoor activities. Although building codes will not prevent incompatible development, they can aid in minimizing impacts on more probable development.

7.1.3 Tools for Private Citizens, Real Estate Professionals, and Businesses

Private Citizens

Individual members of the community should review this AICUZ study and the associated public outreach tools. Knowing the noise sources and levels associated with operations at MCOLF Camp Davis will allow buyers, sellers, lessors, and lessees to make informed real estate decisions.

Real Estate Professionals

Real estate professionals have the ability to ensure that buyers, renters, and lessees are fully aware of what it means to be within areas of elevated noise and/or within APZs. They should present property at times when noise exposure is expected to be highest as well as at times of lower operational activity, so that the prospective resident can make an informed decision.

Businesses

Business entities should become familiar with this document and determine whether the proposed commercial or industrial land use is compatible with the noise zones and APZs of this AICUZ study. The AICUZ maps can support sound decision-making in siting businesses. Lending institutions can limit financing for real estate purchases or loans for business construction that is incompatible with the AICUZ program by restricting or prohibiting funding.

7.2 Recommendations for AICUZ Implementation Strategy

7.2.1 MCOLF Camp Davis Recommendations

Although control over land use and development near MCOLF Camp Davis is the responsibility of Onslow County and the Town of Holly Ridge, the Marine Corps has the ability to and responsibility for implementing actions and programs that support local efforts. To do so, the MCB Camp Lejeune Installation Commander should continue and/or consider the following:

Community Outreach Activities and Presentation of the AICUZ Study

Continue successful community outreach efforts that are in place at MCB Camp Lejeune and MCAS New River. Currently there is a very productive working relationship between the installation's CP&LO, Onslow County, and the Town of Holly Ridge. Several successful initiatives are ongoing, and future initiatives aimed at further protecting Marine Corps assets should continue or expand. The MCB Camp Lejeune CP&LO staff should continue to attend public hearings and provide comments on actions that may affect AICUZ planning, including ensuring that comprehensive plans and land-development regulations are kept up-to-date and regulations are re-amended as necessary to preserve the Marine Corps missions. The 2012 AICUZ study for MCOLF Camp Davis presents an opportunity to continue outreach activities by presenting the findings of this study.

This presentation could be shown individually or collectively to community decision makers, including local planning commissions, city councils, county commissioners, government boards, and other interested agencies. It would provide an opportunity to inform and educate individuals or groups who make land use decisions (e.g., infrastructure siting, schools, zoning changes) that can either protect or threaten aircraft operations at MCOLF Camp Davis. MCB Camp Lejeune and MCAS New River should include AICUZ-specific details on their respective installation websites. Presentation information can support community outreach activities identified above and would inform the public on AICUZ issues, the installation's contribution to the local economy, and the need for responsible land use planning.

Installation Study Integration

The Marine Corps is continually examining local operations in response to changing national defense demands, local training requirements, and public involvement. Several noise and safety-related studies either have been or will be completed for military facilities associated with MCB Camp Lejeune and MCAS New River. These separate studies should be integrated at the installation-level to provide the community with an operational picture of not only a single location such as MCOLF Camp Davis but also how this airfield is part of a larger training concentration area in eastern North Carolina.

Air Operations Procedures

Aircrew discipline in pattern operations should continue to be enforced along with airfield noise abatement procedures, as set forth in Table 4-1. MCB Camp Lejeune and MCAS New River should continue to examine ways to improve noise abatement procedures at MCOLF Camp Davis. When new pilots check into the squadrons at MCAS New River, it may be beneficial to provide training on how their operations at MCOLF Camp Davis can affect community relations by using the 2012 AICUZ map as a training tool.

Noise Complaint Management

As discussed in Section 4.3 of this study, there are procedures in place for handling noise complaints. For future studies, including future revisions of this study, it is recommended that noise complaints be documented in sufficient detail for plotting locations in a spatial database for future planning use. Detailed recording of these complaints can assist in:

- Providing feedback to the local government;
- Determining which flight tracks may be responsible for specific complaints and identifying whether the source of the complaint is related to aviation noise or from other training operations at MCB Camp Lejeune; and
- Supporting improved real estate disclosure processes.

Local Plans, Regulations, and Policies

MCB Camp Lejeune and MCAS New River CP&LO staff should continue to be active participants in making recommendations to local government to foster compatible land use through changes to land use development plans, regulations, and policy decisions. Potential areas to pursue installation involvement in the local planning process include:

- Capital improvements plans, such as potable water lines, sewage transmission lines, road paving and/or improvements, and new right-of-way acquisitions

- Collaboration with local government to sponsor statewide legislation to enact building code changes to improve sound attenuation
- Development of ordinances that promote compatible land uses adjacent to MCOLF Camp Davis
- Review of all proposed plans for lands within the imaginary surfaces around MCOLF Camp Davis to ensure they do not allow obstructions in the vicinity
- Contributing as a key stakeholder in proposed local zoning ordinances (and rezoning), comprehensive plans, subdivisions, site plans, wetland permits, or other development proposal.

7.2.2 State and Local Government Recommendations

Communication and Education

Public relations and education programs engage local citizenry regarding managing and understanding noise and land development problems. Community decision-makers should continue to actively inform and seek input from MCB Camp Lejeune and MCAS New River regarding land use decisions that potentially could affect the operational integrity of MCOLF Camp Davis. To communicate with the public, local government websites should provide acknowledgement of the AICUZ program for MCOLF Camp Davis and provide a link to the MCB Camp Lejeune and MCAS New River websites for information on aircraft operations and the AICUZ program.

Planning Partnerships with the Installation

Just as the Marine Corps should ask to be part of the local planning process, it is incumbent upon Onslow County and the Town of Holly Ridge to seek input from the Marine Corps. When local government considers land use decisions near a military installation and the established AICUZ footprint, they should realize the following:

- Their decisions may decrease the capabilities of the installation, increasing the chances of the local commands having to relocate resources to ensure training is completed.

- Noise contours and APZs comprising the AICUZ footprint are dynamic and may change over time.
- A proactive approach to planning with the Marine Corps should serve the local population by mitigating, in advance, potential problems with noise and safety concerns.
- As mentioned previously, they have a statutory obligation to notify MCB Camp Lejeune of any proposed land use changes within 5 miles of the installation perimeter in accordance with North Carolina General Statutes and to evaluate any comments from the Marine Corps regarding the proposed action.

Pursue Funding from the OEA for a JLUS Study Update

It is recommended that Onslow County apply for funding from the OEA to update the 2003 JLUS study. There have been many changes within the community as well as aboard MCB Camp Lejeune and MCAS New River. Updating the JLUS to include this AICUZ update, in addition to recent and upcoming studies for the other facilities in the area, will provide Onslow County with an updated tool to encourage land uses that are compatible with military operations.

7.2.3 Recommendations for Private Citizens, Real Estate Professionals, and Businesses

Recommendations for Private Citizens

The citizens of Onslow County and the Town of Holly Ridge should increase their awareness of the AICUZ Program at MCOLF Camp Davis and learn about the program's goals and objectives; its value in protecting the health, safety, and welfare of the population; the limits of the program; and the positive community aspects of a successful AICUZ Program. Individuals should take the opportunity to attend Marine Corps open houses and community relations events to learn more about the importance of the training activities occurring in the area, the role of the installation in the community, and to provide constructive feedback to both the Marine Corps and local elected officials.

8 References

American National Standards Institute (ANSI). 1990. Sound Level Descriptors for Determination of Compatible Land Use. ANSI S12.40-1990 and ASA 88-1990.

Blue Ridge Research and Consulting. 2011. Noise Analysis for MCOLF Camp Davis.

Federal Aviation Administration. 2007. Advisory Circular 150/5200-33B. *Hazardous Wildlife Attractants On or Near Airports.*

Federal Aviation Administration. 2010. Code of Federal Regulations, Title 14, Part 77, "Safe, Efficient Use, and Preservation of the Navigable Airspace.

Federal Interagency Committee on Urban Noise (FICUN). August 1980. Guidelines for Considering Noise in Land use Planning and Control.

Federal Interagency Committee on Noise (FICON). August 1992. Federal Agency Review of Selected Airport Noise Analysis Issues.

MCB Camp Lejeune. 2011. *Range and Training Regulations – Standard Operating Procedures for Range Control*. Base Order 3570.1C.

Naval Facilities Engineering Command - Southern Division. 1978. *AICUZ Noise Study for MCAS New River, HOLF Oak Grove and HOLF Camp Davis*. Prepared by Bickerdike/Allen/Bramble.

__________. January 1982. Facility Planning Factor Criteria for Navy & Marine Corps Shore Installations, Appendix E Airfield Safety Clearances. United States Department of the Navy, Naval Facilities Engineering Command. NAVFAC P-80.3.

Naval Safety Center. n.d. Homepage. http://safetycenter.navy.mil/ Statistics>Current Mishap Definitions and Reporting Criteria. Accessed Nov 5, 2010.

Onslow County. 2009. Onslow County Comprehensive Plan.

__________. January 13, 2010. Onslow County Comprehensive Plan (CAMA Core Land Use Plan). Onslow County Comprehensive Plan (CAMA Core Land Use Plan).

The MITRE Corporation. 2008. *Wind Farms and Radar*.

U.S. Census Bureau. 2010. American FactFinder. USCB 2025 Projections; 2009 Population Estimates; and Census 2010, 2000, 1990. Accessed August 10, 2010. http://factfinder.census.gov.

U.S. Department of Defense. 2006. *The Effect of Windmill Farms on Military* Readiness.

__________. 2008. Unified Facilities Criteria. Airfield and Heliport Planning and Design. UFC 3-260-01.

__________. 2011. DODINST 4165.57, Air Installations Compatible Use Zones.

U.S. Department of the Navy. 2008. OPNAVINST 11010.36C/MCO 11010.16, Air Installations Compatible Use Zones Program.

APPENDIX A

Discussion of Noise and Its Effect on the Environment

This page intentionally left blank.

Appendix A Table of Contents

A.1 Basics of Sound 5

A.1.2 A-weighted Sound Level 7

A.1.3 C-weighted Sound Level 7

A.2 Noise Metrics 9

A.2.1 Maximum Sound Level (Lmax) 9

A.2.2 Peak Sound Level (Lpk) 9

A.2.3 Sound Exposure Level (SEL) 10

A.2.4 Number of Events Above a Threshold Level (NAL) 10

A.2.5 Time Above a Threshold Level (TAL) 10

A.2.6 Equivalent Sound Level (Leq) 10

A.2.7 Day-Night Average Sound Level (DNL) and Community Noise Equivalent Level (CNEL) 11

A.2.8 Rate Adjusted Day-Night Average Sound Level (Ldnr) 13

A.3 Noise Effects 15

A.3.1 Annoyance 15

A.3.2 Speech Interference 15

A.3.3 Sleep Interference 17

A.3.3.1 Background 17

A.3.3.2 Recent Sleep Disturbance Research Field and Laboratory Studies 18

A.3.3.3 Federal Interagency Committee on Aviation Noise (FICAN) 18

A.3.3.4 American National Standards Institute (ANSI) 19

A.3.3.5 World Health Organization (WHO) Guidelines 19

A.3.4 Hearing Loss 21

A.3.5 Nonauditory Health Effects 23

A.3.6 Performance Effects 25

A.3.7 Noise Effects on Children 25

A.3.7.1 Effects on Learning and Cognitive Abilities 25
A.3.7.2 Classroom Criteria and Guidelines 26
A.3.7.3 Health Effects 27
A.3.8 Effects on Domestic Animals and Wildlife 28
A.3.8.1 Domestic Animals 29
A.3.8.2 Wildlife 32
A.3.8.2.1 Mammals 33
A.3.8.2.2 Birds 35
A.3.8.2.2.1 Raptors 36
A.3.8.2.2.2 Migratory Waterfowl 38
A.3.8.2.2.3 Wading and Shore Birds 39
A.3.8.3 Fish, Reptiles, and Amphibians 40
A.3.8.4 Summary 40
A.3.9 Property Values 41
A.3.10 Noise Effects on Structure 42
A.3.11 Noise Effects on Terrain 42
A.3.12 Noise Effects on Historical and Archaeological Sites 42
A.4 References 44

List of Figures

A-1. Frequency Response Characteristics of A and C weighting Networks 6
A-2. Typical A-weighted Sound Levels of Common Sounds 8
A-3. Community Surveys of Noise Annoyance 12
A-4. Response of Communities to Noise; Comparison of Original and Current Curve Fits 13
A-5. Indoor Sentence Intelligibility 17
A-6. Recommended Sleep Disturbance Dose-Response Relationship 20

List of Tables

A-1. Hearing Loss Weighting Factors 22

APPENDIX A

Discussion of Noise and Its Effect on the Environment

A.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 that is 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 two sources of equal sound level are combined, the resulting sound level increases by 3 dB, regardless of the initial sound levels. For example:

60 dB + 60 dB = 63 dB, and

80 dB + 80 dB = 83 dB.

