AIR INSTALLATIONS COMPATIBLE USE ZONES STUDY

MCAS New River
Jacksonville, North Carolina

June 2011

DEPARTMENT OF THE NAVY
HEADQUARTERS UNITED STATES MARINE CORPS
3000 MARINE CORPS PENTAGON
WASHINGTON, DC 20350-3000

IN REPLY REFER TO:
11000
LF
SEP 04 2012

From: Commandant of the Marine Corps (LF)
To: Commanding General, Marine Corps Installations East, PSC Box 20005, Marine Corps Base, Camp Lejeune, NC 28542-0005

Subj: MARINE CORPS AIR STATION NEW RIVER, AIR INSTALLAIONS COMPATIBLE USE ZONES (AICUZ) STUDY UPDATE

Ref: (a) AICUZ Update, MCAS New River, June 2011

1. The Air Installation Compatible Use Zones (AICUZ) Study for Marine Corps Air Station New River, as presented by the reference, is approved for implementation.

2. This study is a result of extensive analysis of all known methods to ensure that development of surrounding lands will be compatible with the potential noise and safety hazards associated with military activities at MCAF Quantico.

3. It is envisioned that through wide public distribution of this document and a continuing dialogue between the Commander, MCAS New River and local government officials, these land use recommendations can be adopted.

4. My point of contact for this matter is Major Andrew Marcelis, 571-256-2791.

A. M. Edmonds
By direction

Copy to:
MCI-East
MCAS New River

Air Installations Compatible Use Zones Study for Marine Corps Air Station New River, North Carolina

June 2011

Prepared by:

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

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Table of Contents

Section **Page**

Table of Contents, continued

List of Tables

Table **Page**

List of Figures

Acronyms and Abbreviations

AGL	above ground level
AICUZ	Air Installations Compatible Use Zones
APZ	Accident Potential Zones
ATC	Air traffic control
BASH	Bird Aircraft Strike Hazard
CNO	Chief of Naval Operations
CP&LO	Community Plans & Liaison Officer
CTOL	conventional takeoff/landing
dBA	A-weighted decibel
DNL	day-night average sound level
DoD	Department of Defense
ECP	Encroachment Control Plan
EMI	electromagnetic interference
FAA	Federal Aviation Administration
FEIS	Final Environmental Impact Statement
FICON	Federal Interagency Committee on Aviation Noise
FICUN	Federal Interagency Committee on Urban Noise
FPOD	Flight Path Overlay District
FRS	Fleet Replacement Squadron
FY	Fiscal Year
H&HS	Headquarters and Headquarters Squadron
HUD	Housing and Urban Development
IFR	Instrument Flight Rules
JLUS	Joint Land Use Study
JSF	Joint Strike Fighter
MAG	Marine Air Group
MALS	Marine Aviation Logistics Squadron
MARSOC	Marine Corps Forces - Special Operations Command
MATSS	Marine Aviation Training Systems Site
MAW	Marine Aircraft Wing
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCOLF	Marine Corps Outlying Landing Field

MOA	Military Operations Area
MSL	mean sea level
NM	nautical mile
OPNAVINST	Office of the Chief of Naval Operations Instruction
R-	Restricted Area
STOVL	short takeoff vertical landing
SUA	Special Use Airspace
UFC	Unified Facilities Criteria
USACE	U.S. Army Corps of Engineers
VFR	Visual Flight Rules
V/STOL	vertical and/or short takeoff and landing

1 Introduction

Historically, most military installations were located in rural areas, distant from populated and urbanized areas. Over time, however, many of the communities in the vicinity of these installations have grown in size in terms of population and urban development. As development occurs near and around military bases, more people are exposed to noise and other impacts associated with aircraft and other military operations, resulting in pressures to modify operations, relocate, or even close a military installation. This conflict between urban development and military aircraft and operations is called encroachment.

Encroachment
Encroachment refers to factors that degrade or have the potential to degrade the mission capability of a Marine Corps installation, operational range, training area, associated special use airspace, sea space, radio frequency spectrum and other locations within the white-space where the Marine Corps conducts current and plans future military testing, training and general mission activities (U.S. Marine Corps 2010a).

The U.S. Marine Corps actively supports programs to minimize encroachment and noise impacts, including the requirement that each Marine Corps air installation implement and maintain an Air Installations Compatible Use Zones (AICUZ) Program. The AICUZ Program was instituted by the U.S. Department of Defense (DoD) in response to encroachment around military airfields across the country.

The purpose of the AICUZ Program is to promote public health and safety and to protect the operational capability of the air installation through the local adoption of compatible land use controls and by seeking cooperative efforts to minimize noise and aircraft accident potential. The AICUZ Program recommends land uses that will be compatible with aircraft noise, accident potential, and obstruction clearance criteria associated with military airfield operations. The intent of the program is not to stop civilian land use development, but to promote compatible land use and development near military installations.

The AICUZ Program is implemented at the local level through the development of an installation-specific AICUZ study. Each study is prepared as a planning resource for local planners, developers, governments, and other interested parties to help them anticipate, identify, and implement appropriate land use regulations and other actions to prevent development that is incompatible with airfield operations.

This AICUZ study has been prepared for Marine Corps Air Station (MCAS) New River, North Carolina. The air station is located in eastern North Carolina, approximately 3 miles south of downtown Jacksonville. MCAS New River is separate from but located within the larger Marine Corps Base (MCB) Camp Lejeune complex and is the premier Marine Corps helicopter operating facility on the U.S. East Coast. MCAS New River also has the distinction of being the first Marine Corps installation to house the new MV-22B Osprey, a tilt-rotor aircraft. This AICUZ study is an update of the installation's 2001 AICUZ study (U.S. Marine Corps 2001) and has been prepared to address the future changes in mission, aircraft, and projected operational levels that are expected to occur within the next 10- to 15-year planning period. Projections of aircraft (types and number) and aircraft operations are based upon currently available estimates of future mission requirements.

Section 1 provides background information on the AICUZ Program, including the purpose, scope, and authority. Section 2 describes the air installation, its mission, and the economic impact it has on the surrounding community. Section 3 discusses current aircraft operations and airspace. Section 4 presents prospective aircraft noise exposure contours and changes that have occurred since the 2001 AICUZ study. Section 5 discusses aircraft safety issues, including changes in the Accident Potential Zones (APZs) and other land use issues that could affect pilot safety. Section 6 evaluates the compatibility of surrounding land uses and aircraft operations, and Section 7 provides recommendations for promoting land-use compatibility consistent with the goals of the AICUZ Program. Section 8 provides a list of references for materials used to prepare this report.

1.1 AICUZ Program

The AICUZ Program was established in 1977 by the DoD in response to growing incompatible urban development (encroachment) around military airfields. The purpose of the AICUZ Program is to promote compatible development between air installations and neighboring communities by:

- Protecting the health, safety, and welfare of those living and working near military air installations;
- Protecting the Navy and Marine Corps installation investment by safeguarding the installation's operational capabilities;
- Minimizing noise impacts caused by aircraft operations while meeting operational, training, and flight safety requirements on and in the vicinity of the air installation; and
- Informing the public about the AICUZ Program and seeking cooperative efforts to minimize noise and aircraft accident potential and promote land uses that are compatible with aircraft operations.

1.2 Purpose, Scope, and Authority

The purpose of the ACIUZ Program is to achieve compatibility between air installations and neighboring communities. To implement the AICUZ Program at the local level, each Navy and Marine Corps air installation is required to prepare and maintain an AICUZ study. The study is a planning document that is intended to support local government land use planning programs and processes by providing technical information on military activities.

The scope of the AICUZ study includes a detailed analysis of the following:

- Annual aircraft operations,
- Aircraft noise and accident potential,
- Land-use compatibility,
- Noise-reduction strategies, and
- Strategies or recommendations to address existing and potential incompatible development in the vicinity of the air installation.

Successful implementation of the AICUZ recommendations requires the active involvement of the installation in the surrounding community and the cooperation of local, state, federal, and community leaders to encourage compatible development adjacent to the military airfield.

The authority for the establishment and implementation of the MCAS New River AICUZ Program is derived from the following:

- U.S. DoD Instruction 4165.57, "Air Installations Compatible Use Zones," dated November 8, 1977;
- Office of the Chief of Naval Operations Instruction (OPNAVINST) 11010.36C and Marine Corps Order (MCO) 1010.16, "Air Installations Compatible Use Zones Program," dated October 9, 2008;
- Unified Facilities Criteria (UFC) 3-260-01, Airfield and Heliport Planning and Design, dated May 19, 2006;
- Naval Facilities Engineering Command P-80.3, "Facilities Planning Factor Criteria for Navy and Marine Corps Shore Installations: Airfield Safety Clearances," dated January 1982; and
- United States Department of Transportation, FAA Regulations, Code of Federal Regulations, Title 14, Part 77, "Objects Affecting Navigable Airspace."

1.3 Responsibility for Compatible Land Use

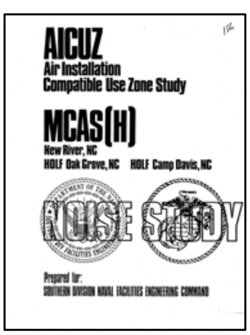
Successful implementation of the AICUZ Program and preventing encroachment depends on a close working relationship between MCAS New River and community leaders.

Military bases are often critical to state and local economies, generating thousands of jobs and millions of dollars in economic activity for the cities, counties, and states in which they are located. Despite these benefits, military installations are under increasing pressure to modify operations, relocate, or even close due to encroachment and perceived noise- and safety-related impacts. Preserving the operational mission and economic benefits of the installation, preventing encroachment, and implementing the AICUZ Program at the local level is the shared responsibility of many, including the U.S. Marine Corps and Navy, local governments, private citizens, real estate professionals, and land use developers. Military installations and local government agencies with planning and zoning authority, in particular, share the responsibility for preserving land-use compatibility near the military installation. However, cooperative action by all involved parties is essential to prevent land-use incompatibility, implement the AICUZ study recommendations, protect public health and safety, and safeguard the military flying mission. Control of land use outside the air installation, which is critical to limiting the number of people exposed to excessive noise and the potential for accidents, is under the exclusive control of state and local governments. Local military or Marine Corps commands act only in an informational role for land use recommendations outside of the installations boundary and hold no jurisdiction over non-military property. Table 1-1 identifies some of the responsibilities of various community stakeholders.

Table 1-1
Responsibility for Compatible Land Uses

Marine Corps	■ Examine air mission for operational changes that could reduce impacts ■ Conduct noise and APZ studies ■ Develop AICUZ maps ■ Examine local land uses and growth trends ■ Make land-use recommendations ■ Release AICUZ study to public ■ Work with local governments and private citizens ■ Monitor operations and noise complaints ■ Update AICUZ studies, as required
Local Government	■ Incorporate AICUZ study recommendations into comprehensive development plans and municipal zoning ordinances ■ Regulate height and obstruction concerns through an airport ordinance ■ Incorporate sound insulation requirements in new construction building codes ■ Require fair disclosure in real estate for all buyers, renters, lessees, and developers
Private Citizens	■ Educate oneself on the importance of the installation's AICUZ Program ■ Identify AICUZ considerations in all property transactions ■ Understand AICUZ effects before buying, renting, leasing, or developing property
Real Estate Professionals	■ Ensure potential buyers and lessees receive and understand AICUZ information on affected properties ■ When working with builders/developers, ensure an understanding and evaluation of the installation's AICUZ Program
Builders/Developers	■ Develop properties in a manner that appropriately protects the health, safety, and welfare of the civilian population by constructing land-use facilities that are compatible with aircraft operations (e.g., sound attenuation features, densities, and occupations)

1.4 Previous AICUZ and Noise Studies



Previous efforts and related noise studies at MCAS New River, including McCutcheon Field and associated landing fields, are discussed below.

Assessment of Aircraft Noise at MCAS New River (Naval Facilities Engineering Command 1978a)

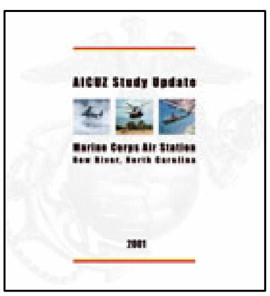
This assessment included an initial noise study and was undertaken in preparation for the 1978 AICUZ Study.

AICUZ Study (Naval Facilities Engineering Command 1978b)

This was the first AICUZ study for MCAS New River. The study included an assessment of aircraft noise at Marine Corps Outlying Landing Field (MCOLF) Camp Davis and MCOLF Oak Grove. The study found that there were no existing or potential land use incompatibilities within the surrounding communities, and all AICUZ noise exposure contours and APZs were located within the MCB Camp Lejeune boundary.

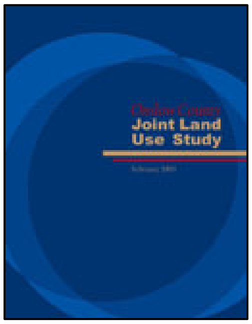
Final Environmental Impact Statement (FEIS) for the Introduction of the V-22 to the Second Marine Aircraft Wing, Eastern North Carolina (U.S. Marine Corps 1999)

A noise study was completed as part of the *FEIS for the Introduction of the V-22 to the Second Marine Aircraft Wing, Eastern North Carolina*. The study analyzed the effects of noise at MCAS New River, including McCutcheon Field and associated landing fields. The study indicated that any noise impacts associated with basing the V-22 tilt-rotor aircraft at MCAS New River would be contained within the landing field and no off-base acreage or populations would be exposed to noise impacts greater than 65 decibels (A-weighted [dBA]).