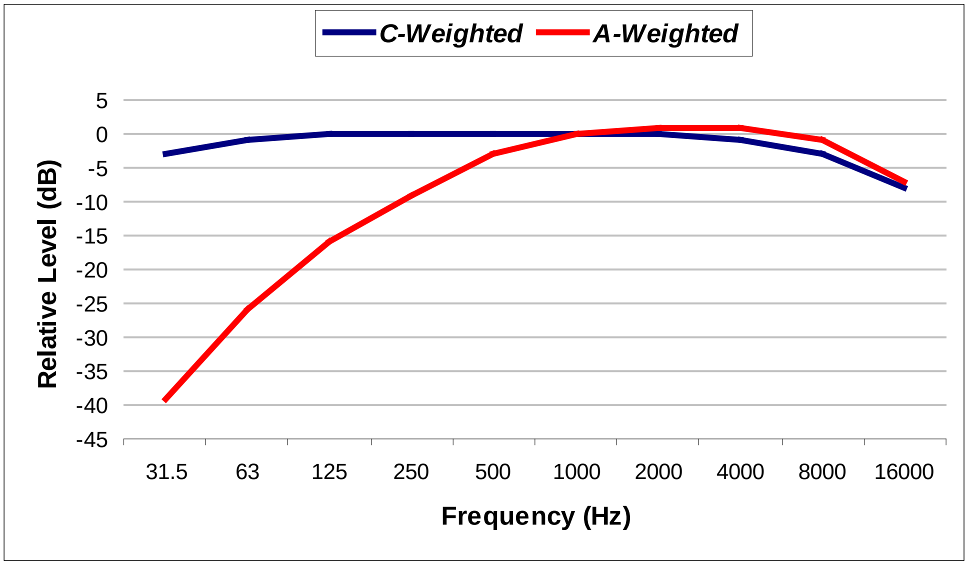
Second, the total sound level produced by two sounds of different levels is usually only slightly more than the higher of the two. For example:

60.0 dB + 70.0 dB = 70.4 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% decrease in sound level but only a 50% 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 (above approximately 10,000 Hz and below approximately 500 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 S1.4 -1983 "Specification of Sound Level Meters"

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

A.1.2 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 to 50 dB (U.S. Environmental Protection Agency 1978).

Figure A-2 is a chart of A-weighted sound levels from typical sounds. Some noise sources (air conditioner, vacuum cleaner) have continuous sounds with levels that 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.

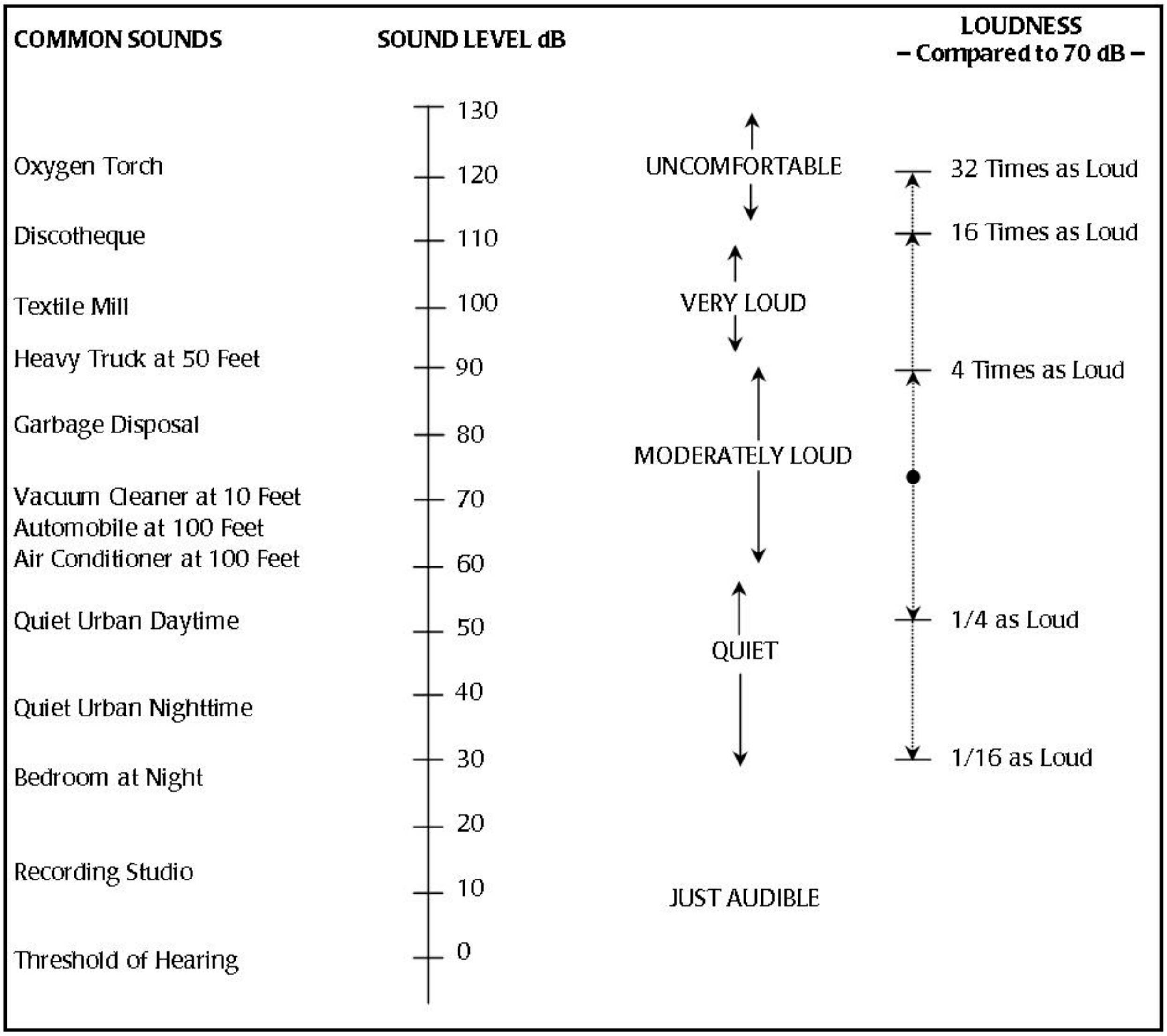
A.1.3 C-weighted Sound Level

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 (American National Standards Institute 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.

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 1992.

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.

A.2 Noise Metrics

A noise metric refers to a unit or quantity that measures an aspect of the received noise used in environmental noise analyses. The metric relates the received noise to its various effects on the environment. To quantify these effects, the Department of Defense and the Federal Aviation Administration use a series of metrics to describe the noise environment. These metrics range from simple to descriptive to complex.

Simple metrics quantify the sound levels occurring during an individual aircraft overflight (single event) and the total noise exposure from the event. Single noise events can be described with Maximum Sound Level and Sound Exposure Level. Another measure of instantaneous level is the Peak Sound Pressure Level, which is used primarily for impulsive noise.

Descriptive metrics are used quantify a listeners experience with regards to a noise environment. Two of the common descriptive metrics are the frequency of occurrence of noise events (Number of Events) and the cumulative duration of the events (Time Above) above a given threshold level.

Complex metrics quantify the cumulative noise exposure using a number of different ways of analyzing the noise based on the expected flight and engine/aircraft maintenance schedule. Some common metrics defined are the Equivalent Sound Level, the Day-Night Average Sound Level, the Community Noise Equivalent Level (State of California 1990), and the Onset-Rate Adjusted Day/Night Average Sound Level. The Day/Night Average Sound Level (or the Community Noise Equivalent Level for California) is the fundamental metric used to describe aircraft noise in and around an airfield. The other metrics supplement the characterization of the noise environment and help to clarify different aspects of the effects (Sharp et al., 2007).

A.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 maximum sound level 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 1/8 second, and is denoted as “fast” response (American National Standards Institute 1988). Slowly varying or steady sounds are generally measured over a period of one second, denoted “slow” response. The maximum sound level 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.

A.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 peak sound pressure level is typically measured using a 20 microseconds or faster sampling rate and is typically based on unweighted or linear response of the meter.

A.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 maximum noise level 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 maximum sound level (L_{max}) occurs instantaneously. SEL represents the best metric to compare noise levels from different overflights.

A.2.4 Number of Events Above a Threshold Level (NA_L)

The Number of Events Above a threshold level describes the number of noise events that exceed a threshold level during a defined time period. The threshold level can be defined by either the L_{max} or SEL metric and the value is denoted by the subscript. For example, NA_{65} denotes the number of events that exceed 65 dB for a given time period. The time period can range from a particular hour of the day to a 24 hour day and it depends on the descriptive nature of the NA analysis. For example, to determine the number of event occurring during a school day the time period would include the hours of the local school being analyzed. It is important to note that the metric used for the threshold and time period are not explicitly stated in the NA metric and must be defined in the text description of the analysis.

A.2.5 Time Above a Threshold Level (TA_L)

The Time Above a threshold level is a measure of the total time the noise level exceeds the threshold level during a defined time period. TA is expressed in minutes and describes the time noise levels are elevated above a level. For example, TA_{65} represents the time that the noise levels are above 65 dB. However, it does not describe the magnitude of the elevated noise levels. As with NA, the time period over which TA is evaluated can vary from one hour to a 24 hour day and it depends of the application of the TA analysis. It is important to note that the time period is not explicitly stated in the metric and must be defined in the text description of the analysis.

A.2.6 Equivalent Sound Level (L_{eq})

Another complex noise metric that is useful in describing noise is the equivalent sound level. L_{eq} is calculated to determine the steady-state noise level over a specified time period. The L_{eq} metric can provide a more accurate quantification of noise exposure for a specific period, particularly for daytime periods when the nighttime penalty under the day-night average sound level metric is inappropriate.

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. Because of the way it is computed, the L_{eq} is effectively a sum of noise energy 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.