AICUZ Study Update (U.S. Marine Corps 2001)

This study updated and revised the 1978 MCAS New River AICUZ study based on operational changes and forecasts, including the introduction of the MV-22 tilt-rotor aircraft to MCAS New River. The study incorporated, as a baseline, the noise exposure contours, and information published in the 1999 *FEIS for the Introduction of the V-22 to the Second Marine Aircraft Wing, Eastern North Carolina* (U.S. Marine Corps 1999). The study concluded with an expansion of the shape of the 1978 AICUZ noise exposure contours and APZs at MCAS New River. The noise exposure contours and APZs were found to be primarily within the boundary of MCB Camp Lejeune, and no major land use incompatibilities were identified.



Onslow County Joint Land Use Study (JLUS) (Onslow County 2003a)

The JLUS examined short- and long-term land use planning issues and conflicts between the military and civilian communities in the areas surrounding MCB Camp Lejeune and MCAS New River. The study concluded with a series of recommendations and implementation strategies to reduce future military and civilian land use conflicts. The study was conducted by a consortium of local government entities, the DoD, and the Marine Corps.

1.5 Need for an AICUZ Update

AICUZ studies are updated when an air installation experiences, or is expected to experience, a significant change in aircraft operations (e.g., number of takeoffs and landings), a change in the type of aircraft stationed and operating at the installation, or changes in flight paths and procedures. This study updates the MCAS New River 2001 AICUZ study (U.S. Marine Corps 2001) and has been prepared to address the reasonably foreseeable changes in projected aircraft operational levels, aircraft mix, and flight tracks that can be expected to occur within the next 10- to 15-year planning period.

This AICUZ study considers current and projected future changes to aircraft operations at MCAS New River, including:

- Four new rotary-wing squadrons associated with the U.S. Marine Corps initiative;
- Increased MV-22B Osprey training operations;
- Introduction of the Joint Strike Fighter (F-35B); and
- Establishment of the U.S. Marine Corps' Forces Special Operations Command (MARSOC) at MCB Camp Lejeune.

1.5.1 Changes in Operations Level

Since publication of the 2001 AICUZ study, the operational tempo at MCAS New River has fluctuated, with total annual flight operations dropping to 39,444 operations in 2003 and peaking at 60,741 operations in 2006 (see Table 1-2). In 2007, MCAS New River experienced 52,309 annual operations. However, annual flight operations are projected to increase at MCAS New River in the next 10- to 15-year planning period due to new mission programs associated with the U.S. Marine Corps initiative, including two new CH-53E Super Stallion squadrons and two new squadrons operating the AH-1W Super Cobra and UH-1N Huey rotary-wing aircraft. In addition, two new MV-22B Osprey aircraft squadrons have replaced two CH-46E Sea Knight rotary-wing squadrons. MCAS New River is also projected to increase its operational levels due to planned increases in MV-22B training operations and the establishment of MARSOC at MCB Camp Lejeune. Section 3 presents more details on projected changes in operational levels at MCAS New River.

Table 1-2
Comparison of Annual Operations at MCAS New River

Calendar Year	Marine Corps	Other Military	Civil – General Aviation	TOTAL
2007	50,905	397	1,007	52,309
2006	58,370	762	1,609	60,741
2005	51,903	494	1,980	54,377
2004	42,176	493	1,069	43,738
2003	38,347	154	943	39,444
2002	50,613	630	1,391	52,634
2001	51,730	455	1,209	53,394
Source: Wyle 2008				

1.5.2 Changes in Aircraft Mix

MCAS New River is utilized for a variety of military training and testing purposes. Activities involve the use of rotary-wing, tilt-rotor, and fixed-wing aircraft. The air station is the U.S. Marine Corps' premier rotary-wing aircraft facility on the East Coast and is home to the Marine Corps' MV-22B Osprey tilt-rotor aircraft.

As mentioned in Section 1.5.1, the number of aircraft squadrons and the tempo of air operations are projected to increase at MCAS New River. Since 2001, a large portion of the aircraft utilizing MCAS New River has included the CH-53E Super Stallion rotary-wing and MV-22B Osprey tilt-rotor aircraft. In the next 10- to 15-year planning period, two new CH-53E Super Stallion squadrons and two new squadrons operating the AH-1W Super Cobra and UH-1N Huey rotary-wing aircraft will be added to MCAS New River. In addition, two new MV-22B Osprey aircraft squadrons have replaced two CH-46E Sea Knight rotary-wing squadrons. The CH-46E rotary-wing aircraft no longer utilize MCAS New River. For the purposes of the noise analysis prepared for this AICUZ Study however, the final two squadrons of CH-46E were modeled. Although the CH-46E no longer operates at MCAS New River the noise profiles for the CH-46E are similar to the MV-22; thus, the CH-46E serves as a surrogate for these final two squadrons that transitioned to the MV-22. All other MV-22 squadrons were modeled using MV-22 noise profile data and the full impact of the noise generation from the MV-22 has been captured in this analysis.

Even with the addition of the new squadrons, the aircraft mix utilizing the air station will not be significantly different from the existing mix and will still be dominated by the CH-53E rotary-wing and MV-22B tilt-rotor aircraft. In addition, future transient operations can be expected to include the F-35B Lightning II, a short takeoff vertical landing (STOVL) version of the Joint Strike Fighter (JSF) as it comes online in the future. The F-35B will replace the AV-8B Harrier, which has conducted transient operations at MCAS New River in the past. Table 1-3 provides a comparison of MCAS New River's 2001 and 2011 aircraft mix.

Table 1-3
Aircraft Mix, MCAS New River

Aircraft Type	Number of Squadrons		
	Current	2001 AICUZ [a]	2011 AICUZ
CH-53E	3	3	5
UH-1N/AH-1W [b]	2	2	4
CH-46E	2	0 [c]	2 [c]
MV-22B	6	7	8
Total	**13**	**12**	**19**

Source: U.S. Marine Corps 2001; Wyle 2008

Note:
[a] 2001 AICUZ projection for year 2015 squadron mix.
[b] Squadron includes both the UH-1N and AH-1W rotary-wing aircraft.
[c] The CH-46E was projected to be phased out at the end of the 2001 AICUZ study planning period (2015). The two squadrons were replaced by the MV-22 during the development of this AICUZ Study. This change has a negligible impact on the noise analysis.

1.5.3 Changes in Flight Tracks and Procedures

Changes have occurred with regard to MCAS New River's arrival, departure, and touch-and-go flight tracks and procedures in recent years. The most significant changes have been the addition of six new departure flight tracks with a combined 2,888 annual flight operations, and four new touch-and-go pattern tracks with a combined 76 annual flight operations. See Section 3.4 for specific flight tracks flown at MCAS New River. Flight tracks are provided for all fixed-wing, tilt-rotor, and rotary-wing aircraft.

2 MCAS New River

2.1 Location

MCAS New River is located on the south bank of the New River, in eastern North Carolina, approximately 3 miles south of downtown Jacksonville, the county seat of Onslow County. The air station is comprised of approximately 3,728 acres within the northwestern portion of the larger 129,899-acre MCB Camp Lejeune complex. Figure 2-1 indicates the regional location of the air station.

2.2 Mission

The mission of MCAS New River is to “maintain and operate facilities and provide services and material to support ground combat forces located at MCB Camp Lejeune and perform such other air operations as requested.” The station is the premier Marine Corps helicopter operating facility on the East Coast. Several major tenants of the air station conduct predominantly rotary-wing and tilt-rotor operations, including units of the 2nd Marine Aircraft Wing (MAW), Marine Air Group (MAG) 26 and MAG 29, and their subordinate aircraft squadrons. Both MAGs provide direct aircraft support to U.S. Marine Corps Forces Command in the form of troop transport, observation, heavy lift capability, command and control, and light attack. Other major commands include Marine Corps Air Station Headquarters and Headquarters Squadron (H&HS), Marine Wing Support Squadron 272, Marine Air Control Squadron 2, the U.S. Air Force’s 360th Training Squadron Operating Location “B,” Marine Aviation Training Systems Site (MATSS) New River, and Marine Aviation Logistics Squadron (MALS) 26 and MALS 29.

2.3 History

The history of MCAS New River began in 1941 when farmland was purchased by the U.S. government to build a military airfield. The airfield was placed under the command of MCB Camp Lejeune and

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\L:\Buffalo\New_River\Maps\MXD\Draft_AICUZ\January_2009\Figure 2-1 Regional Location Map.mxd

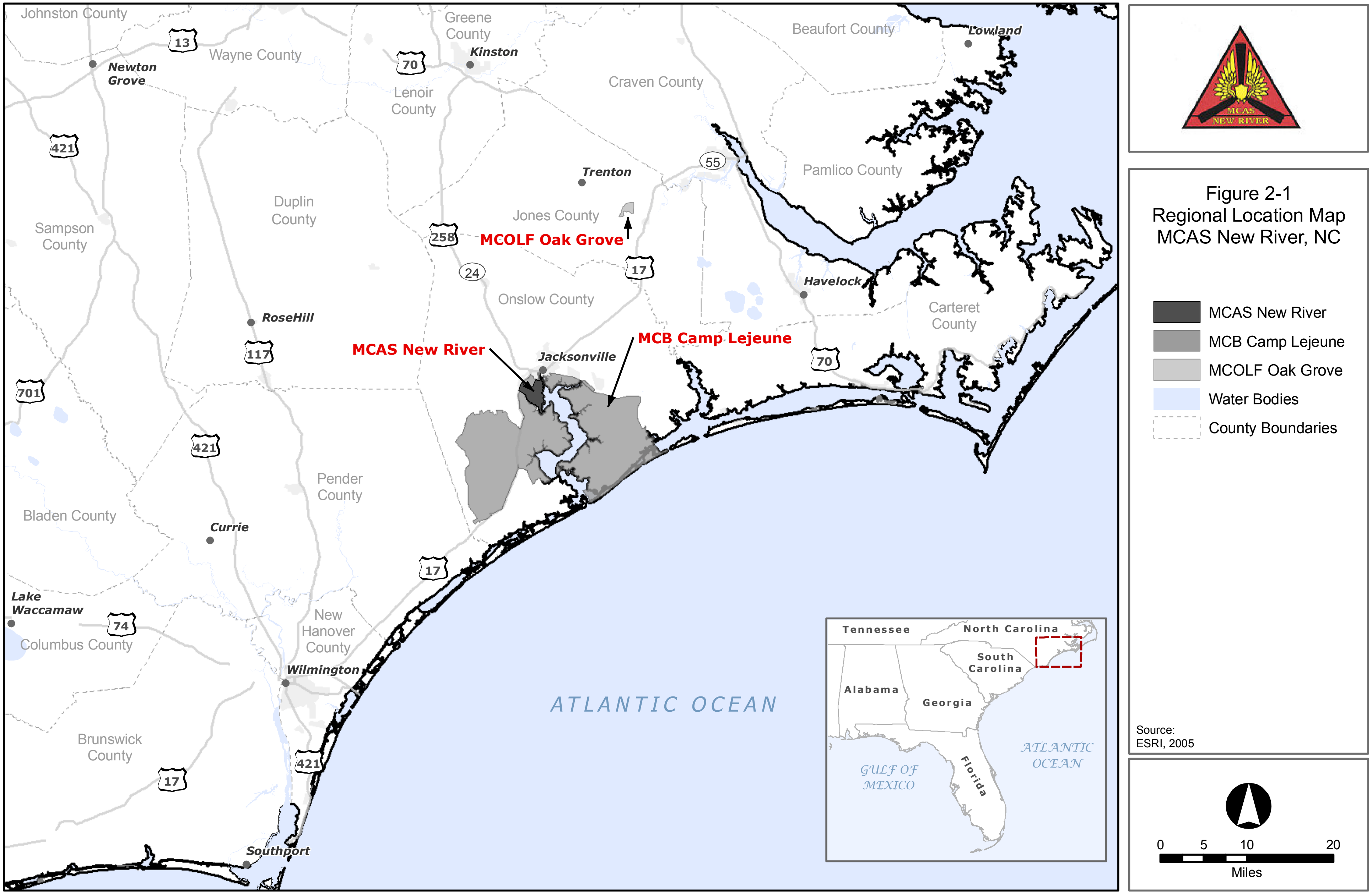

Figure 2-1
Regional Location Map
MCAS New River, NC

received its first squadron, Marine Bombing Squadron-612, in 1943. In 1944, the airfield was officially commissioned as Peterfield Point, delineating the airfield from MCB Camp Lejeune. The airfield was briefly closed after World War II, but it was reopened in 1951 as Marine Corps Air Facility Peterfield Point, Camp Lejeune. In 1952, the facility was renamed Marine Corps Air Facility New River. MAG 26 was transferred to the air facility from MCAS Cherry Point in 1956. In 1968, the facility was designated Marine Corps Air Station (Helicopter) New River and became a major operational Marine Corps facility. A major Marine Corps reorganization occurred in 1972, and the station's airfield was named McCutcheon Field in honor of Brigadier General Keith B. McCutcheon. Since that time, MCAS New River has operated as a major Marine Corps rotary- and tilt-rotor operational facility. MCAS New River also has the distinction of being the only Marine Corps installation to house the new MV-22B Osprey, a tilt-rotor aircraft.

2.4 McCutcheon Field

MCAS New River's airfield, McCutcheon Field, is 26 feet above mean sea level (MSL). The airfield consists of two asphalt runways, 05/23 and 01/19. Runway 23 is the primary calm wind runway. MCAS New River's runways are designated as Class A fixed-wing runways, and they are also used by rotary-wing and tilt-rotor aircraft. In addition, there are six taxiways and seven mats (1 through 7). Mat 1 is the parking area for the air station's UC-12B Huron fixed-wing and transient aircraft. Runway arresting gear is not currently available at the air station (U.S. Marine Corps 2007).