A.2.7 Day-Night Average Sound Level (DNL) and Community Noise Equivalent Level (CNEL)

Day-Night Average Sound Level and Community Noise Equivalent Level are complex metrics that account for the SEL of 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 level, includes a 5-decibel penalty on noise during the 7:00 p.m. to 10:00 p.m. time period, and a 10-decibel penalty on noise during the 10:00 p.m. to 7:00 a.m. time period. It should be noted that CNEL is only used by the state of California.

The above described metrics 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 metrics account for the maximum noise levels, the duration of the events (sorties or operations), and the number of events that occur over a 24-hour period. Like SEL, neither DNL nor CNEL represent the sound level heard at any particular time, but represents the total sound energy received (with weighting for night-time operations). While it is normalized as an average, it represents all of the sound energy, and is therefore a cumulative measure.

The penalties added to both the DNL and CNEL metrics 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 inclusion of daytime and nighttime periods in the computation of the DNL and CNEL reflects their basic 24-hour definition. It 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 day. For some military airbases, where daily operations are not consistent throughout the year, a 24-hour DNL or CNEL can be based on an average busy day basis so that the calculated noise is not diluted by periods of low activity.

Although DNL and CNEL provide a single measure of overall noise impact, they do not provide specific information on the number of noise events or the individual sound levels that occur during the 24-hour day. For example, a daily average sound level of 65 dB could result from a very few noisy events or a large number of quieter events.

Daily average sound levels are typically used for the evaluation of community noise effects (i.e., long-term annoyance), and particularly for analyzing 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 (U.S. Environmental Protection Agency 1978 and Schultz 1978). The correlation from Schultz's original 1978 study is shown in Figure A-3. It represents the results of a large number of social surveys relating community responses to various types of noises, measured in day-night average sound level.

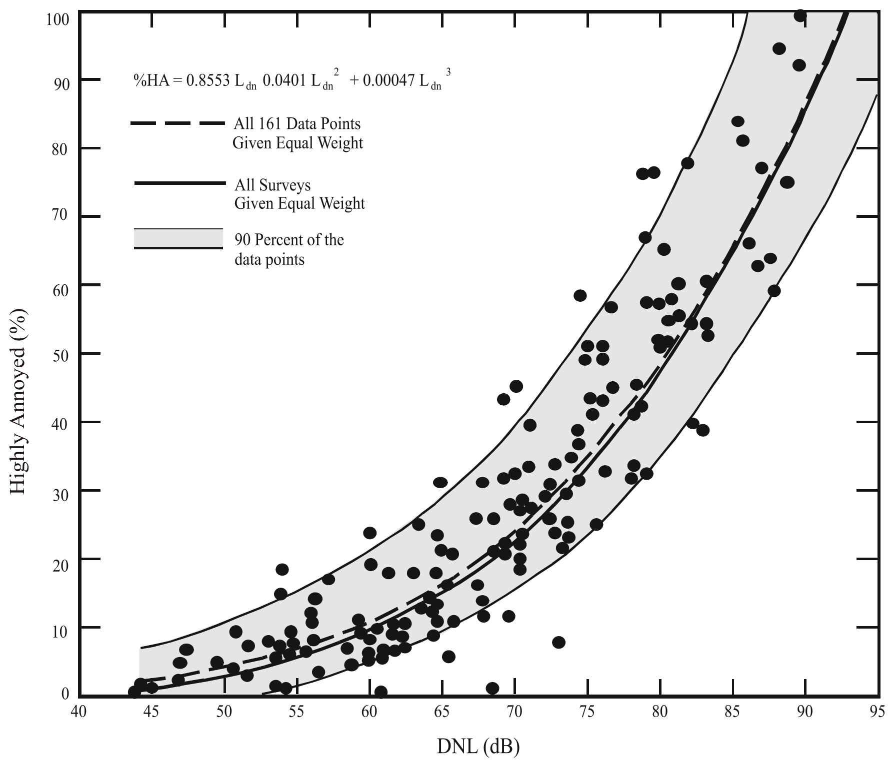


Figure A-3. Community Surveys of Noise Annoyance

A more recent study has reaffirmed this relationship (Fidell et al., 1991). Figure A-4 (Federal Interagency Committee On Noise 1992) shows an updated form of the curve fit (Finegold et al., 1994) in comparison with the original. The updated fit, which does not differ substantially from the original, is the current preferred form. 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. The correlation coefficients for the annoyance of individuals are relatively low, however, 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. However, for the evaluation of community noise impacts, the scientific community has endorsed the use of DNL (American National Standards Institute 1980; American National Standards Institute 1988; U.S. Environmental Protection Agency 1974; Federal Interagency Committee On Urban Noise 1980 and Federal Interagency Committee On Noise 1992).

The use of DNL (CNEL in California) has been criticized as not accurately representing community annoyance and land-use compatibility with aircraft noise. Much of that criticism stems from a lack of understanding of the basis for the measurement or calculation of DNL. One frequent criticism is based on the inherent feeling that people react more to single noise events and not as much to "meaningless" time-average sound levels.

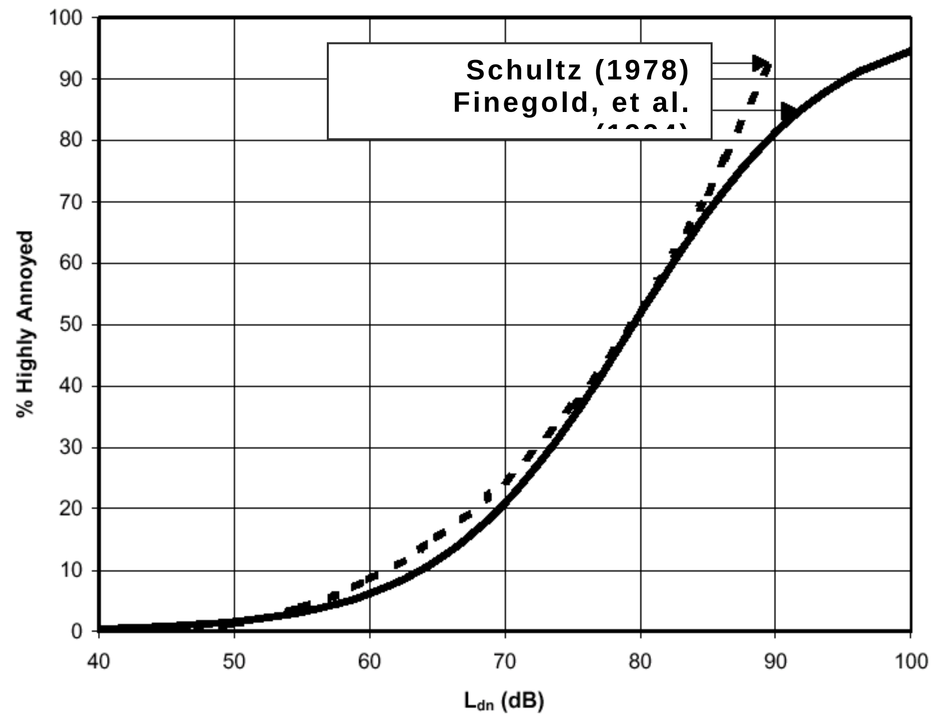


Figure A-4. Response of Communities to Noise; Comparison of Original (Schultz, 1978) and Current (Finegold et al., 1994) Curve Fits

In fact, a time-average noise metric, such as DNL and CNEL, takes into account both the noise levels of all individual events that occur during a 24-hour period and the number of times those events occur. The logarithmic nature of the decibel unit causes the noise levels of the loudest events to control the 24-hour average.

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 day-night average sound level 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 day-night average sound level 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.

A.2.8 Rate Adjusted Day-Night Average Sound Level (L_{dnr})

Military aircraft flying on Military Training Routes (MTRs) and in 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, overflights along MTRs are highly sporadic, ranging from 10 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-airspeed 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, often seasonal, occurrences of aircraft overflights along MTRs and in Restricted Areas/Ranges, the number of daily operations is determined from the number of flying days in the calendar month with the highest number of operations in the affected airspace or MTRs. This avoids dilution of the exposure from periods of low activity, much the way that the average busy day is used around military airbases. The cumulative exposure to noise in these areas is computed by DNL over the busy month, but using SELr 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 $CNEL_{mr}$.

A.3 Noise Effects

A.3.1 Annoyance

The primary effect of aircraft noise on exposed communities is one of long-term annoyance. Noise annoyance is defined by the Environmental Protection Agency (EPA) as any negative subjective reaction on the part of an individual or group (U.S. Environmental Protection Agency 1974). As noted in the discussion of DNL above, community annoyance is best measured by that metric.

The results of attitudinal surveys, conducted to find percentages of people who express various degrees of annoyance when exposed to different levels of DNL, are very consistent. The most useful metric for assessing people's responses to noise impacts is the percentage of the exposed population expected to be "highly annoyed." A wide variety of responses have been used to determine intrusiveness of noise and disturbances of speech, sleep, television or radio listening, and outdoor living. The concept of "percent highly annoyed" has provided the most consistent response of a community to a particular noise environment. The response is remarkably complex, and when considered on an individual basis, widely varies for any given noise level (Federal Interagency Committee On Noise 1992).

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.

A.3.2 Speech Interference

Speech interference associated with aircraft noise is a primary cause of annoyance to individuals on the ground. 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 also important in classrooms, offices, and industrial settings and can cause fatigue and vocal strain in those who attempt to communicate over the noise. Speech is an acoustic signal characterized by rapid fluctuations in sound level and frequency pattern. It is essential for optimum speech intelligibility to recognize these continually shifting sound patterns. Not only does noise diminish the ability to perceive the auditory signal, but it also reduces a listener's ability to follow the pattern of signal fluctuation. In general, interference with speech communication occurs when intrusive noise exceeds about 60 dB (Federal Interagency Committee On Noise 1992).

In 1974, the EPA (1974) identified a goal of an indoor 24-hour average sound level of $L_{eq}(24)$ of 45 dB to minimize speech interference. Indoor speech interference can be expressed as a percentage of sentence intelligibility among two people speaking in relaxed conversation approximately three feet apart in a typical living room or bedroom as shown in Figure A-5 (U.S. Environmental Protection Agency 1974). The percentage of sentence intelligibility is a non-linear function of the (steady) indoor background A-weighted sound level. Such a curve-fit yields 100 percent sentence intelligibility for background levels below 57 dB and yields less than 10 percent intelligibility for background levels above 73 dB. The function is especially sensitive to changes in sound level between 65 dB and 75 dB. As an example of this sensitivity, a 1 dB increase in background sound level from 70 dB to 71 dB yields a 14 percent decrease in sentence intelligibility. The sensitivity of speech interference to noise at 65 dB and above is consistent with the criterion of DNL 65 dB generally taken from the Schultz curve. This is consistent with the observation that speech interference is the primary cause of annoyance.

Another aspect of speech interference is word intelligibility, which is important for children in the classroom and ESL students. Disruption of classroom instruction is a primary concern because of the impacts on children's learning. For teachers to be clearly understood by their student, it is important that regular voice communication is clear and uninterrupted. Not only does the steady 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. Results of research on the impact of noise on the classroom environment are discussed in Section A.3.7.