Class A Runways
Class A fixed-wing runways are used primarily by light aircraft and are not used intensively by heavy or high-performance aircraft. Typically, less than 10% of all operations involve heavy (e.g., C-130) or high-performance (e.g., F/A-18) aircraft.

Table 2-1 provides the dimensions of the two runways, and Figure 2-2 illustrates their layout.

Table 2-1
McCutcheon Field Runways

Runway	Length (feet)	Width (feet)
Runway 05/23	5,115	150
Runway 01/19	4,790	150

Source: U.S. Marine Corps 2007

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\L:\Buffalo\New_River\Maps\MXD\Draft_AICUZ\January_2009\Figure 2-2 Airfield Map.mxd

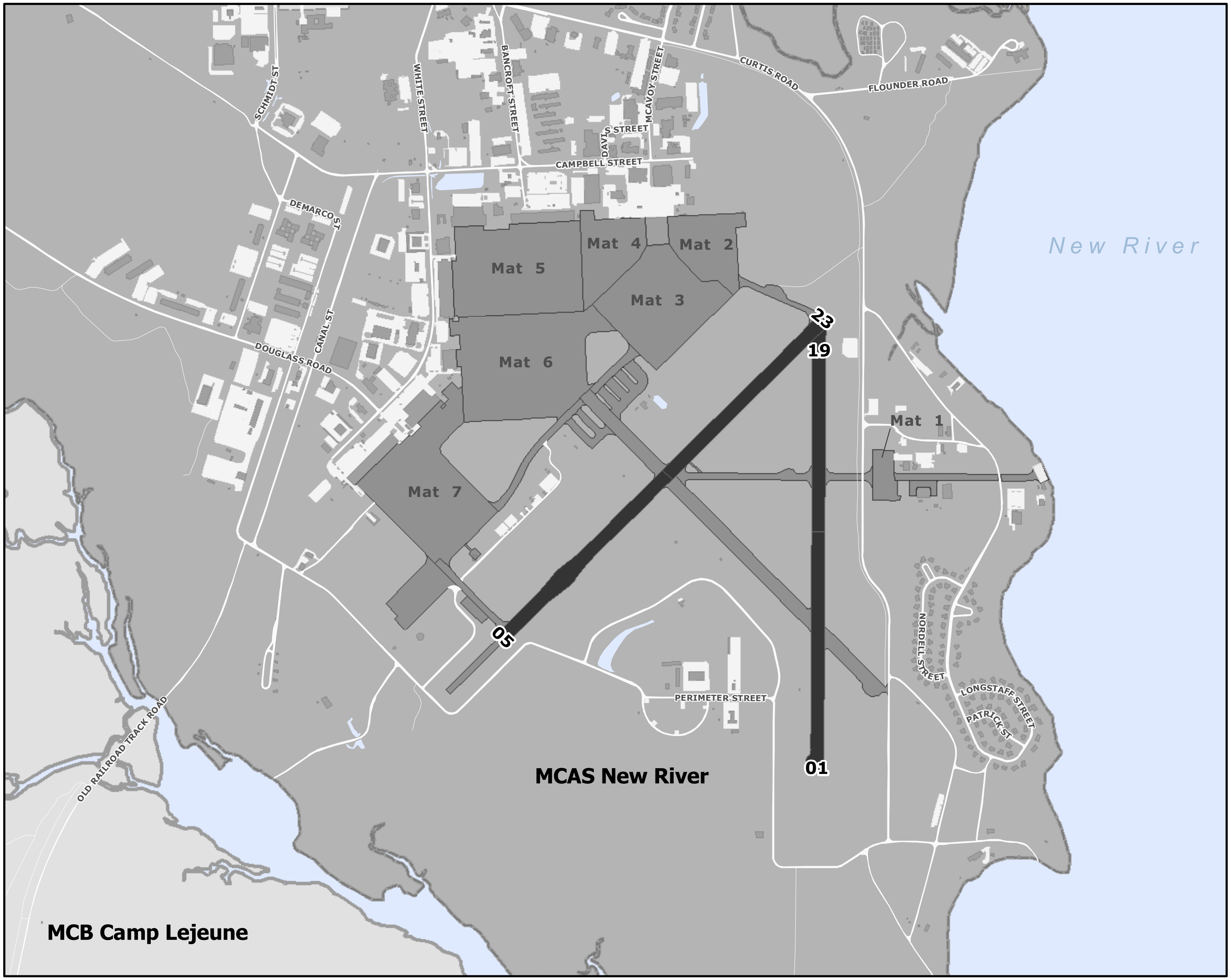
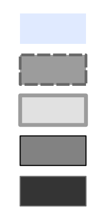
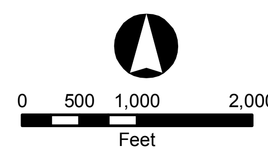


Figure 2-2
McCutcheon Field
Airfield Map
MCAS New River, NC



Source:
ESRI, 2005



2.5 Local Economic Impacts

MCB Camp Lejeune and MCAS New River play a significant economic role at the state and local levels. The installations contribute directly to the economic development of the surrounding community through employment, capital investments, and defense contracting, and indirectly through increased demand for local goods and services and increased household spending by service members and military retirees. The installations are critical to the state and local economies, accounting for thousands of jobs and generating millions of dollars in economic activity and tax revenue.

The total MCAS New River workforce for 2010 included 7,605 military and civilian employees. In addition, 1,986 retired military and 8,920 dependant family members reside in the area surrounding MCAS New River. In 2010, MCAS New River had a direct economic impact of nearly $483 million (U.S. Marine Corps 2010b). This included the salaries of active and retired military members and civilian employees, procurement, and construction activities. The jobs specifically associated with MCAS New River and the spending associated with both the workers and the facility ripple through the entire economy of eastern North Carolina. As a result, the military creates a stable and consistent source of employment and tax revenue for the local economy. Table 2-2 provides a summary of the total economic impact of MCAS New River.

Table 2-2
FY 2010 MCAS New River Economic Impact

Military Salaries	
Active	$245,990,265
Retired	$37,619,400
Civilian Salaries	$36,348,223
Procurement	$35,714,217
Construction	$107,000,000
Other including Education and Contributions	$20,286,055
Total	$482,958,160
Source: U.S. Marine Corps 2010b	

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3 Aircraft Operations

Aircraft operations are the main source of noise at MCAS New River. Aircraft noise consists of two major sound sources: flight operations and ground engine maintenance "run-ups," which are associated with pre-flight and maintenance checks. The level of noise exposure is related to a number of variables, including aircraft type, engine power settings, altitudes at which aircraft fly, direction of aircraft during run-ups, duration of run-ups, flight tracks, temperature, relative humidity, and frequency and time of operations. Generally, these factors fluctuate from year to year. Small fluctuations in the annual number of operations of like aircraft will not have a significant effect on community noise exposure.

This section presents a brief overview of the types of aircraft that utilize MCAS New River, the organization of air station squadrons, aircraft operational areas, and a description of air operations, including the number of operations and flight tracks used to conduct the operations.

3.1 Aircraft Types

MCAS New River is utilized primarily by rotary-wing and tilt-rotor aircraft. Below is a representation of some of the aircraft that are proposed to operate at MCAS New River.

3.1.1 Rotary-wing Aircraft

CH-53E Super Stallion. The Super Stallion is the largest helicopter in the U.S. military inventory. It is used by the Marine Corps to transport personnel and equipment and heavy-lift external loads. With its maximum lift capability of 16 tons, the CH-53E is the only helicopter capable of lifting some of the Marine Corps' new weapon systems, including the M-198 Howitzer and the variants of the Light Armored

Vehicle. The CH-53E will be replaced by the CH-53K Super Stallion Heavy Lift Replacement beginning in FY2017, which will provide even greater lift capacity than the CH-53E variant.

AH-1W Super Cobra. The Super Cobra is a day/night marginal weather Marine Corps attack helicopter that provides en route escort for assault helicopters and their embarked forces. It has an air-to-air and precision guided munitions capabilities. The primary mission of the AH-1W aircraft is as an armed tactical helicopter capable of close air support, low-altitude and high-speed flight, target search and acquisition, reconnaissance by fire, multiple weapons fire support, troop helicopter support, and point target attack of threatening armor. The AH-1W provides fire support and fire support coordination to landing forces during amphibious assaults and subsequent operations ashore. The AH-1W will be upgraded to the AH-1Z beginning in 2015, which will provide the aircraft with a four-blade rotor, improved avionics, up-rated transmission and a new targeting system.

UH-1N Huey. The UH-1Ns are widely used in transport, airborne battlefield command and control, troop insertion/extraction, fire support coordination, medical evacuation, search and rescue, armed escort/visual reconnaissance, and utility roles throughout the Navy and Marine Corps. The Huey provides utility combat helicopter support to the landing force commander during ship-to-shore movement and in subsequent operations ashore. Like the AH-1W, the UH-1N is undergoing modernization. It will be replaced by the UH-1Y beginning in 2011, with a four-blade rotor system. The Y model includes an upgraded rotor system, engine, and transmission for increased payload capabilities, greater range, and a higher maximum cruise speed than the UH-1N.

3.1.2 Tilt-rotor Aircraft

MV-22B Osprey. The Osprey is a joint-service, multi-mission, tilt-rotor aircraft with vertical take-off and landing capability. It performs vertical take-off and landings as effectively as a conventional helicopter and has the long-range cruise abilities of a twin-turboprop aircraft. It is an assault transport for troops, equipment, and supplies and is capable of operating from ships or from expeditionary airfields ashore. The Osprey replaced the CH-46E at MCAS New River and has a greater range, speed, ceiling, and payload than its predecessor.

3.1.3 Fixed-wing Aircraft

AV-8B Harrier II. The AV-8B is a vertical and/or short take-off and landing (V/STOL) strike aircraft. The aircraft is a single-seat, light attack aircraft that provides offensive air support to Marine Corps ground forces. The V/STOL capability is unique and allows the AV-8B to operate from a variety of ships, expeditionary airfields, forward site or damaged airfields. The AV-8B is being replaced with the F-35B Lightning II aircraft at MCAS New River beginning in approximately 2019. No AV-8B aircraft are homebased at MCAS New River. They are transient to the airfield with limited operations.

F-35B Lightning II (Joint Strike Fighter). The F-35B is the Marine Corps' variant of the JSF. The aircraft is a highly advanced, single-engine, single-seat, stealth, supersonic, multi-role strike-fighter aircraft that can take off from conventional runways, amphibious ships, and unimproved surfaces. Its unique short takeoff vertical landing (STOVL) technology enables the F-35B to take off and land vertically and operate as a fixed-wing jet aircraft once airborne. No F-35B aircraft will be homebased at MCAS New River. They will be transient to the airfield with limited operations.

UC-12B Huron. The UC-12B is the U.S. Navy/Marine Corps version of the King Air A200C, a twin-turboprop, fixed-wing aircraft. The basic mission of the UC-12B aircraft is to provide on-call 24-hour, 7-day-a-week transportation of passengers and/or light cargo. The UC-12B will be upgraded to the UC-12W at MCAS New River beginning in 2011.

C-130 Hercules. The Hercules is a four-turboprop aircraft whose multi-role, multi-mission includes tactical tanker/transport, aerial refueling, aerial delivery of troops and cargo, emergency resupply, emergency medical evacuation, tactical insertion of combat troops and equipment, and evacuation missions. No C-130 aircraft are homebased at MCAS New River. They are transient to the airfield with limited operations.

3.2 Squadron Organization

MCAS New River is home to Marine Air Group (MAG) 26 and MAG 29 and their subordinate aircraft squadrons, including:

- Two CH-53E heavy-lift fleet squadrons (HMH-461 and HMH-264);
- One CH-53E Fleet Replacement Squadron (FRS) (HMT-302);
- Two UH-1N/AH-1W light/attack fleet squadrons (HML/A-167 and HML/A-269);
- Seven MV-22B squadrons (VMX-22, VMM-162, VMM-261, VMM-263, VMM-264, VMM-266, and VMM-365); and
- One MV-22B FRS (VMMT-204).

New mission programs associated with the U.S. Marine Corps initiative are also scheduled to come online at MCAS New River in the next 10- to 15-year planning period. These new mission programs include the following:

- Two new CH-53E squadrons (HMH-366 and a currently unnamed squadron); and

- Two additional UH-1N/AH-1W light/attack fleet squadrons (HML/A-467 and HML/A-567).

3.3 Operational Areas

MCAS New River aircraft presently conduct training operations in the areas to the north and west of the air station. The local flying area for rotary-wing aircraft is an area extending 100 nautical miles (NM) in radius from MCAS New River (but not extending beyond the coast of the Atlantic Ocean). The local flying area for fixed-wing and tilt-rotor aircraft is an area extending 350 NM in radius from MCAS New River (but not extending beyond the coast of the Atlantic Ocean).

3.3.1 Airspace

The use of airspace over MCAS New River is dictated by the Federal Aviation Administration (FAA) National Airspace System. This system is designed to ensure the safe, orderly, and efficient flow of commercial, private, and military aircraft. MCAS New River is located in airspace assigned to Washington Center by the FAA. Washington Center has delegated control of local airspace to Cherry Point Approach Control. Cherry Point has, in turn, delegated control of local airspace to the New River Radar Facility by Letter of Agreement.

MCAS New River aircraft utilize the airspace around MCAS New River, which includes Class "D" and "E" airspace and four special use airspace (SUA) areas. The areas are graphically depicted on Figure 3-1 and are described below:

- **MCAS New River Class "D" Surface Area** – the airspace extending upward from the surface to and including 2,500 feet MSL within a 5-mile radius of MCAS New River.

- **Class "E" Airspace Extension** – the airspace extending upward from the surface within 3.2 miles each side of New River TACAN 239° radial, extending from the 5-mile radius of MCAS New River to 7 miles southwest of the TACAN.

- **MCAS New River/Albert J. Ellis Airport/Onslow Memorial Hospital Class "E" Airspace** – the airspace extending upward from 700 feet or more above the surface within a 6.4-mile radius of the Albert J. Ellis Airport, and within a 6-mile radius of the point in space serving Onslow Memorial Hospital.

Airspace is the three-dimensional space above the earth's surface. Airspace is a finite resource and is managed by the FAA for the benefit and use of all aviation sectors needing access to it—commercial, general, and military.

Controlled Airspace
Controlled airspace is divided into six classes, A through E and G. These six classes identify airspaces that support airport operations and designated airways, affording en route transit from place to place. In addition, these classes also dictate pilot qualification requirements, rules of flight that must be followed, and the type of equipment necessary to operate within an airspace class.

Special Use Airspace
The SUA designation alerts non-participating aircraft (civil or military) to the possible presence of military activity or unusual flight conditions.

Restricted Areas
Restricted areas define airspace where the flight of aircraft, while not wholly prohibited, is subject to restrictions. Restricted areas denote the existence of unusual, often invisible, hazards to aircraft such as artillery firing, aerial gunnery, or guided missiles.

- **Restricted Area (R-) 5303A/B/C** – Surface up to 17,999 feet.
- **R-5304A/B/C** – Surface up to 17,999 feet.
- **R-5306D/E** – Surface up to 17,999 feet.
- Military Operations Area (MOA) Hatteras F – 3,000 feet to 13,000 feet.

Military Operations Areas
MOAs consist of airspace of defined vertical and lateral limits established for the purpose of separating certain military training activities (such as air combat maneuvers, intercepts, acrobatics, etc.) from instrument flight rules (IFR) air traffic. Non-military aircraft are not prohibited from operating within the boundaries of an MOA.

Additional information regarding MCAS New River airspace is outlined in ASO P3710.7T, Marine Corps Air Station New River Air Operations Manual (U.S. Marine Corps 2009).

3.3.2 Low Work Areas

Low work operations consist of rotary-wing aircraft hover work and other low-altitude training operations. They are conducted in designated areas within the boundary of MCAS New River at altitudes less than 50 feet above ground level (AGL). At MCAS New River, there are two different areas of the airfield for low work operations—the Midfield Hover Area and the Northeast Grass Area. The Midfield Hover Area comprises three separate sites: Midfield Hover Area West (MDW), Midfield Hover Area North (MDN), and Midfield Hover Area East (MDE). The Northeast Grass Area comprises two sites: Northeast Grass Area North (NGN) and Northeast Grass Area South (NES). Figure 3-2 identifies the locations of these five low work areas.

3.4 Aircraft Operations

The main noise sources at MCAS New River are aircraft operations, including flight arrivals, departures, pattern work, and low-level activities (i.e., hovers). Engine maintenance operations, or run-ups, also contribute to noise at MCAS New River.

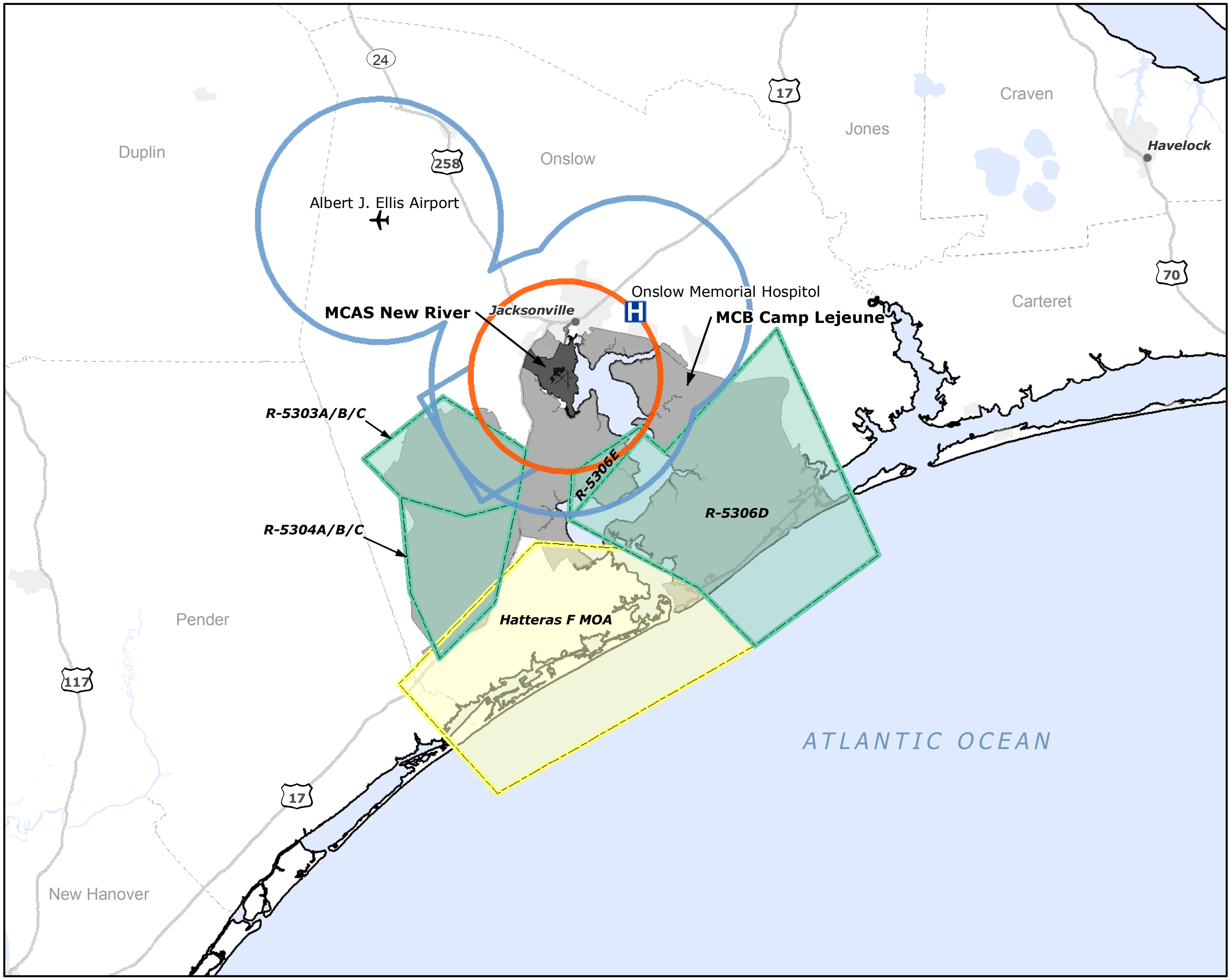


Figure 3-1
Airspace
MCAS New River, NC

Source:
ESRI, 2005

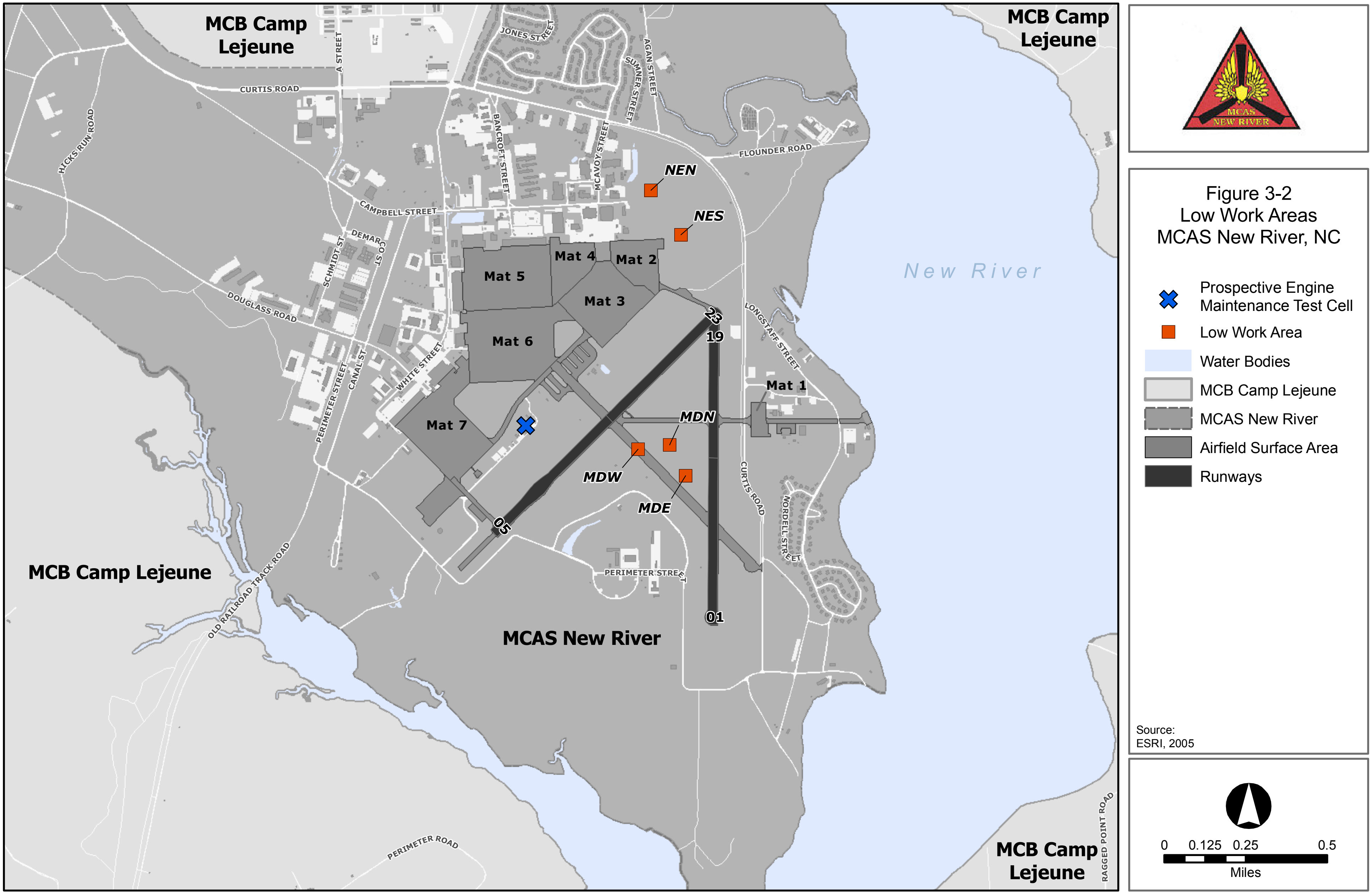


Figure 3-2
Low Work Areas
MCAS New River, NC

3.4.1 Flight Operations

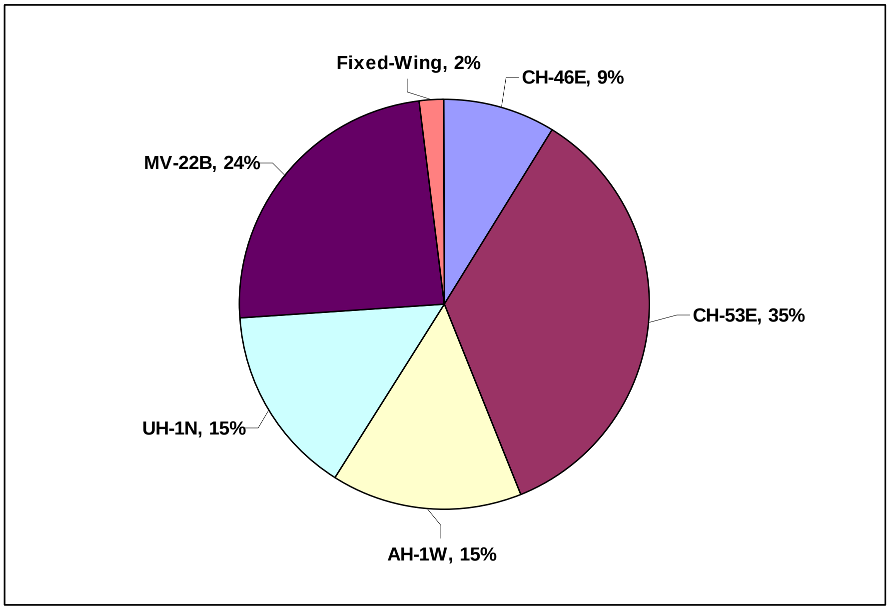
A flight operation refers to anytime an aircraft crosses over the runway threshold of an airfield. Rotary-wing, tilt-rotor, and fixed-wing flight operations at MCAS New River include the following:

- **Departure.** An aircraft taking off to a local training area, a non-local training area, or as part of a training maneuver.
- **Arrival (straight-in/full-stop).** An aircraft lines up on the runway centerline, descends gradually, lands, comes to a full stop, and then taxis off the runway.
- **Overhead Arrival.** An expeditious arrival using visual flight rules. An aircraft approaches the runway 500 feet above the altitude of the landing pattern. Approximately halfway down the runway, the aircraft performs a 180-degree turn to enter the landing pattern. Once established in the pattern, the aircraft lowers landing gear and flaps and performs a 180-degree descending turn to land on the runway.
- **Ground Control Approach (GCA).** A radar or "talk down" approach directed from the ground by air traffic control (ATC) personnel. ATC personnel provide pilots with verbal course and glide slope information, allowing them to make an instrument approach during inclement weather.
- **Touch-and-Go Operation.** An aircraft lands and takes off on a runway without coming to a full stop. After touching down, the pilot immediately goes to full power and takes off again. The touch-and-go is counted as two operations—the landing is counted as one operation, and the takeoff is counted as another.