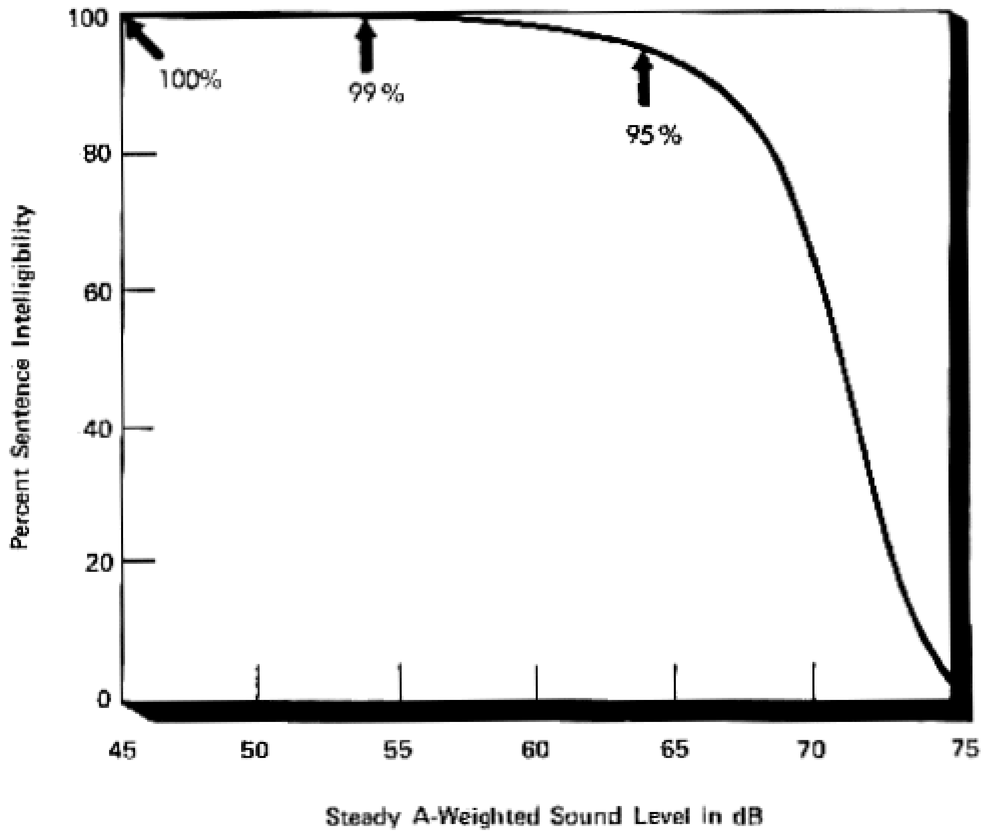


Figure A-5. Indoor Sentence Intelligibility (Source: EPA 1974)

A.3.3 Sleep Interference

Disturbance of sleep is a major concern for communities exposed to nighttime aircraft noise. Although no scientific evidence directly relates nighttime aircraft noise and irreversible long-term health effects such as stress-induced illnesses, sleep disturbance is major cause of annoyance for the community. Consequently, numerous research studies 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: Laboratory studies performed in the 1960s and 1970s and Field observations performed from the 1990s to the present.

A.3.3.1 Background

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 and or the probability of awakening during the night from nighttime operations. 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. Federal Interagency Committee On Noise (FICON) (1992) produced a guidance document that provided an overview of the most pertinent sleep disturbance research that had been conducted throughout the 1970s. Literature reviews and meta analysis conducted by Lukas (1975), Griefahn (1978) and Pearsons et al. (1989) made use of the existing datasets that indicated the effects of nighttime noise various sleep-state changes and awakenings. 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 (% awakening) as a function of the exposure to single event noise levels expressed in terms of SEL. This curve was based on the research conducted by Finegold et al. (1994) for the U.S. Air Force. The dataset included most of the research performed up to that point, and predicted that 10 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.

A.3.3.2 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 form 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 disturbance were not related to individual outdoor noise events, but were instead the result of indoor noise sources and other non-noise-related factors (Reyner and Horne, 1995) . 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 (Pearsons et al., 1995).

A.3.3.3 Federal Interagency Committee on Aviation Noise (FICAN)

The interim FICON dose-response curve (1992) 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 tended to shown 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 the 1992 UK Field Study (Ollerhead et al., 1992), 1992 Los Angeles/Castle Air Force Base Field Study for the USAF (Fidell et al., 1994), 1995 Denver Study (Fidell et al., 1995), along with the datasets from six previous field studies (FICAN, 1997).

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 three 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 assuming 15 and 25 dB noise level reduction from outdoor to indoor with windows open and closed, respectively.

The FICAN 1997 curve is represented by the following equation:

Percent Awakenings = 0.0087 x [SEL-30]1.79.

This relationship has recently been supported by results from a recent research study conducted by the German Aerospace Center (DLR) (Basner et al., 2004).

A3.3.4 American National Standards Institute (ANSI)

In 2008, ANSI published a standard on predicting the probability of awakening in the community, "Methods for Estimation of Awakenings Associated with Outdoor Noise Events Heard in Homes" (2008). The methodology outlined in this procedure estimated the probability of a single awakening during an average night of sleep. The standard provides for two estimation procedures based on the status of the noise. If the source noise has been continuously present in the area, the following equation is used to estimate the probability of awakening from a single event, $P_{A,single}$:

$$P_{A,\sin gle} = \frac{1}{1+e^{-Z}},$$

where Z = -7.594 + 0.04444*SEL+0.00336*T_{retire}, SEL is the predicted or measured indoor value and T_{retire} is the time in minutes since retiring.

If a noise source is new to an area than the FICAN 1997 curve is used to predict $P_{A,single}$ with no adjustment made for time since retiring. Both of these equations are limited to indoor SEL values of 100 dB or less. Either of these methods estimates the probability of a single awakening at a specific location on an average night.

A3.3.5 World Health Organization (WHO) Guidelines

The World Health Organization (WHO) (2000) concluded that high sound levels created by both intermittent and continuous noise leads to sleep disturbance in residential situations. The guidelines mentions that current research has indicated measurable effects on sleep begin when steady-state noise exceeds an 8-hour L_{eq} value of 30 dB indoors. Similarly, WHO concluded that research has shown that individual, intermittent noise sources have a measurable effect on sleep at indoor L_{max} levels of 45 dB or higher. The guidelines simply recommend limiting the number of events, but they do not provide exact guidance on the allowable number of events at the recommended thresholds.

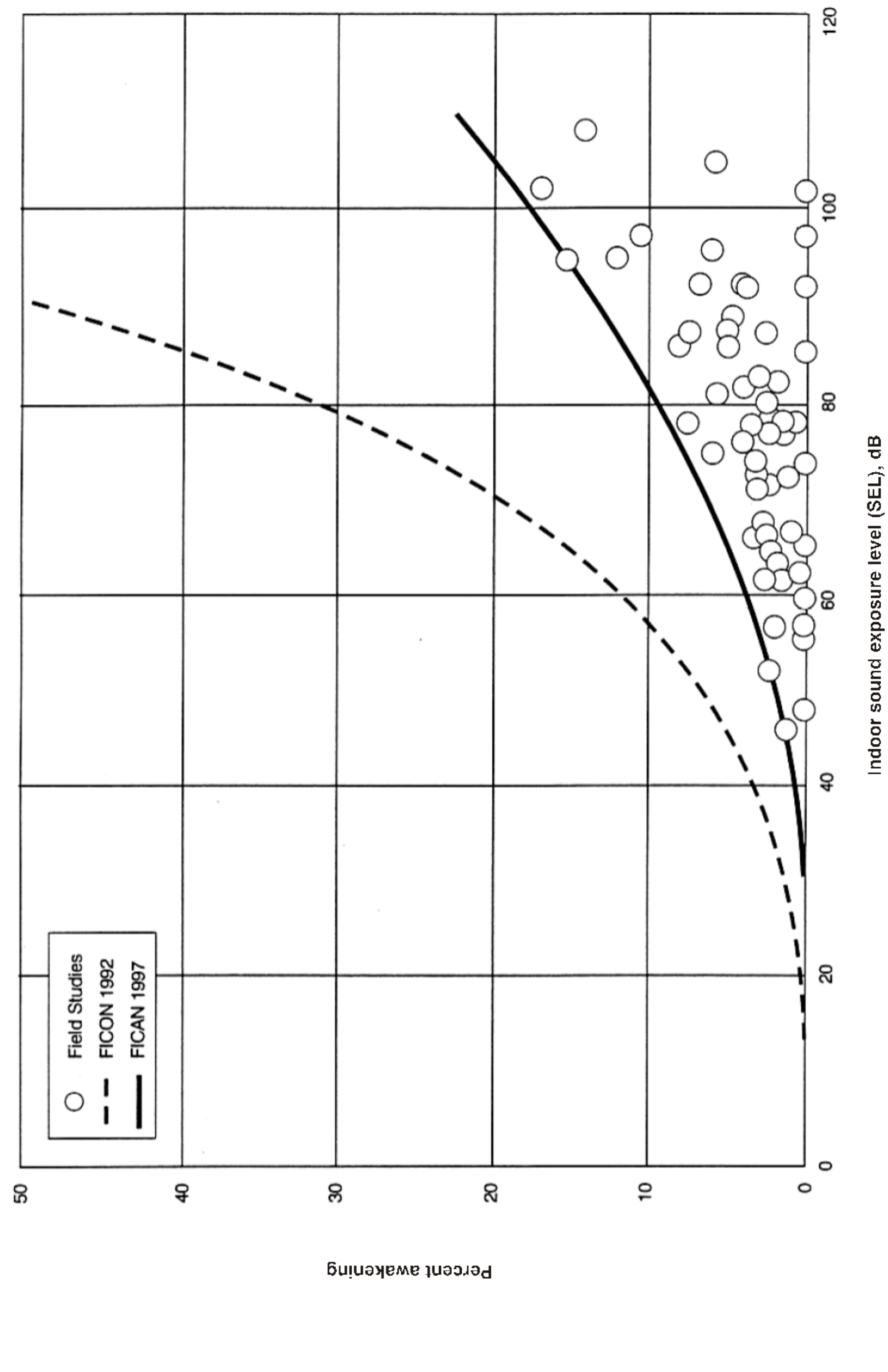


Figure A-6. Recommended Sleep Disturbance Dose-Response Relationship

A.3.4 Hearing Loss

Considerable data on hearing loss have been collected and analyzed. It has been well established that continuous exposure to high noise levels will damage human hearing (U.S. Environmental Protection Agency 1978). People are normally capable of hearing up to 120 dB over a wide frequency range. Hearing loss is generally interpreted as the shifting of a higher sound level of the ear's sensitivity or acuity to perceive sound. This change can either be temporary, called a temporary threshold shift (TTS), or permanent, called a permanent threshold shift (PTS) (Berger et al., 1995).

The EPA has 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% of the population from greater than a 5 dB PTS (U.S. Environmental Protection Agency 1978). Similarly, the National Academy of Sciences Committee on Hearing, Bioacoustics, and Biomechanics (CHABA) identified 75 dB as the minimum level at which hearing loss may occur (Committee on Hearing, Bioacoustics, and Biomechanics 1977). However, it is important to note that continuous, long-term (40 years) exposure is assumed by both EPA and CHABA before hearing loss may occur.

Federal workplace standards for protection from hearing loss allow a time-average level of 90 dB over an 8-hour work period or 85 dB over a 16-hour period. 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 a time-average sound level of 70 dB over a 24-hour period.

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).

A laboratory study measured changes in human hearing from noise representative of low-flying aircraft on MTRs. (Nixon et al., 1993). In this study, participants were first subjected to four overflight noise exposures at A-weighted levels of 115 dB to 130 dB. One-half of the subjects showed no change in hearing levels, one-fourth had a temporary 5-dB increase in sensitivity (the people could hear a 5-dB wider range of sound than before exposure), and one-fourth 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 resulted in the participants hearing a wider range of sound, but within 10 dB of their original range.