3.4.2 Annual Aircraft Operations

Projections of aircraft operations are based upon currently available estimates of future mission requirements within the next 10- to 15-year planning period. The projected average number of future operations at MCAS New River, including arrivals, departures, overhead arrivals, and pattern operations, is 92,711 per year (Wyle 2008). An operation consists of any time an aircraft crosses over the runway threshold. Consequently, while a takeoff or a landing are each counted as a single operation, a pattern counts as two. The majority of projected air operations at MCAS New River involve rotary-wing and tilt-rotor aircraft, 74% and 24%, respectively. Approximately 2% of all operations involve fixed-wing aircraft. The principal aircraft operating at MCAS New River are the CH-53E Super Stallion helicopter (35%) and the MV-22B Osprey (24%). Other airframes that contribute to the airfield's operations include the UH-1N Huey (15%) and the AH-1W Super Cobra (15%). Most fixed-wing operations at MCAS New River involve transient aircraft. The only fixed-wing aircraft homebased at MCAS New River is the UC-12B Huron. Future fixed-wing aircraft that may utilize the airfield include the C-130 Hercules and the F-35B Lightning II JSF (which is replacing the AV-8B). Figure 3-3 identifies the mix of aircraft projected to utilize MCAS New River.

Projected annual flight operations per aircraft are shown in Table 3-1. The projections of future operations are conservative forecasts, are higher than operational levels in recent years, and are used solely for future planning purposes.



Source: Wyle 2008

Note: At the time of the noise study (2008), two squadrons of CH-46E aircraft were still stationed at MCAS New River. They have since been replaced by MV-22B aircraft.

Figure 3-3 Aircraft Mix, MCAS New River (2009)

Table 3-1
Projected Annual Flight Operations at MCAS New River

Aircraft Type	Departure			Arrival			Overhead Arrival			GCA[1]			Touch and Go[1]			TOTAL		
	0700-2200	2200-0700	Total	0700-2200	2200-0700	Total	0700-2200	2200-0700	Total	0700-2200	2200-0700	Total	0700-2200	2200-0700	Total	0700-2200	2200-0700	Total
MCAS New River Aircraft																		
CH-46E[2]	3,096	210	3,306	2,908	396	3,304	0	0	0	212	32	244	864	98	962	7,080	736	7,816
CH-53E	12,240	750	12,990	11,965	1,025	12,990	0	0	0	730	85	815	5,750	250	6,000	30,685	2,110	32,795
AH-1W	4,544	296	4,840	3,840	1,000	4,840	0	0	0	400	52	452	3,236	296	3,532	12,020	1,644	13,664
UH-1N	4,788	296	5,084	4,084	1,000	5,084	0	0	0	408	52	460	3,236	296	3,532	12,516	1,644	14,160
MV-22B	8,408	528	8,936	7,272	544	7,816	992	128	1,120	944	144	1,088	3,248	280	3,528	20,864	1,624	22,488
UC-12B	529		529	504	29	533				140	28	168	64		64	1,237	57	1,294
Transient Aircraft																		
F-35B	120		120	48		48	72		72	12		12	12		12	264	0	264
C-130	59		59	56	3	59										115	3	118
Other Transient Jet Aircraft[3]	76		76	76		76				20		20				172	0	172
Total	33,860	2,080	35,940	30,753	3,997	34,750	1,064	128	1,192	2,866	393	3,259	16,410	1,220	17,630	84,953	7,818	**92,771**

[1]Counted as two operations, a takeoff, and a landing.

[2] The CH-46 aircraft previously stationed at MCAS New River during development of the noise study have since been replaced by MV-22 aircraft. This change would have a negligible impact on the overall noise contour presented in this AICUZ Study.

[3] The C-500 (Cessna Citation) was used to represent other transient jet aircraft operating at MCAS New River (Wyle 2008).

Source: Wyle 2008

Flight tracks are represented as single lines, but the actual flight path varies depending on aircraft performance, pilot technique, and weather conditions.

3.4.3 Runway and Flight Track Utilization

Runway utilization by tilt-rotor and rotary- and fixed-wing aircraft at MCAS New River is shown in Table 3-2. Rotary-wing and tilt-rotor aircraft also utilize the low work areas identified in Section 3.3.2. Aircraft approaching or departing from the air station are assigned specific routes or flight tracks. The designated runways for the airfield are identified in Section 2.4. Flight tracks are represented as single lines, but actual flight paths vary due to aircraft performance, pilot technique, and weather conditions, such that the actual flight track is a band, often one-half to several miles wide. The flight tracks presented in this AICUZ study are idealized representations. Figures 3-4 through 3-6 illustrate the major departures, arrivals, and pattern flight tracks for tilt-rotor and rotary- and fixed-wing aircraft operating at MCAS New River.

Table 3-2
Runway Utilization, MCAS New River

Runway	Utilization
1	6%
5	17%
19	16%
23	61%

Source: Wyle 2008

3.4.4 Low Work and Maintenance Run-Up Operations

Table 3-3 presents the annual low work operations by location and aircraft type. Approximately 4,854 low work operations are projected to occur per year, with 86% occurring at the Midfield Hover Area. The average duration of a low work operation is between three and five minutes.

© Ecology & Environment, Inc. GIS Department Project #002215.NU04.02
\L:\Buffalo\New_River\Maps\MXD\Draft_AICUZ\January_2009\Figure 3-4 Arrival Flight Tracks.mxd

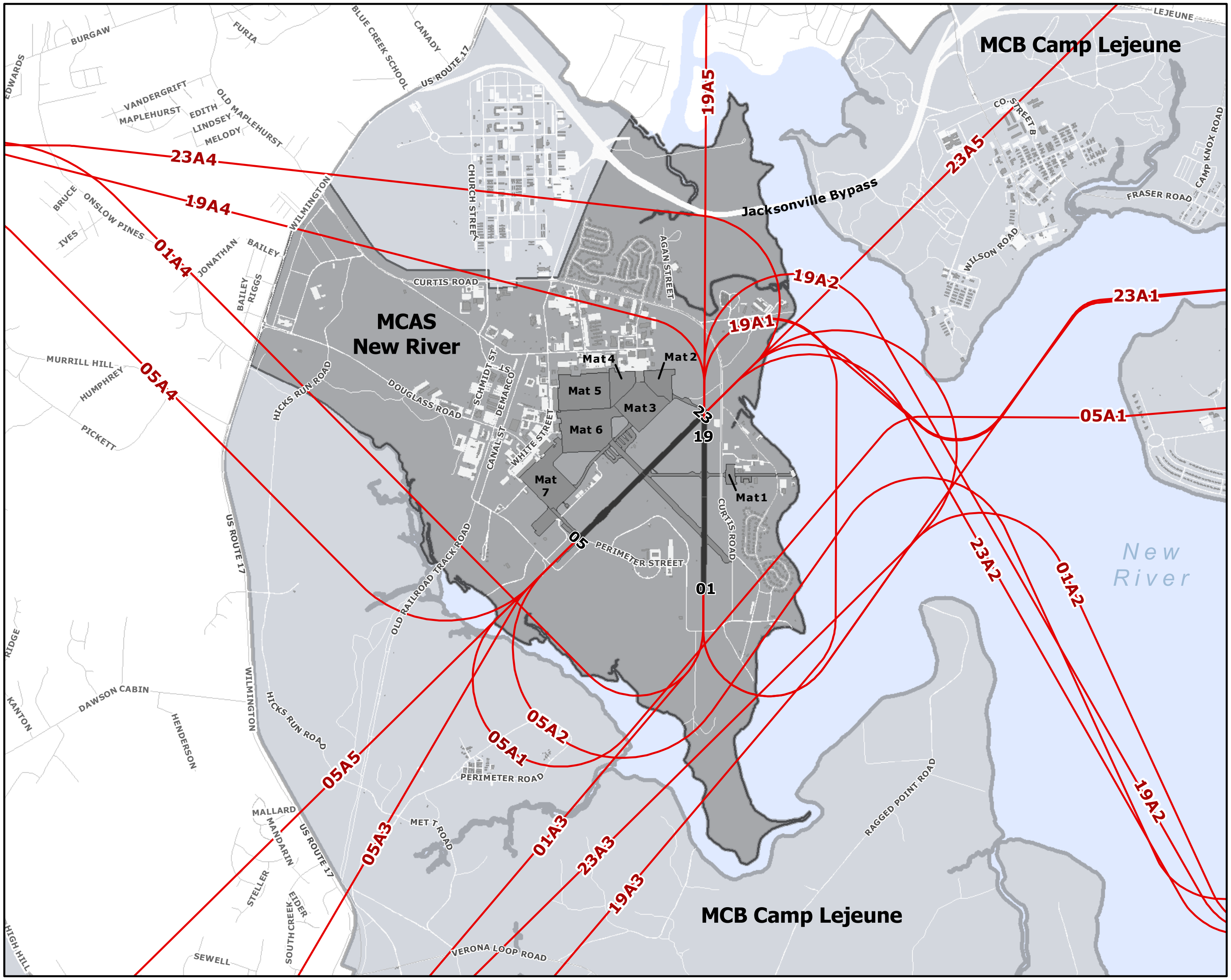


Figure 3-4
Arival Flight Tracks
MCAS New River, NC

- Arrival Flight Tracks
- Runways
- MCAS New River
- MCB Camp Lejeune
- Water Bodies

Source: Wyle, 2008.

0 0.25 0.5 1
Miles

© Ecology & Environment, Inc. GIS Department   Project #002215.NU04.02
\L:\Buffalo\New_River\Maps\MXD\Draft_AICUZ\January_2009\Figure 3-5 Departure Flight Tracks.mxd

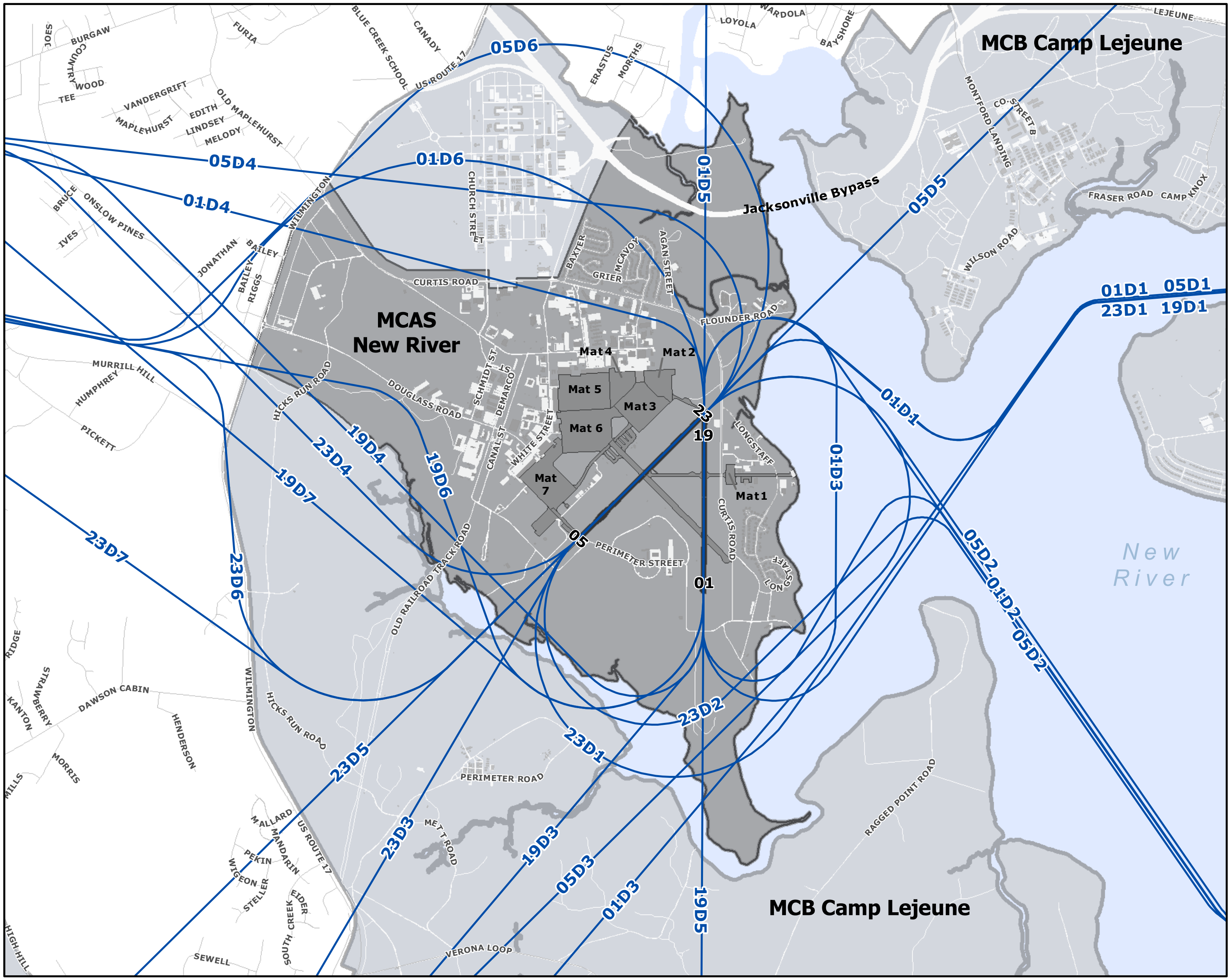


Figure 3-5
Departure Flight Tracks
MCAS New River, NC

- Departure Flight Tracks
- Runways
- MCAS New River
- MCB Camp Lejeune
- Water Bodies

Source: Wyle, 2008.