In another study of 115 test subjects between 18 and 50 years old, temporary threshold shifts were measured after laboratory exposure to military low-altitude flight (MLAF) noise (Ising et al., 1999). According to the authors, the results indicate that repeated exposure to MLAF 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.

Because it is unlikely that airport neighbors will remain outside their homes 24 hours per day for extended periods of time, there is little possibility of hearing loss below a day-night average sound level of 75 dB, and this level is extremely conservative.

For average sound levels above 75 dB, a potential exists for moderate hearing loss for a small segment of the community who spend significant time outdoors during the day over a 40 year period. To address this potential noise induced hearing loss, the EPA (1974) has recommend a method to assess the potential average hearing loss induced on the total exposed population (PHL) based on procedures developed for assessing occupational noise exposure hazards. This method involves calculating the potential noise-induced permanent threshold shift (NIPTS) and exposed total population.

First, the average NIPTS is estimated based on the following equation:

$$\text{Ave NIPTS} = (\text{DNL} - 75\text{dB})^2/40.$$

This equation provides the following hearing loss weighting factors, H_i, as a function of ranges in DNL levels as provided in Table A-1.

Table A-1. Hearing Loss Weighting Factors

DNL Range	H_i
75-76	0.01
76-77	0.06
77-78	0.16
78-79	0.31
79-80	0.51
80-81	0.76
81-82	1.06
82-83	1.41
83-84	1.81
84-85	2.26
85-86	2.76
86-87	3.31
87-88	3.91
88-89	4.56
89-90	5.26

These factors represent the NIPTS values average over frequency, time, and population percentiles. Thus, they can not be used to estimate the effect on any individual within the exposed population. To estimate the potential average change in hearing level in decibels for a population exposed to the average sound levels over a 40 year time period, these weighting factors are multiplied with exposed populations with one decibel bands and then divided by the total population. The equation for this estimate is provided by

$$PHL = \frac{\sum_i H_i P'_i}{\sum_i P'_i},$$

where P'_i denotes the number of people in the *i*th range of the DNL range (US EPA, 1974; Harris, 1998). For example, if there were 100 people in the total population with 40 within the 75 to 76 DNL range, 30 within 76 to 77 DNL range, 20 with 77 to 78 DNL range, and 10 within 78 to 79 DNL range, the PHL would be the following:

$$PHL = \frac{0.01*40+0.06*30+0.16*20+0.31*10}{40+30+20+10} = \frac{8.5}{100} = 0.085dB/\,person.$$

This metric provides a comparative metric to assess the impacts from various alternatives. However, care should be taken to define the proper base population which should not be varied within a comparison. For comparing alternatives, the base population should be the maximum population exposed to levels greater than 75 dB DNL among all of the alternatives being considered (EPA 1974).

A.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 (1974) 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 (Schwartze 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 affects on pregnant women and the unborn fetus (Harris 1997).

A.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.

A.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 much of the research has focused on the effects of noise on children’s learning and cognitive abilities, and few studies have investigated annoyance and stress response as well.

A.3.7.1 Effects on Learning and Cognitive Abilities

Most of the recent research studies have focused on direct comparisons between two groups: high-noise and low-noise exposure. The comparisons highlight differences in learning skills between these two groups from long-term exposure to noise. As such these studies are observing the long-term effects of aircraft noise exposure on learning skills and not temporary interference and/or annoyance.

Studies conducted in Europe and the United States have found that long-term exposure to aircraft noise has impaired long-term memory, reading comprehension and problem-solving skills in children ages 8 through 14. A study conducted in Munich (Hygge et al., 1996) observed how readings skills varied with changes in of long-term aircraft. Children's relative performance to a control group worsened in the years following the opening of an airport. Moreover, children's performance improved at a location where an airport closed. The researchers concluded that the effect of the long-term aircraft noise exposure resulted in deficits in reading and long-term memory and the effect took several years to develop.

Similar studies have been conducted near Heathrow Airport in West London, UK (Haines et al., 2001a) and in Los Angeles (Cohen et al., 1980) which found impaired reading and problem-solving skills in students in high-noise environments compared to control groups in low noise environments.

The Road traffic and Aircraft Noise exposure and Children's cognition and Health, termed the RANCH Project, used a different approach to test the effects of aircraft noise exposure on children's learning skills (Stansfeld et al., 2005). The project studied reading comprehension in student populations located near three major European airports. Schools were selected according to increasing noise levels from aircraft operations at the airports. Reading comprehension was measured using standardized tests and the results showed an inverse relationship between reading scores and aircraft noise. The readings scores decreased as the aircraft noise increased.

Studies have also shown some relationship between aircraft noise and student motivation (Cohen et al., 1980; Maxwell and Evans, 2000). These studies have observed that students in higher noise environments tend to have lower motivation compared to a control group. This observation suggests that high noise can contribute to an attitude of "giving up" or "learned helplessness." Moreover, studies have also demonstrated a link between aircraft noise and annoyance in children (Haines et al., 2001a; Maxwell and Evans, 2000; and Stansfeld et al., 2005).

The important observation from these studies is that long-term aircraft noise does have a negative effect on the development of children's learning skills. The short coming of the studies is that they mainly provide results in relative terms, which limits the identification of noise levels where impairment is certain to occur. The RANCH project made an attempt to develop exposure-effect relationships between noise exposure and learning impairment.

However, at this point, a threshold noise level at which impairment starts has yet to be identified because of the many confounding factors related to the development of children's learning skills.

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).

A.3.7.2 Classroom Criteria and Guidelines

In the recent release (2002) of the "Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools," the American National Standards Institute refers to studies that suggest that loud and frequent background noise can affect the learning patterns of young children. 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. ANSI has approved a new standard for acoustical performance criteria in schools. The new criteria 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 (American National Standards Institute, 2002).

The basics of speech communication govern the criteria for classroom sound environment. Both ANSI and the American Speech-Language-Hearing Association (1995) recommend at least a 15 dB signal-to-noise ratio in the classroom to ensure that children with hearing impairments and language disabilities can achieve high speech intelligibility (i.e. teacher's voice should be at least 15 dB above the classroom background sound level for clear communication with all students). Since average adult male or female voice registers a minimum of L_{max} 50 dB in the rear of the classroom, this criteria requires that the continuous background noise level inside the classroom should not exceed an L_{eq} of 35 dB. This criterion is also supported by WHO (2000).

The Federal Aviation Administration (FAA) (1985) guidelines used to determine eligibility for noise insulation funding state that the design objective for a classroom is an interior L_{eq} of 45 dB from aircraft operations occurring during normal school hours. However, noise near an airfield is not continuous, but consist of individual events which temporarily increase the sound level as an aircraft flies by. Thus, the steady-state sound level classroom criteria need to be supplemented to account for this type of intermittent noise. As such, time-average metrics are not appropriate for evaluating classroom interference from aircraft operations.

In 1998, Lind, Pearsons, and Fidell (1998) concluded that if an aircraft noise event reached a maximum indoor noise level of 50 dB, 90% of the words would be understood by students throughout the classroom. On the other hand, Bradley (1993) concluded that SEL was a better indicator of indoor speech interference from aircraft overflights. Bradley's work indicates that for speakers talking with a casual vocal effort, 95% speech intelligibility would be achieved when the SEL values did not exceed and indoor level of 60 dB. These two findings are approximately equal since for aircraft noise SEL levels are approximately 10 dB higher than its corresponding L_{max} level.

For intermittent noise events, ANSI states that the background sound level criteria can be relaxed since speech interference would only occur for short time periods. The ANSI recommends that the background sound level should have an L_{eq} of no more than 40 dB for the noisiest hour as long as the noise level does not exceed 40 dB for more than 10% of that hour (ANSI, 2002).

A.3.7.3 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, relatively recent 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, Haines et al. (2001b and 2001c) analyzed cortisol and urinary catecholamine levels in school children as measurements of stress response to aircraft noise. 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).

A.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. Manci et al. (1988), assert that the consequences that physiological effects may have on behavioral patterns are 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 Manci 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 overflown 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 (Manci 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.

A.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 (Cottereau 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., 1990). 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).

A.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).

A.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 Manci 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., 1991a).

A.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 1 to 5 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 Manci et al., 1988). Ravens responded by emitting protestation calls, flapping their wings, and soaring.

Manci 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.

A.3.8.2.2.1 RAPTORS

In a literature review of raptor responses to aircraft noise, Manci 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 Serice 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.

A.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).

A.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% 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 1969, sonic booms were potentially linked to a mass hatch failure of Sooty Terns on the Dry Tortugas (Austin et al, 1969). 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 1991b; Bowles et al 1994; Cottereau 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.

A.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 Manci 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. Crocodilians 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 crocodilians (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.

A3.8.4 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.

A.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 DNL, and sites are conditionally acceptable with special approvals and noise attenuation in the 65 to 75 DNL noise zone and the greater than 75 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 commerical 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 LDN 65dB. 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/Tucson, AZ, Fidell found the homes near the airbase 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 base. 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.

A.3.10 Noise Effects on Structures

Normally, the most sensitive components of a structure to airborne noise are the windows and, infrequently, the plastered walls and ceilings. An evaluation of the peak sound pressures impinging on the structure is normally used to determine the possibility of damage. In general, with peak sound levels above 130 dB, there is the possibility of the excitation of structural component resonances. While certain frequencies (such as 30 hertz for window breakage) may be of more concern than other frequencies, conservatively, only sounds lasting more than one second above a sound level of 130 dB are potentially damaging to structural components (Committee on Hearing, Bioacoustics, and Biomechanics 1977).

Noise-induced structural vibration may also cause annoyance to dwelling occupants because of induced secondary vibrations, or rattling of objects within the dwelling such as hanging pictures, dishes, plaques, and bric-a-brac. Window panes may also vibrate noticeably when exposed to high levels of airborne noise. In general, such noise-induced vibrations occur at peak sound levels of 110 dB or greater. Thus, assessments of noise exposure levels for compatible land use should also be protective of noise-induced secondary vibrations.

A.3.11 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.

A.3.12 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 supersonic 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.

A.4 References

Acoustical Society of America. 1980. *San Diego Workshop on the Interaction Between Manmade Noise and Vibration and Arctic Marine Wildlife. Acoust*. Soc. Am., Am. Inst. Physics, New York. 84 pp.

American National Standards Institute. 1980. *Sound Level Descriptors for Determination of Compatible Land Use*. ANSI S3.23-1980.

American National Standards Institute. 1988. *Quantities and Procedures for Description and Measurement of Environmental Sound*: Part 1. ANSI S12.9-1988.

American National Standards Institute. 1996. *Quantities and Procedures for Description and Measurement of Environmental Sound*: Part 4. ANSI S12.9-1996.

American National Standards Institute. 2002. *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools.* ANSI S12.60-2002.

American National Standards Institute. 2008. *Methods for Estimation of Awakenings Associated with Outdoor Noise Events Heard in Homes*: Part 6. ANSI S12.9-2008.

American Speech-Language-Hearing Association. 1995. *Guidelines for Acoustics in Educational Environments*, V.37, Suppl. 14, pp. 15-19.

Anderson, D.E., O.J. Rongstad, and W.R. Mytton. 1989. *Responses of Nesting Red-tailed Hawks to Helicopter Overflights*. The Condor, Vol. 91, pp. 296-299.

Andrus, W.S., M.E. Kerrigan, and K.T. Bird. 1975. *Hearing in Para-Airport Children*. Aviation, Space, and Environmental Medicine, Vol. 46, pp. 740-742.

Austin, O.L., Jr., W.B. Robertson, Jr., and G.E. Woolfenden. 1970. *Mass hatching failure in Dry Tortugas sooty terns (Sterna fuscata)*. (Abstract only). Page 627 in K.H. Voous, ed. Proc. 15th Int. 0rnithol. Congr. The Hague, Netherlands.

Basner, M., et al. 2004. *Effects of nocturnal Aircraft Noise*, Volume 1, Executive Summary, (English translations) DLR-Forschungsbericht 2004-07/E, German Aerospace Center (DLR), Insitute of Aerospace Medicine, Cologne, Germany.

Berger, E. H., W.D. Ward, J.C. Morrill, and L.H. Royster. 1995. *Noise And Hearing Conservation Manual*, Fourth Edition. American Industrial Hygiene Association, Fairfax, Virginia.

Berglund, B., and T. Lindvall, eds. 1995. *Community Noise*. Institute of Environmental Medicine.

Beyer, D. 1983. *Studies of the Effects of Low-Flying Aircraft on Endocrinological and Physiological Parameters in Pregnant Cows*. Veterinary College of Hannover, München, Germany.

Black, B., M. Collopy, H. Percivial, A. Tiller, and P. Bohall. 1984. *Effects of Low-Altitude Military Training Flights on Wading Bird Colonies in Florida*. Florida Cooperative Fish and Wildlife Research Unit, Technical Report No. 7.

Bond, J., C.F. Winchester, L.E. Campbell, and J.C. Webb. 1963. *The Effects of Loud Sounds on the Physiology and Behavior of Swine*. U.S. Department of Agriculture Agricultural Research Service Technical Bulletin 1280.

Bowles, A.E., C. Book, and F. Bradley. 1990. *Effects of Low-Altitude Aircraft Overflights on Domestic Turkey Poults*. USAF, Wright-Patterson AFB, AL/OEBN Noise Effects Branch.

Bowles, A.E., B. Tabachnick, and S. Fidell. 1991a. *Review of the Effects of Aircraft Overflights on Wildlife*. Volume II of III, Technical Report, National Park Service, Denver, Colorado.

Bowles, A.E., F.T. Awbrey, and J.R. Jehl. 1991b. *The Effects of High-Amplitude Impulsive Noise On Hatching Success: A Reanalysis of the Sooty Tern Incident*, HSD-TP-91-0006.

Bowles, A.E., M. Knobler, M.D. Sneddon, and B.A. Kugler. 1994. *Effects of Simulated Sonic Booms on the Hatchability of White Leghorn Chicken Eggs,* AL/OE-TR-1994-0179.

Bowles, A.E. 1995. *Responses of Wildlife to Noise*. In R.L. Knight and K.J. Gutzwiller, eds., "Wildlife and Recreationists: Coexistence through Management and Research," Island Press, Covelo, California, pp.109-156.

Bradley, J.S. 1993. *NRC-CNRC NEF Validation Study: Review of Aircraft Noise and its Effects,* National Research Council Canada and Transport Canada, Contract Report A-1505.5.

Brown, A.L. 1990. *Measuring the Effect of Aircraft Noise on Sea Birds*. Environment International, Vol. 16, pp. 587-592.

Bullock, T.H., D.P. Donning, and C.R. Best. 1980. *Evoked Brain Potentials Demonstrate Hearing in a Manatee (Trichechus inunguis)*. Journal of Mammals, Vol. 61, No. 1, pp. 130-133.

Burger, J. 1981. *Behavioral Responses of Herring Gulls (Larus argentatus) to Aircraft Noise*. Environmental Pollution (Series A), Vol. 24, pp. 177-184.

Burger, J. 1986. The *Effect of Human Activity on Shorebirds in Two Coastal Bays in Northeastern United States*. Environmental Conservation, Vol. 13, No. 2, pp. 123-130.

Cantrell, R.W. 1974. *Prolonged Exposure to Intermittent Noise: Audiometric, Biochemical, Motor, Psychological, and Sleep Effects*. Laryngoscope, Supplement I, Vol. 84, No. 10, p. 2.

Casady, R.B., and R.P. Lehmann. 1967. *Response of Farm Animals to Sonic Booms*. Studies at Edwards Air Force Base, June 6-30, 1966. Interim Report, U.S. Department of Agriculture, Beltsville, Maryland, p. 8.

Chen, T., S. Chen, P. Hsieh, and H. Chiang. 1997. *Auditory Effects of Aircraft Noise on People Living Near an Airport*. Archives of Environmental Health, Vol. 52, No. 1, pp. 45-50.

Chen, T., and S. Chen. 1993. *Effects of Aircraft Noise on Hearing and Auditory Pathway Function of School-Age Children*. International Archives of Occupational and Environmental Health, Vol. 65, No. 2, pp. 107-111.

Cogger, E.A., and E.G. Zegarra. 1980. *Sonic Booms and Reproductive Performance of Marine Birds: Studies on Domestic Fowl as Analogues*. In Jehl, J.R., and C.F. Cogger, eds., "Potential Effects of Space Shuttle Sonic Booms on the Biota and Geology of the California Channel Islands: Research Reports," San Diego State University Center for Marine Studies Technical Report No. 80-1.

Cohen, S., G.W. Evans, D.S. Krantz, and D. Stokols. 1980. *Physiological, Motivational, and Cognitive Effects of Aircraft Noise on Children: Moving from Laboratory to Field*. American Psychologist, Vol. 35, pp. 231-243.

Committee on Hearing, Bioacoustics, and Biomechanics. 1977. *Guidelines for Preparing Environmental Impact Statements on Noise*. The National Research Council, National Academy of Sciences.

Conomy, J.T., J.A. Dubovsky, J.A. Collazo, and W. J. Fleming. 1998. *Do Black Ducks and Wood Ducks Habituate to Aircraft Disturbance?* Journal of Wildlife Management, Vol. 62, No. 3, pp. 1135-1142.

Cottereau, P. 1972. *Les Incidences Du 'Bang' Des Avions Supersoniques Sur Les Productions Et La Vie Animals*. Revue Medicine Veterinaire, Vol. 123, No. 11, pp. 1367-1409

Cottereau, P. 1978. *The Effect of Sonic Boom from Aircraft on Wildlife and Animal Husbandry*. In "Effects of Noise on Wildlife," Academic Press, New York, New York, pp. 63-79.

Crowley, R.W. 1978. *A Case Study of the Effects of an Airport on Land Values*. Journal of Transportation Economics and Policy, Vol. 7. May.

Davis, R.W., W.E. Evans, and B. Wursig, eds. 2000. *Cetaceans, Sea Turtles, and Seabirds in the Northern Gulf of Mexico: Distribution, Abundance, and Habitat Associations*. Volume II of Technical Report, prepared by Texas A&M University at Galveston and the National Marine Fisheries Service. U.S. Department of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0006 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana, OCS Study MMS 2000-003.

Dooling, R.J. 1978. *Behavior and Psychophysics of Hearing in Birds*. J. Acoust. Soc. Am., Supplement 1, Vol. 65, p. S4.

Dufour, P.A. 1980. *Effects of Noise on Wildlife and Other Animals: Review of Research Since 1971*. U.S. Environmental Protection Agency.

Edmonds, L.D., P.M. Layde, and J.D. Erickson. 1979. *Airport Noise and Teratogenesis*. Archives of Environmental Health, Vol. 34, No. 4, pp. 243-247.

Edwards, R.G., A.B. Broderson, R.W. Harbour, D.F. McCoy, and C.W. Johnson. 1979. *Assessment of the Environmental Compatibility of Differing Helicopter Noise Certification Standards*. U.S. Dept. of Transportation, Washington, D.C. 58 pp.

Ellis, D.H., C.H. Ellis, and D.P. Mindell. 1991. *Raptor Responses to Low-Level Jet Aircraft and Sonic Booms*. Environmental Pollution, Vol. 74, pp. 53-83.

Evans, G.W., and L. Maxwell. 1997. *Chronic Noise Exposure and Reading Deficits: The Mediating Effects of Language Acquisition*. Environment and Behavior, Vol. 29, No. 5, pp. 638-656.

Evans, G.W., and S.J. Lepore. 1993. *Nonauditory Effects of Noise on Children: A Critical Review*. Children's Environment, Vol. 10, pp. 31-51.

Evans, G.W., M. Bullinger, and S. Hygge. 1998. *Chronic Noise Exposure and Physiological Response: A Prospective Study of Children Living under Environmental Stress*. Psychological Science, Vol. 9, pp. 75-77.

Federal Aviation Administration (FAA). 1985. *Airport Improvement Program (AIP) Handbook*, Order No. 100.38.

Federal Interagency Committee on Aviation Noise (FICAN). 1997. *Effects of Aviation Noise on Awakenings from Sleep*. June.

Federal Interagency Committee On Noise (FICON). 1992. *Federal Agency Review of Selected Airport Noise Analysis Issues*. August.

Federal Interagency Committee on Urban Noise (FICUN). 1980. *Guidelines for Considering Noise in Land-Use Planning and Control*. U.S. Government Printing Office Report #1981-337-066/8071, Washington, D.C.

Fidell, S., D.S. Barber, and T.J. Schultz. 1991. *Updating a Dosage-Effect Relationship for the Prevalence of Annoyance Due to General Transportation Noise*. J. Acoust. Soc. Am., Vol. 89, No. 1, pp. 221-233. January.

Fidell, S., K. Pearsons, R. Howe, B. Tabachnick, L. Silvati, and D.S. Barber. 1994. *Noise-Induced Sleep Disturbance in Residential Settings*. USAF, Wright-Patterson AFB, Ohio: AL/OE-TR-1994-0131.

Fidell, S., R. Howe, B. Tabachnick, K. Pearsons, and M. Sneddon. 1995. *Noise-induced Sleep Disturbance in Residences near two Civil Airports* (Contract NAS1-20101) NASA Langley Research Center.

Fidell, S., B. Tabachnick, and L. Silvati. 1996. *Effects of Military Aircraft Noise on Residential Property Values*. BBN Systems and Technologies, BBN Report No. 8102.

Finegold, L.S., C.S. Harris, and H.E. von Gierke. 1994. *Community Annoyance and Sleep Disturbance: Updated Criteria for Assessing the Impact of General Transportation Noise on People*. Noise Control Engineering Journal, Vol. 42, No. 1, pp. 25-30.

Fisch, L. 1977. *Research Into Effects of Aircraft Noise on Hearing of Children in Exposed Residential Areas Around an Airport*. Acoustics Letters, Vol. 1, pp. 42-43.

Fleischner, T.L., and S. Weisberg. 1986. *Effects of Jet Aircraft Activity on Bald Eagles in the Vicinity of Bellingham International Airport*. Unpublished Report, DEVCO Aviation Consultants, Bellingham, WA.

Fleming, W.J., J. Dubovsky, and J. Collazo. 1996. *An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina*. Final Report by the North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University, prepared for the Marine Corps Air Station, Cherry Point.

Fraser, J.D., L.D. Franzel, and J.G. Mathiesen. 1985. *The Impact of Human Activities on Breeding Bald Eagles in North-Central Minnesota*. Journal of Wildlife Management, Vol. 49, pp. 585-592.

Frerichs, R.R., B.L. Beeman, and A.H. Coulson. 1980. *Los Angeles Airport Noise and Mortality: Faulty Analysis and Public Policy*. Am. J. Public Health, Vol. 70, No. 4, pp. 357-362. April.