0 0.25 0.5 1
Miles

\L:\Buffalo\New_River\Maps\MXD\Draft_AICUZ\January_2009\Figure 3-6 Closed Pattern Flight Tracks.mxd

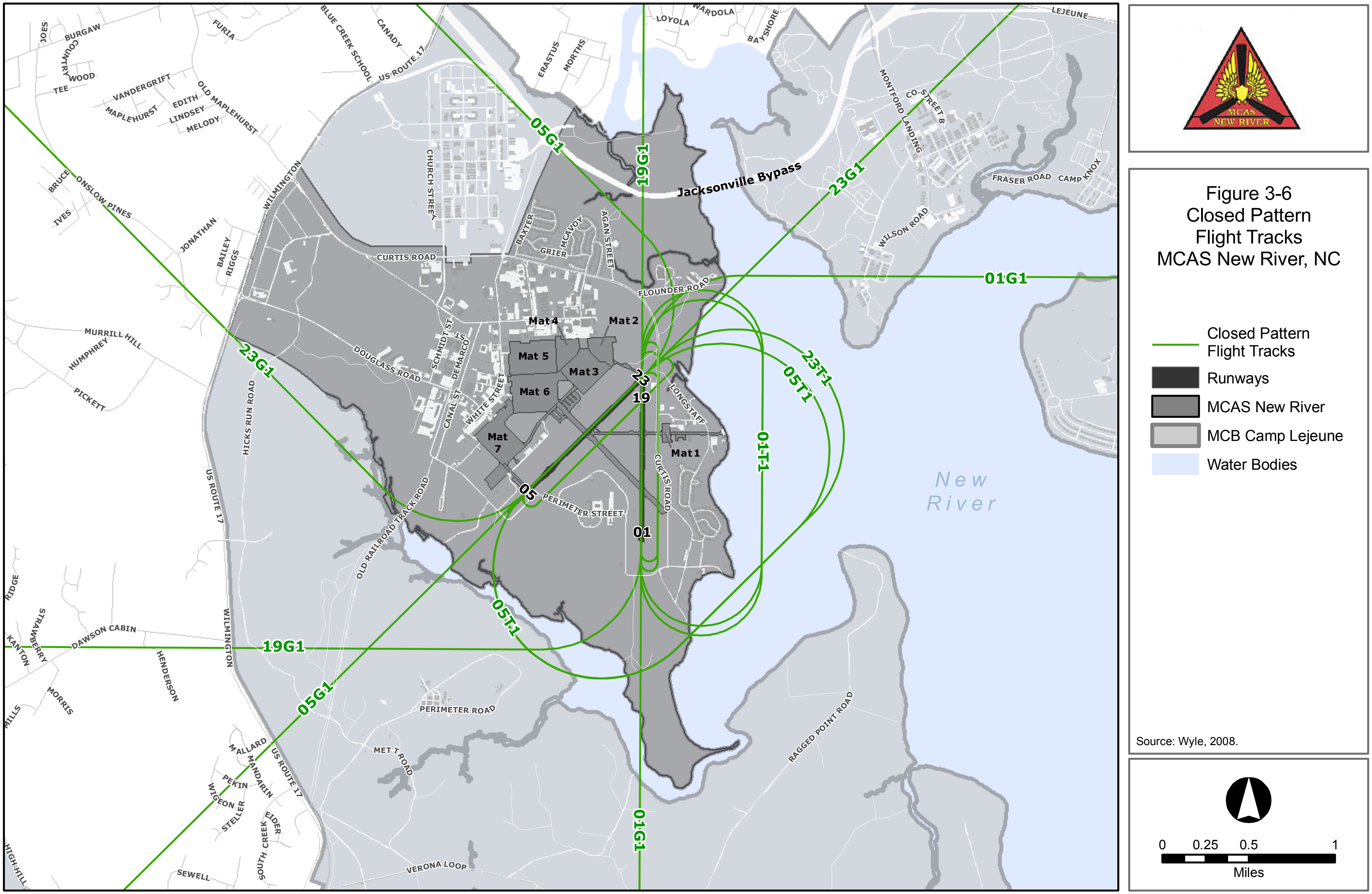


Figure 3-6
Closed Pattern
Flight Tracks
MCAS New River, NC

Table 3-3
Projected Low Work Operations at MCAS New River

Location		Aircraft Type[1]	Annual Number of Low Work Operations	Average Time (min) per Activity
Midfield Hover Area	East	CH-46E	333	3.3
		CH-53E	367	3.3
		AH-1W	183	3.3
		UH-1N	183	3.3
		MV-22B	500	3.3
	North	CH-46E	333	3.3
		CH-53E	367	3.3
		AH-1W	183	3.3
		UH-1N	183	3.3
		MV-22B	500	3.3
	West	CH-46E	333	3.3
		CH-53E	367	3.3
		AH-1W	183	3.3
		UH-1N	183	3.3
		MV-22B	500	3.3
Northeast Grass Area	North	MV-22B	375	5.0
		CH-46E	18	5.0
	South	MV-22B	375	5.0
		CH-46E	18	5.0
		Total	**5,484**	**3.66**

Source: Wyle 2008

[1] The CH-46 aircraft previously stationed at MCAS New River during development of the noise study have since been replaced by MV-22 aircraft. This change would have a negligible impact on the overall noise contour presented in this AICUZ Study.

Maintenance run-ups associated with maintenance operations are projected to take place in a new maintenance test cell facility located to the west of Runway 05/23. Construction of the new facility will enable all engine maintenance operations to be completed indoors. Run-ups are projected to last from 90 to 105 minutes, and it is expected that 944 engine maintenance operations will occur per year. Approximately 897 maintenance run-ups are expected to occur between the hours of 7:00 A.M. and 10:00 P.M., and approximately 47 run-ups are expected to occur between 10:00 P.M. and 7:00 A.M.

4 Aircraft Noise

The identification of areas impacted by aircraft noise is a critical factor when planning land uses in the vicinity of air facilities. Because the noise from aircraft operations can significantly impact areas surrounding an installation, MCAS New River has prepared noise exposure contours that define land areas adjacent to the airfield that may experience noise impacts. This section discusses these noise contours and compares them to the contours identified in the 2001 AICUZ study. This section also describes how the contours were developed, how noise complaints are handled, and specific flight procedures MCAS New River has enacted to reduce noise impacts.

A-weighted Decibel
Places a greater emphasis on frequencies that are detected by people with a normal auditory range by de-emphasizing the very low and very high frequency components of sound.

4.1 What is Sound/Noise?

All sounds come from a sound source. It takes energy to produce this sound, and this energy is transmitted through the air in sound waves. These sound waves impinge upon our ears, creating the sound we hear. Unwanted sound is defined as noise. Examples of potential sources of noise include roadway traffic, construction activities, railway activities, and aircraft operations. Whether sound becomes noise depends on the listener, but sound can become noise when it interferes with normal activities.

In this study, all sound or noise levels are measured in A-weighted decibels (dBA), which are units of sound pressure adjusted to the range of human hearing. Normal speech has a noise level of approximately 60 dBA. Generally, sound levels above 120 dBA will begin to provide discomfort to the human auditory system with the threshold of pain at about 140 dBA (Berglund and Lindvall 1995).

The noise exposure from aircraft at MCAS New River, as with other military installations, is measured using the day-night average sound level noise metric (DNL). The DNL metric, established in 1980 by the Federal Interagency Committee on Urban Noise (FICUN), presents a reliable measure of community sensitivity to aircraft noise and has become the standard metric used in the United States (except California, which uses a similar metric, the Community Noise Equivalent Level).

The DNL, expressed in decibels, represents the average sound exposure during a 24-hour period and does not represent the sound level for a specific noise event. The DNL also incorporates an additional 10 decibels to events occurring between 10:00 P.M. and 7:00 A.M. This 10-decibel "penalty" represents the added intrusiveness of sounds occurring during normal sleeping hours, both because of the increased sensitivity to noise during those hours and because ambient sound levels at night are typically lower.

The DNL provides a single measure of overall noise impact by combining factors most noticeable about noise annoyance, including maximum noise levels and number of events over a 24-hour period. Scientific studies and social surveys conducted to evaluate community annoyance from many types of environmental noise have found the DNL to be the best measure of that annoyance (Federal Interagency Committee on Urban Noise 1980; U.S. Environmental Protection Agency 1982; American National Standards Institute 1990; Federal Interagency Committee on Noise 1992). Although DNL provides a single measure of overall noise impact, it does not provide specific information on the number of noise events or the individual sound levels that occur during the day. For example, a DNL of 65 dBA could result from a very few noisy events or a large number of quieter events.

4.2 Airfield Noise Sources

The main sources of noise at airfields are flight and maintenance run-up operations. Computer models are used to develop noise exposure contours based on information about these operations, including:

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

- Flight track;
- Aircraft power settings, speeds, and altitudes;
- Number and duration of maintenance run-ups;
- Terrain;
- Surface type (e.g., land or water); and
- Environmental data (temperature and humidity).

4.3 Noise Complaints

Aircraft noise has the potential to impact the quality of life of those experiencing it and can become a major compatibility issue for an air station and the surrounding community. Individual response to noise levels varies and is influenced by many factors, including:

- Activity the individual is engaged in at the time of the noise event;
- General sensitivity to noise;
- Time of day;
- Length of time an individual is exposed to noise;
- Predictability of noise; and
- Weather conditions.

A small change in dBA will not generally be noticeable. As the change in dBA increases, the individual perception is greater, as shown in Table 4-1.

Table 4-1
Subjective Response to Noise

Change	Change in Perceived Loudness
+1 dBA	Requires close attention to notice
+3 dBA	Barely noticeable
+5 dBA	Quite noticeable
+10 dBA	Dramatic – twofold change
+20 dBA	Striking – fourfold change

To mitigate adverse noise conditions, MCAS New River continually reviews its airfield operating activities with the aim of minimizing potential noise impacts on the surrounding community. If a noise concern arises, members of the public may call the MCB Camp Lejeune 24-hour Noise Complaint Hotline (910-451-9079) or MCAS New River Operations (910-449-6311) to report a concern. MCAS New River Operations personnel are responsible for collecting, documenting, and researching noise complaints. All noise complaints are investigated by the MCAS New River Operations personnel, and corrective actions are taken, as appropriate. Noise complaint procedures for MCAS New River are established in *ASO P3710.7T, Marine Corps Air Station New River Air Operations Manual.*

4.4 Noise Abatement Procedures at MCAS New River

In recognition of community response to aircraft noise, MCAS New River actively employs operational measures to reduce noise to the extent practicable, commensurate with safety and operational training requirements. Noise abatement procedures are contained in *ASO P3710.7T, Marine Corps Air Station New River Air Operations Manual* (U.S. Marine Corps 2009). The manual establishes the rules and regulations that apply to aircraft operating in the airspace under the control and cognizance of MCAS New River and vehicle operations on the airfield movement areas (e.g., runway, taxiways). The following are operational noise abatement procedures that have been adopted at MCAS New River:

- Pilots operating from MCAS New River shall be sensitive to the effects of noise on the surrounding communities and take all steps necessary to reduce aircraft noise and minimize annoyance experience by persons on the ground. It is not enough that the pilot is satisfied that persons/property are not endangered. Pilots shall make a definite effort to fly in a manner such that individuals on the ground do not believe they or their property is endangered.
- Pilots shall avoid overflight of populated areas to the maximum extent practicable. When overflying populated areas, pilots shall maintain a minimum altitude of 1,000 feet AGL unless the local course rules specify a lower altitude.
- ATC shall not authorize close-in downwind patterns after sunset.

- ATC shall not authorize use of the local traffic pattern after 11 P.M.

4.5 Noise Exposure Contours

In support of this AICUZ study, a noise study was conducted to define noise exposure contours at MCAS New River. The noise exposure contours were prepared using NOISEMAP, a widely accepted computer model that projects noise impacts around military airfields. Using NOISEMAP, the Marine Corps models noise exposure contours based on prospective aircraft activity at the installation and site-specific operational data such as flight tracks, type and mix of aircraft, aircraft profiles (airspeed, altitude, power settings), and frequency and times of operations. The noise exposure contours graphically illustrate where aircraft noise occurs in and around an airfield and at what sound level. The contours generally follow the flight paths of aircraft.

The noise contours are depicted in 5-dBA increments (60, 65, 70, 75, 80, and 85 DNL). The DNL is depicted visually as a noise exposure contour that connects points of equal value. For land use planning purposes, the contours are divided into the following three noise zones:

- **Noise Zone 1 (64 DNL and below)** [1] – Generally considered an area of low or no noise impact;
- **Noise Zone 2 (65 to 74 DNL)** – An area of moderate impact requiring some land use controls; and
- **Noise Zone 3 (75 DNL and above)** – The most severely impacted area and requiring the greatest degree of land use control.

Land use compatibility information and recommendations for MCAS New River are presented in Sections 6 and 7, respectively.

4.5.1 2011 AICUZ Noise Exposure Contours

The 2011 AICUZ noise exposure contours for MCAS New River are shown on Figure 4-1. The contours are located primarily within the

[1] For purposes of analysis in the AICUZ study, Noise Zone 1 is analyzed between the 60 to 64 DNL noise contours.