Gladwin, D.N., K.M. Manci, and R. Villella. 1988. *Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife*. Bibliographic Abstracts. NERC-88/32. U.S. Fish and Wildlife Service National Ecology Research Center, Ft. Collins, Colorado.

Green, K.B., B.S. Pasternack, and R.E. Shore. 1982. *Effects of Aircraft Noise on Reading Ability of School-Age Children*. Archives of Environmental Health, Vol. 37, No. 1, pp. 24-31.

Griefahn, B. 1978. *Proceedings of Third Int. Cong. On Noise as a Public Health Problem*, Research on Noise Disturbed Sleep Since 1973, pp. 377-390 (as appears in NRC-CNRC NEF Validation Study: (2) *Review of Aircraft Noise and Its Effects*, A-1505.1, pg. 31).

Grubb, T.G., and R.M. King. 1991. *Assessing Human Disturbance of Breeding Bald Eagles with Classification Tree Models*. Journal of Wildlife Management, Vol. 55, No. 3, pp. 500-511.

Gunn, W.W.H., and J.A. Livingston. 1974. *Disturbance to Birds by Gas Compressor Noise Simulators, Aircraft, and Human Activity in the MacKenzie Valley and the North Slope*. Chapters VI-VIII, Arctic Gas Biological Report, Series Vol. 14.

Haines, M.M., S.A. Stansfeld, R.F. Job, B. Berglund, and J. Head. 2001a. *A Follow-up Study of Effects of Chronic Aircraft Noise Exposure on Child Stress Responses and Cognition*. International Journal of Epidemiology, Vol. 30, pp. 839-845.

Haines, M.M., S.A. Stansfeld, R.F. Job, B. Berglund, and J. Head. 2001b. *Chronic Aircraft Noise Exposure, Stress Responses, Mental Health and Cognitive Performance in School Children*. Psychological Medicine, Vol. 31, pp.265-277. February.

Haines, M.M., S.A. Stansfeld, S. Brentnall, J. Head, B. Berry, M. Jiggins, and S. Hygge. 2001c. *The West London Schools Study: the Effects of Chronic Aircraft Noise Exposure on Child Health*. Psychological Medicine, Vol. 31, pp. 1385-1396. November.

Hanson, C.E., K.W. King, M.E. Eagan, and R.D. Horonjeff. 1991. *Aircraft Noise Effects on Cultural Resources: Review of Technical Literature*. Report No. HMMH-290940.04-1, available as PB93-205300, sponsored by National Park Service, Denver CO.

Harris, C.M., Editor. 1998. *Handbook of Acoustical Measurements and Noise Control*. Acoustical Society of America, Woodbury, NY.

Harris, C.S. 1997. *The Effects of Noise on Health*. USAF, Wright-Patterson AFB, Ohio, AL/OE-TR-1997-0077.

Hygge, S., G.W. Evans, M. Bullinger. 1996. *The Munich airport noise study: Cognitive effects on children from before to after the change over of airports*. In F.A. Hill and R. Lawrence (eds.) Inter Noise 96. Noise Control – The Next 25 Years, Vol. 5, pp. 2189-92. Institute of Acoustics, St. Albans, UK.

Hygge, S., G.W. Evans, and M. Bullinger. 2002. *A Prospective Study of Some Effects of Aircraft Noise on Cognitive Performance in School Children*. Psychological Science Vol. 13, pp. 469-474.

Ising, H., Z. Joachims, W. Babisch, and E. Rebentisch. 1999. *Effects of Military Low-Altitude Flight Noise I Temporary Threshold Shift in Humans*. Zeitschrift fur Audiologie (Germany), Vol. 38, No. 4, pp. 118-127.

Jehl, J.R., and C.F. Cooper, eds. 1980. *Potential Effects of Space Shuttle Sonic Booms on the Biota and Geology of the California Channel Islands*. Research Reports, Center for Marine Studies, San Diego State University, San Diego, CA, Technical Report No. 80-1. 246 pp.

Jones, F.N., and J. Tauscher. 1978. *Residence Under an Airport Landing Pattern as a Factor in Teratism*. Archives of Environmental Health, pp. 10-12. January/ February.

Kovalcik, K., and J. Sottnik. 1971. *Vplyv Hluku Na Mliekovú Úzitkovost Kráv [The Effect of Noise on the Milk Efficiency of Cows]*. Zivocisná Vyroba, Vol. 16, Nos. 10-11, pp. 795-804.

Kryter, K.D. 1984. *Physiological, Psychological, and Social Effects of Noise*. NASA Reference Publication 1115. July.

Kryter, K.D., and F. Poza. 1980. *Effects of Noise on Some Autonomic System Activities*. J. Acoust. Soc. Am., Vol. 67, No. 6, pp. 2036-2044.

Kushlan, J.A. 1978. *Effects of Helicopter Censuses on Wading Bird Colonies*. Journal of Wildlife Management, Vol. 43, No. 3, pp. 756-760.

LeBlanc, M.M., C. Lombard, S. Lieb, E. Klapstein, and R. Massey. 1991. *Physiological Responses of Horses to Simulated Aircraft Noise*. U.S. Air Force, NSBIT Program for University of Florida.

Lind, S.J., K. Pearsons, and S. Fidell. 1998. *Sound Insulation Requirements for Mitigation of Aircraft Noise Impact on Highline School District Facilities*, Volume I, BBN Systems and Technologies, BBN Report No. 8240.

Lukas, J.S. 1975. Noise and Sleep: *A Literature Review and a Proposed Criterion for Assessing Effect*. In Darly N. May, ed., "Handbook of Noise Assessment," Van Nostrand Reinhold Company: New York, pp. 313-334.

Lynch, T.E., and D.W. Speake. 1978. *Eastern Wild Turkey Behavioral Responses Induced by Sonic Boom*. In "Effects of Noise on Wildlife," Academic Press, New York, New York, pp. 47-61.

Manci, K.M., D.N. Gladwin, R. Villella, and M.G Cavendish. 1988. *Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: A Literature Synthesis*. U.S. Fish and Wildlife Service National Ecology Research Center, Ft. Collins, CO, NERC-88/29. 88 pp.

Maxwell, L.E., and G.W. Evans. 2000. *The Effects of Noise on Pre-School Children's Pre-reading Skills*, Journal of Environmental Psychology, No. 20.

Meacham, W.C., and N. Shaw. 1979. *Effects of Jet Noise on Mortality Rates*. British Journal of Audiology, Vol. 13, pp. 77-80. August.

Metro-Dade County. 1995. *Dade County Manatee Protection Plan*. DERM Technical Report 95-5. Department of Environmental Resources Management, Miami, Florida.

Michalak, R., H. Ising, and E. Rebentisch. 1990. Acute *Circulatory Effects of Military Low-Altitude Flight Noise*. International Archives of Occupational and Environmental Health, Vol. 62, No. 5, pp. 365-372.

Nelson, J.P. 1978. *Economic Analysis of Transportation Noise Abatement*. Ballenger Publishing Company, Cambridge, MA.

North Atlantic Treaty Organization. 2000. *The Effects of Noise from Weapons and Sonic Booms, and the Impact on Humans, Wildlife, Domestic Animals and Structures*. Final Report of the Working Group Study Follow-up Program to the Pilot Study on Aircraft Noise, Report No. 241. June.

National Park Service. 1994. Report to Congress: *Report on Effects of Aircraft Overflights on the National Park System*. Prepared Pursuant to Public Law 100-91, The National Parks Overflights Act of 1987. 12 September.

Newman, J.S., and K.R. Beattie. 1985. *Aviation Noise Effects*. U.S. Department of Transportation, Federal Aviation Administration Report No. FAA-EE-85-2.

Nixon, C.W., D.W. West, and N.K. Allen. 1993. *Human Auditory Responses to Aircraft Flyover Noise*. In Vallets, M., ed., Proceedings of the 6th International Congress on Noise as a Public Problem, Vol. 2, Arcueil, France: INRETS.

Ollerhead, J.B., C.J. Jones, R.E. Cadoux, A. Woodley, B.J. Atkinson, J.A. Horne, F. Pankhurst, L. Reyner, K.I. Hume, F. Van, A. Watson, I.D. Diamond, P. Egger, D. Holmes, and J. McKean. 1992. *Report of a Field*

Study of Aircraft Noise and Sleep Disturbance. London: Department of Safety, Environment and Engineering, Civil Aviation Authority. December.

Parker, J.B., and N.D. Bayley. 1960. *Investigations on Effects of Aircraft Sound on Milk Production of Dairy Cattle, 1957-58*. U.S. Agricultural Research Services, U.S. Department of Agriculture, Technical Report Number ARS 44-60.

Pater, L.D., D.K. Delaney, T.J. Hayden, B. Lohr, and R. Dooling. 1999. *Assessment of Training Noise Impacts on the Red-cockaded Woodpecker: Preliminary Results – Final Report*. Technical Report. U.S. Army, Corps of Engineers, CERL, Champaign, IL, Report Number 99/51, ADA Number 367234.

Pearsons, K.S., D.S. Barber, B.G. Tabachnick, and S. Fidell. 1995. *Predicting Noise-Induced Sleep Disturbance*. J. Acoust. Soc. Am., Vol. 97, No. 1, pp. 331-338. January.

Pearsons, K.S., D.S. Barber, and B.G. Tabachnick. 1989. *Analyses of the Predictability of Noise-Induced Sleep Disturbance*. USAF Report HSD-TR-89-029. October.

Pulles, M.P.J., W. Biesiot, and R. Stewart. 1990. *Adverse Effects of Environmental Noise on Health : An Interdisciplinary Approach*. Environment International, Vol. 16, pp. 437-445.

Reyner, L.A. and J.A. Horne. 1995. *Gender and Age-Related Differences in Sleep Determined by Home-Recorded Sleep Logs and Actimetry from 400 Adults, Sleep*, 18: 127-134.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. *Marine Mammals and Noise*. Academic Press, San Diego, CA.

Rosenlund, M., N. Berglind, G. Bluhm, L. Jarup, and G. Pershagen. 2001. *Increased Prevalence of Hypertension in a Population Exposed to Aircraft Noise*. Occupational and Environmental Medicine, Vol. 58, No. 12, pp. 769-773. December.

Schultz, T.J. 1978. *Synthesis of Social Surveys on Noise Annoyance*. J. Acoust. Soc. Am., Vol. 64, No. 2, pp. 377-405. August.

Schwartze, S., and S.J. Thompson. 1993. *Research on Non-Auditory Physiological Effects of Noise Since 1988: Review and Perspectives*. In Vallets, M., ed., Proceedings of the 6th International Congress on Noise as a Public Problem, Vol. 3, Arcueil, France: INRETS.

Sharp, Ben, Albee, William, Conner, Thomas, and Bassarab, Royce. 2007. *Improving Aviation Noise Planning, Analysis and Public Communication with Supplemental Metrics: Guide to Using Supplemental Metrics*, Wyle Report, WR 07-03.

Smith, D.G., D.H. Ellis, and T.H. Johnston. 1988. *Raptors and Aircraft. In R.L Glinski, B. Gron-Pendelton, M.B. Moss, M.N. LeFranc, Jr., B.A. Millsap, and S.W. Hoffman, eds., Proceedings of the Southwest Raptor Management Symposium*. National Wildlife Federation, Washington, D.C., pp. 360-367.

Stansfeld, Berglund, Clark, Lopex-Barrio, Fischer, Ohrstrom, Haines, Head, Hygge, van Kamp et al. 2005. *Aircraft and Road Traffic Noise and Children's Cognition and Health: A Cross-National Study*. The Lancet, Volume 365, Issue 9475, 4 June 2005-10 June 2005, pp. 1942-1949.

State of California. 1990. *Administrative Code Title 21*.

Stusnick, E., D.A. Bradley, J.A. Molino, and G. DeMiranda. 1992. *The Effect of Onset Rate on Aircraft Noise Annoyance, Volume 2: Rented Home Experiment*. Wyle Laboratories Research Report WR 92-3. March.

Tetra Tech, Inc. 1997. *Final Environmental Assessment Issuance of a Letter of Authorization for the Incidental Take of Marine Mammals for Programmatic Operations at Vandenberg Air Force Base, California*. July.

Ting, C., J. Garrelick, and A. Bowles. 2002. *An Analysis of the Response of Sooty Tern eggs to Sonic Boom Overpressures*. J. Acoust. Soc. Am., Vol. 111, No. 1, Pt. 2, pp. 562-568.

Trimper, P.G., N.M. Standen, L.M. Lye, D. Lemon, T.E. Chubbs, and G.W. Humphries. 1998. *Effects of Low-level Jet Aircraft Noise On the Behavior of Nesting Osprey*. Journal of Applied Ecology, Vol. 35, pp. 122-130.

U.S. Air Force. 1993. *The Impact of Low Altitude Flights on Livestock and Poultry*. Air Force Handbook. Volume 8, Environmental Protection. 28 January.

U.S. Air Force. 1994a. *Air Force Position Paper on the Effects of Aircraft Overflights on Domestic Fowl*. Approved by HQ USAF/CEVP. 3 October.

U.S. Air Force. 1994b. *Air Force Position Paper on the Effects of Aircraft Overflights on Large Domestic Stock*. Approved by HQ USAF/CEVP. 3 October.

U.S. Air Force. 2000. *Preliminary Final Supplemental Environmental Impact Statement for Homestead Air Force Base Closure and Reuse*. Prepared by SAIC. 20 July.

U.S. Department of the Navy. 2002. *Supplement to Programmatic Environmental Assessment for Continued Use with Non-Explosive Ordnance of the Vieques Inner Range, to Include Training Operations Typical of Large Scale Exercises, Multiple Unit Level Training, and/or a Combination of Large Scale Exercises and Multiple Unit Level Training*. March.

U.S. Environmental Protection Agency. 1974. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety*. U.S. Environmental Protection Agency Report 550/9-74-004. March.

U.S. Environmental Protection Agency. 1978. *Protective Noise Levels*. Office of Noise Abatement and Control, Washington, D.C. U.S. Environmental Protection Agency Report 550/9-79-100. November.

U.S. Fish and Wildlife Service. 1998. *Consultation Letter #2-22-98-I-224 Explaining Restrictions on Endangered Species Required for the Proposed Force Structure and Foreign Military Sales Actions at Cannon AFB, NM*. To Alton Chavis HQ ACC/CEVP at Langley AFB from Jennifer Fowler-Propst, USFWS Field Supervisor, Albuquerque, NM. 14 December.

U.S. Forest Service. 1992. *Report to Congress: Potential Impacts of Aircraft Overflights of National Forest System Wilderness*. U.S. Government Printing Office 1992-0-685-234/61004, Washington, D.C. von Gierke, H.E. 1990. The Noise-Induced Hearing Loss Problem. NIH Consensus Development Conference on Noise and Hearing Loss, Washington, D.C. 22–24 January.

Ward, D.H., and R.A. Stehn. 1990. *Response of Brant and Other Geese to Aircraft Disturbances at Izembek Lagoon, Alaska*. Final Technical Report, Number MMS900046. Performing Org.: Alaska Fish and Wildlife Research Center, Anchorage, AK. Sponsoring Org.: Minerals Management Service, Anchorage, AK, Alaska Outer Continental Shelf Office.

Ward, D.H., E.J. Taylor, M.A. Wotawa, R.A. Stehn, D.V. Derksen, and C.J. Lensink. 1986. *Behavior of Pacific Black Brant and Other Geese in Response to Aircraft Overflights and Other Disturbances at Izembek Lagoon, Alaska*. 1986 Annual Report, p. 68.

Weisenberger, M.E., P.R. Krausman, M.C. Wallace, D.W. De Young, and O.E. Maughan. 1996. *Effects of Simulated Jet Aircraft Noise on Heart Rate and Behavior of Desert Ungulates*. Journal of Wildlife Management, Vol. 60, No. 1, pp. 52-61.

Wesler, J.E. 1977. *Concorde Operations At Dulles International Airport*. NOISEXPO '77, Chicago, IL. March.

Wever, E.G., and J.A. Vernon. 1957. *Auditory Responses in the Spectacled Caiman*. Journal of Cellular and Comparative Physiology, Vol. 50, pp. 333-339.

World Health Organization. 2000. *Guidelines for Community Noise*. Berglund, B., T. Lindvall, and D. Schwela, eds.

Wu, Trong-Neng, J.S. Lai, C.Y. Shen, T.S Yu, and P.Y. Chang. 1995. *Aircraft Noise, Hearing Ability, and Annoyance*. Archives of Environmental Health, Vol. 50, No. 6, pp. 452-456. November-December.

This page intentionally left blank.

APPENDIX B

Land Use Compatibility Recommendations

This page intentionally left blank.

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]
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;	N	N	N	Y	25	30	N

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
	manufacturing							
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]
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

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
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
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

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

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

Notes:

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. 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.

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**

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 where the normal noise level is low.
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.
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.
30. If the project or proposed development is noise sensitive, use indicated NLR; if not, land use is compatible without NLR.
31. Land use compatible, provided special sound reinforcement systems are installed.
32. Residential buildings require an NLR of 25.
33. Residential buildings require an NLR of 30.
34. Residential buildings not permitted.
35. Land use not recommended, but if the community decides use is necessary, hearing protection devices should be worn by personnel.

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.

APPENDIX C

Request for Approval of Outlying Landing Field Clearance Criteria for Helicopter/Tilt-Rotor Aircraft

This page intentionally left blank.

UNITED STATES MARINE CORPS
U.S. MARINE CORPS BASES ATLANTIC
1775 FORRESTAL DRIVE
NORFOLK, VIRGINIA 23551-2400

IN REPLY REFER TO
11132
FADJ
30 Nov 10

SECOND ENDORSEMENT on CO, MCB CamLej ltr 11132 GER of 10 Nov 10

From: Commander, U.S. Marine Corps Bases, Atlantic
To: Commander, Naval Facilities Engineering Command

Subj: REQUEST FOR APPROVAL OF OUTLYING LANDING FIELD CLEARANCE CRITERIA FOR HELICOPTER/TILT-ROTO AIRCRAFT

1. Forwarded, recommending approval.

J. M. McNeal

J. M. MCNEAL
Executive Director

Copy to:
CG, MCI East
CO, MCB CamLej

UNITED STATES MARINE CORPS
MARINE CORPS BASE
PSC BOX 20004
CAMP LEJEUNE NC 28542-0004

11000

IN REPLY REFER TO:
11132
GER
NOV 1 8 2010

From: Commanding Officer, Marine Corps Base, Camp Lejeune
To: Commander, Naval Facilities Engineering Command, 1322 Patterson Ave SE, Suite 1000, Washington Navy Yard, Washington, DC 20374-5065
Via: (1) Commanding General, Marine Corps Installation East
(2) Commanding General, U.S. Marine Forces Command

Subj: REQUEST FOR APPROVAL OF OUTLYING LANDING FIELD CLEARANCE CRITERIA FOR HELICOPER/TILT-ROTOR AIRCRAFT

Ref: (a) UFC 3-260-1 (Airfield and Heliport Planning and Design)
(b) OPNAVINST 11010.36C (Air Installation Compatibility Use Zone program)

Encl: (1) Helicopter/Tilt ROTOR OLF

1. This command requests approval of the proposed airfield surfaces requirement, as detailed below, for Outlying Landing Fields (OLF) utilized by helicopter/tilt-rotor aircraft. In addition, we recommend that upon approval, this criterion be incorporated into reference (a). This criterion should serve as planning criteria for all OLFs utilized by the MV-22 tilt-rotor aircraft throughout the Marine Corps. This request addresses both the Oak Grove and Camp Davis OLFs.

2. The Department of Defense initiated reference (b) to protect the public's health, safety, and welfare while protecting military operational capabilities. The basis of the program is the Air Installation Compatibility Use Zone (AICUZ) study which includes a detailed analysis of aircraft noise, accident potential, and land use compatibility in the vicinity of the air installation. Headquarters Marine Corps has designated that Marine Corps Air Station (MCAS), New River, MCOLF Camp Davis, and MCOLF Oak Grove are required to have an AICUZ study and update as circumstances require such action. The original AICUZ studies for MCOLF's Oak Grove and Camp Davis were completed in 1978 as part of the MCAS New River AICUZ study. Additionally, a subsequent noise analysis was completed in 1999 for the introduction of the MV-22 to 2d Marine Aircraft Wing. A 2001 AICUZ update completed for MCAS New River did not include an update for MCOLF Oak Grove or MCOLF Camp Davis. Funding has been allocated for updating the AICUZ studies for all three airfields. The problem associated with the MCOLF Oak Grove AICUZ is outlined in the following paragraphs.

3. Reference (a) currently classifies runways as either Class A (used primarily by small light aircraft, ordinarily less than 8000 feet) or Class B (all other larger, heavier aircraft) for shore establishments based on aircraft type. This document is the sole source document that establishes MCOLF Oak Grove as a Class A runway. This is the same runway classification used for defining accident-potential areas established in reference (b).

4. This criterion was used to establish OLF Oak Grove as a Class A runway in the final draft AICUZ Study (March 2010). It further established clear zones in accordance with reference (a). Clear zones for a Class A runway are 3000'

Subj: REQUEST FOR APPROVAL OF OUTLYING LANDING FIELD CLEARANCE CRITERIA FOR HELICOPER/TILT-ROTOR AIRCRAFT

in length by 1000' in width. These clear zones would extend beyond the confines of the OLF and differs from the MV-22 Environmental Impact Study dealing with MCOLF Oak Grove which states all clear zones would remain within base property lines.

5. Runway 05/23 at Oak Grove was recently repaved to accommodate the MV-22. The design criteria established flight clearances to provide a middle ground somewhere between the standard Class A airfield and the more confined Landing Zone (LZ). Similarly, OLF Camp Davis is being scoped for repaving. The surface requirements in enclosure (1) meet the standards for both OLF's. Additional requirements to accommodate Max Gross Weight rolling landings and rolling takeoff distances can be incorporated on a case-by-case basis.

6. There are no current plans to conduct fixed-wing aircraft operations at either OLF.

7. With concurrence of the MV-22 Site Activation Team, Marine Air Group 26; MCAS, New River Operations; Marine Corps Installations East Aviation Plans and Policy, Range Development, and Management Division, and Government and External Relations Office, it was agreed that the AICUZ study should be held in abeyance pending approved planning criteria for OLFs utilized by the MV-22. This same group has approved the recommended requirements.

8. In order to facilitate the completion of the MCOLF Oak Grove AICUZ study we request a response by 15 December 2010.

9. The point of contact on this matter is Mr. Tim McCurry, Marine Corps Liaison for Government and External Relations, (910)451-6945, timothy.mccurry@usmc.mil or Mr. David Turner, Aviation Facilities Planning Officer, (910) 450-9372, david.d.turner1@usmc.mil.

D. J. LECCE

Copy to:
CMC (LFL, ASL)