© Ecology & Environment, Inc. GIS Department   Project #002215.NU04.02
\Path: L:\Buffalo\New_River\Maps\MXD\Draft_AICUZ\January_2009\Figure 4-1 2009 Noise Contours Rev02 Feb2011.mxd

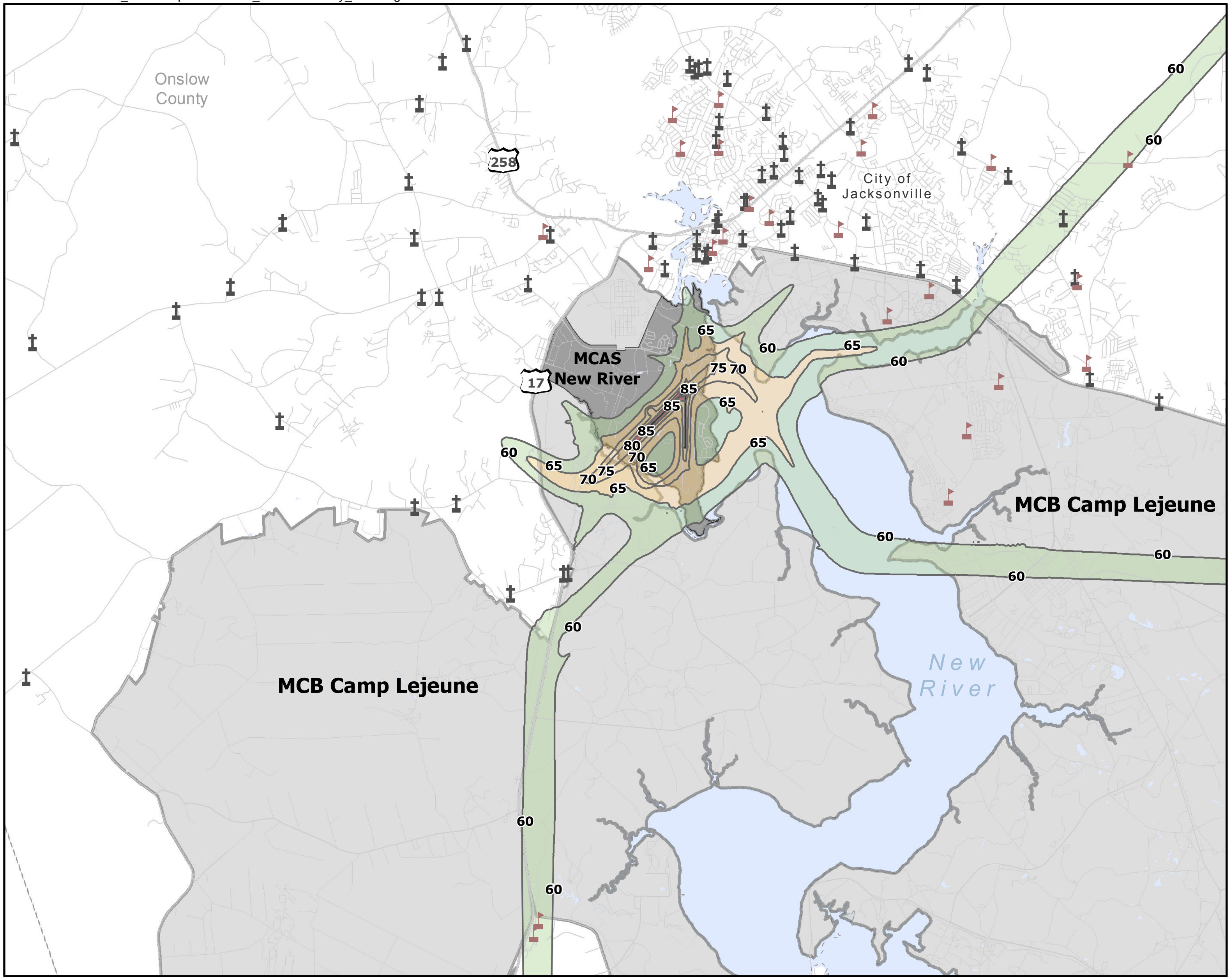
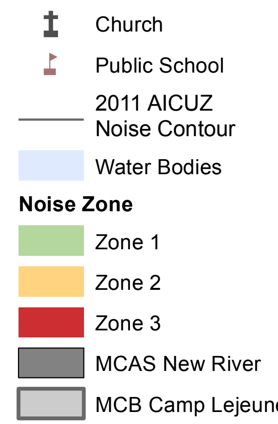


Figure 4-1
2011 AICUZ
Noise Exposure Contours
MCAS New River, NC



Source:
ESRI, 2005;
MCAS New River, 2008;
USMC GEOFidelis

boundaries of MCAS New River and MCB Camp Lejeune or overlie the New River, a natural water body. Three arms of the 2011 AICUZ noise exposure contours, encompassing approximately 2,594 acres, extend outside of the MCAS New River and MCB Camp Lejeune property line. The majority of the noise exposure contours located off-base, encompassing approximately 2,572 acres, are within the 60 to 64 DNL noise zone (Noise Zone 1). A smaller portion, encompassing approximately 22 acres, is within the 65 to 70 DNL noise zone contour (a portion of Noise Zone 2). No noise contour greater than 70 DNL has been identified outside of the MCAS New River and MCB Camp Lejeune property line. The arm extending over the western boundary of MCAS New River is a result of the projected fixed-wing departures, most notably the transient F-35B aircraft operations (Wyle 2008). The arms extending over the northeastern and southern boundaries of MCB Camp Lejeune are a result of rotary-wing aircraft departures and arrivals. Rotary-wing aircraft depart MCAS New River airspace by climbing to 1,000 feet AGL and, once outside of the MCAS New River airspace, descending to 500 feet AGL to continue on their flight route. The land parcels underlying these noise zones are zoned for residential, business, and agricultural land uses. Land use compatibility information and recommendations for MCAS New River are presented in Sections 6 and 7, respectively.

4.5.2 Comparison of 2001 AICUZ and 2011 AICUZ Noise Exposure Contours

This section compares the 2011 AICUZ noise exposure contours to the previous contours published in the 2001 AICUZ study. The comparison helps identify changes to noise exposure based on prospective changes in aircraft operations and allows the targeting of land use recommendations to mitigate noise impacts.

A comparison of 2001 AICUZ and 2011 AICUZ noise contours at MCAS New River indicates a reduction in overall noise exposure outside of the installation boundary (see Figure 4-2). Compared to the 2001 AICUZ noise contours, the 2011 AICUZ noise exposure contours move away from the northern and western borders of MCAS New River and are focused mostly over the airfield and the New River. Overall, the

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\L:\Buffalo\New_River\Maps\MXD\Draft_AICUZ\January_2009\Figure 4-1 2009 Noise Contours Rev01.mxd 04/15/2009

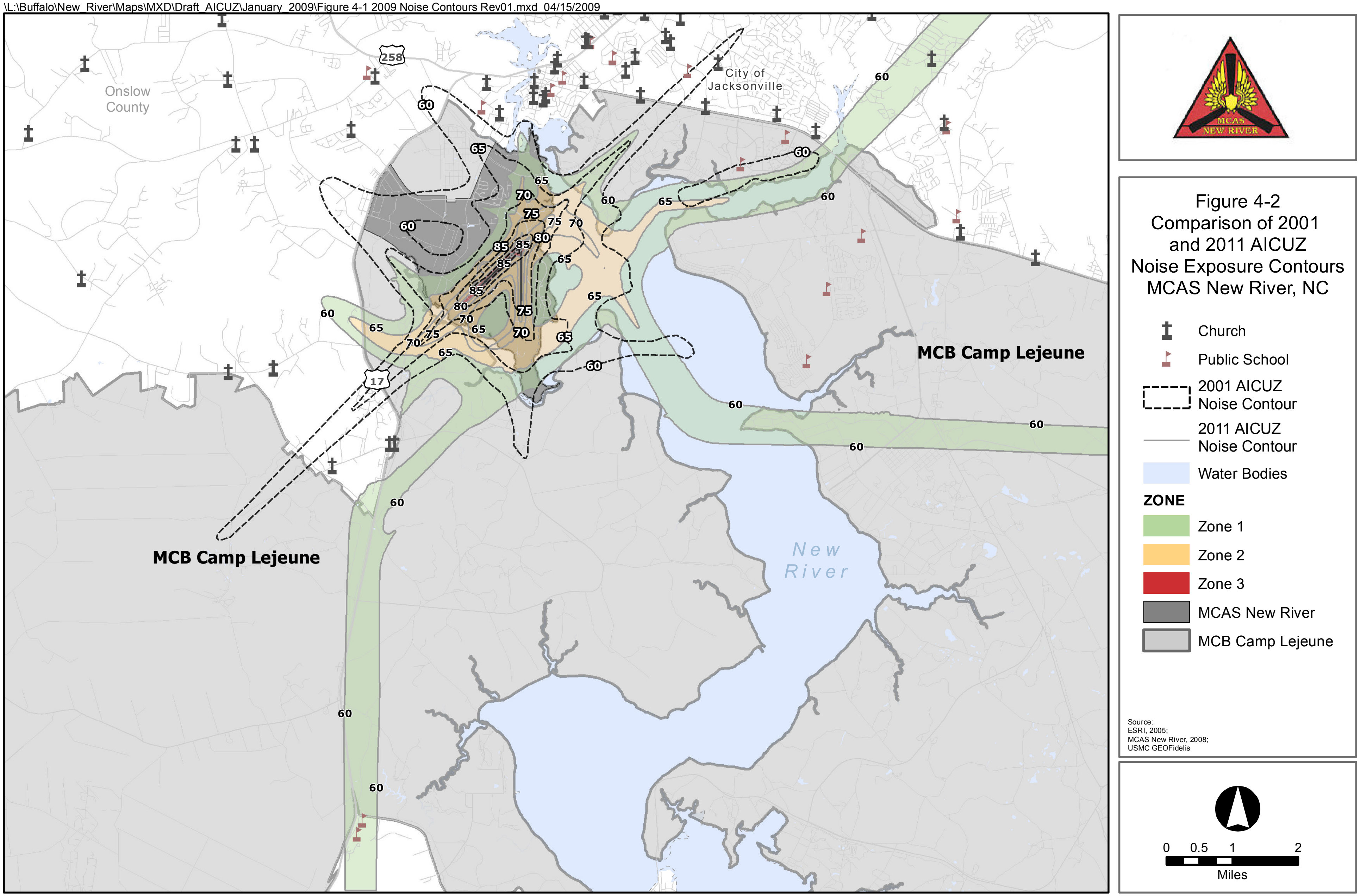

Figure 4-2
Comparison of 2001
and 2011 AICUZ
Noise Exposure Contours
MCAS New River, NC

area covered by the noise zones decreased by approximately 100 acres between 2001 and 2011, as shown in Table 4-2.

Table 4-2
Comparison of Land Area within Noise Zones, MCAS New River[1]

Noise Zone (DNL)	TOTAL LAND AREA 2001 AICUZ (acres)	TOTAL LAND AREA 2011 AICUZ (acres)
Noise Zone 1 (64 DNL and below)[2]	12,923	11,542
Noise Zone 2 (65 to 74 DNL)	1,689	3,089
Noise Zone 3 (75 DNL and above)	211	92
Total	**14,823**	**14,723**

Source: Wyle 2008

[1] Includes land areas both on- and off-station
[2] For purposes of analysis in the AICUZ study, Noise Zone 1 is analyzed between the 60 to 64 DNL noise contours.

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5 Airfield Safety

This section describes airfield-specific Accident Potential Zones (APZs) and airfield safety issues such as imaginary surface areas, the Bird Aircraft Strike Hazard (BASH) Program, and measures to avoid other hazards within the airfield vicinity that can obstruct or interfere with aircraft operations, pilot vision, communications, or aircraft electronics.

5.1 Accident Potential Zones

In the 1970s, the DoD conducted a tri-service study of historic aircraft accident data to identify accident potential in the areas surrounding military airfields. The study found that more aircraft mishaps occur on or near the runway or along the centerline of the runway, diminishing in likelihood with distance. Based on the study, the DoD established APZs. An APZ is a ground area where an aircraft accident is more likely to occur (if one were to occur). The APZs do not predict the probability of an accident, but define areas where land use activities should be restricted or limited to protect the public from potential aircraft mishaps. Restricting or limiting land use development in these areas does not provide complete protection from aircraft mishaps but does limit the potential consequences of such an event.

An APZ is comprised of three distinct components: a Clear Zone, APZ I, and APZ II. The size and application of APZs are determined by installation-specific operational considerations, including the following:

- Runway classification,
- Type and volume of flight operations,
- Aircraft traffic patterns (flight tracks), and
- Local command considerations.

While the likelihood of an aircraft mishap is very small, the Marine Corps has identified APZs around MCAS New River's airfield to assist in land-use planning. Based on this information, the Marine Corps recommends that land uses that concentrate large numbers of people (e.g., apartments, churches, schools) be located outside of identified APZs.

Descriptions of standard APZs are included in Section 5.1.2. Designated APZs for MCAS New River are discussed in Section 5.1.3 and 5.1.4.

5.1.1 Aircraft Mishaps

There are three "severity classes" for aircraft mishaps. The most severe, a Class 'A' mishap, is an accident in which the total cost of damage to property or aircraft exceeds $1 million, an aircraft is destroyed or missing, or a fatality or permanent total disability results from the direct involvement of naval aircraft. (Department of Defense 2005).

According to the Naval Safety Center, there have been two Class 'A' mishaps at or in the vicinity of MCAS New River in the past 10 years (Hobbs 2008).

5.1.2 Aircraft APZs

Based on the runway classification, operational tempo, existing APZs, and local command considerations, Class A fixed-wing Runway APZs have been applied to MCAS New River's runways. Figure 5-1 illustrates the configuration of a standard Class A fixed-wing Runway APZ, which includes the following:

- **Clear Zone.** Runway clear zones are areas on the ground located at the ends of each runway. The clear zone is the area with the greatest potential for the occurrence of an aircraft mishap. For this reason, and to protect aircraft operations, a clear zone should remain undeveloped. For U.S. Navy and Marine Corps installations, a standard Class A clear zone is 3,000 feet long and 1,000 feet wide. The clear zone is required for all active runway ends.

- **APZ I.** APZ I is an area on the ground located beyond the clear zone of the runway. The area has a potential for accidents, and development in these areas should be restricted. A Class A APZ I is 2,500 feet long and 1,000 feet wide and may be either rectangular or curved to conform to the shape of the predominant flight track.

- **APZ II.** APZ II is an area on the ground located beyond APZ I (or the clear zone if APZ I is not used) that has a measurable potential for aircraft accidents relative to APZ I or the clear zone. APZ II is always provided where APZ I is required. A Class A APZ II is 2,500 feet long and 1,000 feet wide and may be either rectangular or curved to conform to the shape of the predominant flight track.

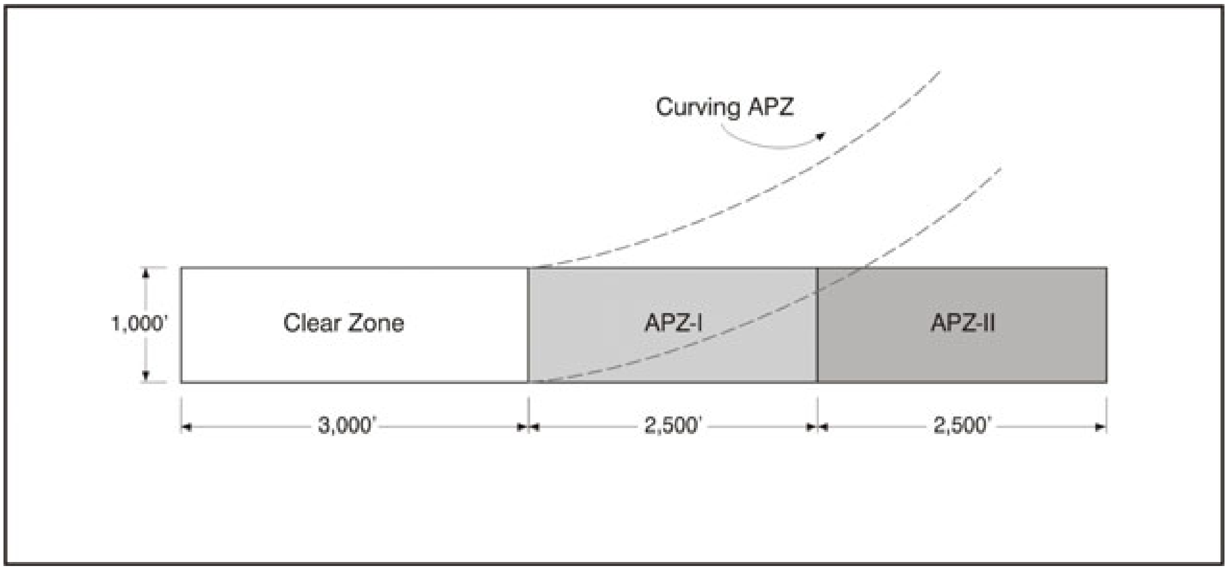


Figure 5-1 Standard Accident Potential Zones – Class A Fixed-wing Runway

5.1.3 2011 AICUZ APZs

The designated APZs for MCAS New River are illustrated on Figure 5-2 and are provided for general land-use planning purposes. The APZs comprise a total of 1,205 acres. MCAS New River's APZs, including clear zones, are mostly located within the boundaries of MCAS New River and MCB Camp Lejeune. The only exception is a 2.9-acre area located at the northern tip of Runway 19 APZ II. However, this small area is located over the New River, which is a water body and thus a compatible use for APZ II. Table 5-1 provides the total acreage of land within the clear zone, APZ I, and APZ II at MCAS New River and MCB Camp Lejeune.

Specific land use recommendations for MCAS New River's clear zones and APZs are presented in Section 6.

© Ecology & Environment, Inc. GIS Department Project #002215.NU04.02
\L:\Buffalo\New_River\Maps\MXD\Draft_AICUZ\January_2009\Figure 5-2 APZs.mxd

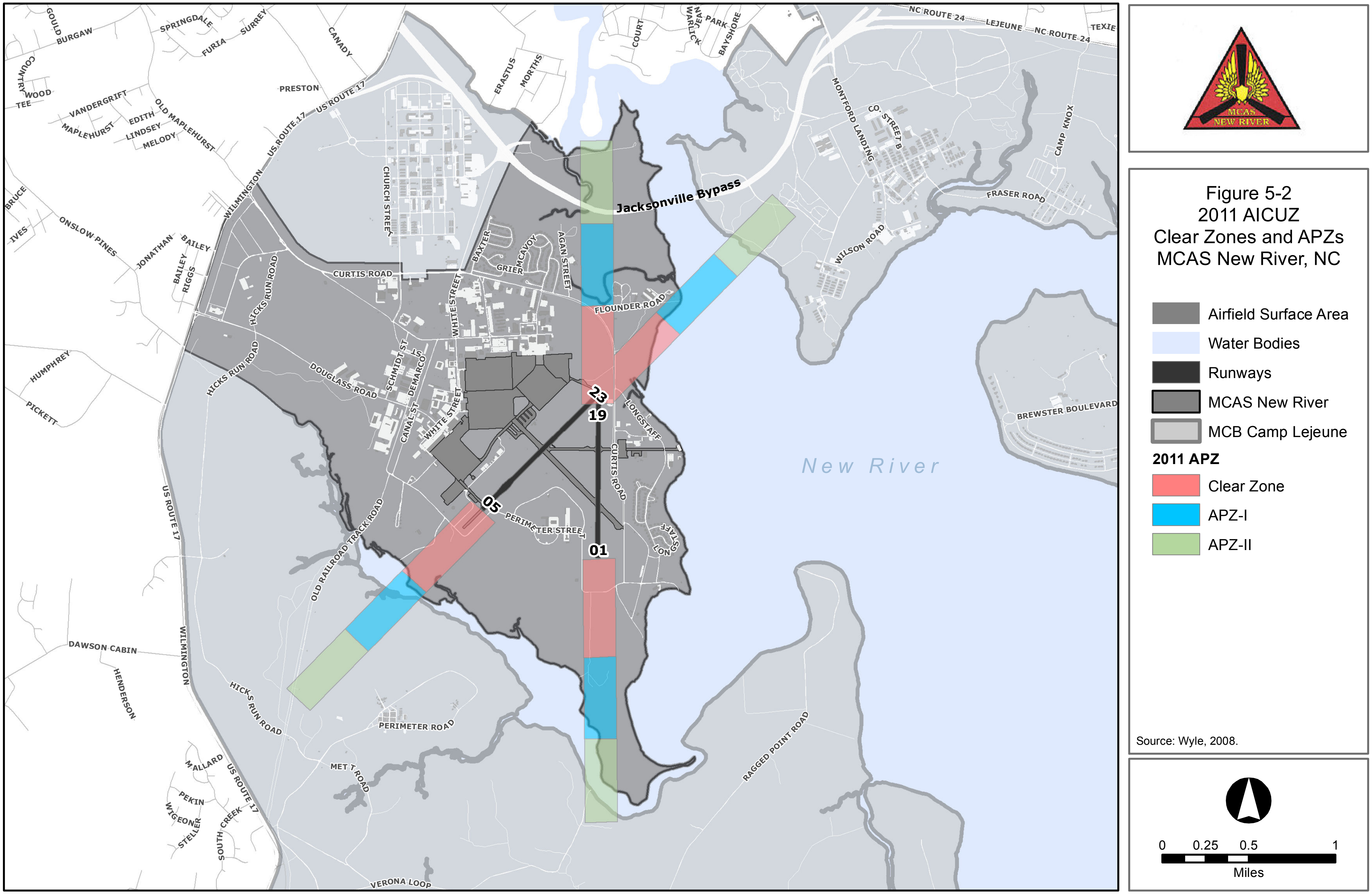


Figure 5-2
2011 AICUZ
Clear Zones and APZs
MCAS New River, NC

Source: Wyle, 2008.

Table 5-1
Land Area within 2011 AICUZ APZs, MCAS New River[1]

Location	Acres
Clear Zone	489
APZ I	227
APZ II	489
Total	**1,205**

[1] Includes land area both on- and off-station

5.1.4 Comparison of 2001 AICUZ and 2011 AICUZ APZs

The 2011 APZs for MCAS New River remain unchanged from those identified in the 2001 AICUZ study.

5.2 Flight Safety

5.2.1 Imaginary Surfaces

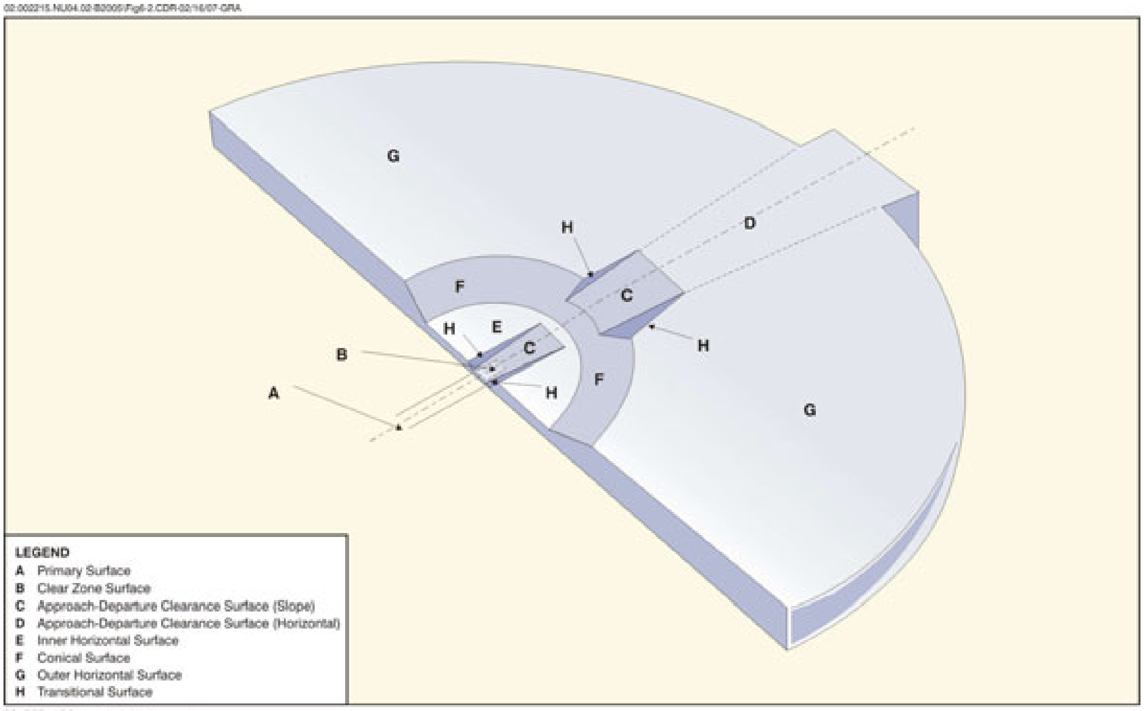
In addition to the APZs, the FAA and the military have defined flight safety zones (imaginary surfaces) below aircraft arrival and departure flight tracks and areas surrounding the airfield. Imaginary planes and transition surfaces define the required airspace that must remain free of obstructions to ensure safe flight approaches, departures, and patterns. Obstructions may include natural terrain and man-made features (e.g., planted vegetation, buildings, towers, poles) and other vertical obstructions to airspace navigation. The flight safety zones are designed to minimize the potential harm if a mishap were to occur. The dimensions of the imaginary surface area for Class A fixed-wing runways are provided in Table 5-2. Figure 5-3 shows the composite imaginary and transitional surfaces at MCAS New River.

Table 5-2
Imaginary Surfaces – Class A Fixed-wing Runways

Planes and Surfaces	Geographical Dimensions
Class A	
Primary Surface	Aligned longitudinally with each runway. Extends 200 feet beyond the end of the runway and is 1,000 feet wide.
Clear Zone	Extends 3,000 feet beyond the end of the runway and is 1,000 feet wide. Also see Section 5.1.2.
Approach Surface	Longitudinally centered with the runway and extending beyond the primary surface.
Horizontal	Horizontal plane 150 feet above the established airport elevation. Constructed by swinging arcs around the end of the primary surface.
Conical Surface	20:1 slope surface extending beyond the horizontal surface.

Table 5-2
Imaginary Surfaces – Class A Fixed-wing Runways

Planes and Surfaces	Geographical Dimensions
Transitional Surface	An inclined plane that connects the primary surface and the approach-departure clearance surface to the inner horizontal surface, conical surface, and outer horizontal surface. These surfaces extend outward and upward at right angles to the runway centerline, extended at a slope of 7:1 from the sides of the primary surface and from the sides of the approach surfaces.
Source: U.S. Department of Transportation, Federal Aviation Administration 2006; U.S. Department of the Navy 1981.	



SOURCE: US Department of the Navy 1999.

Figure 5-3 Imaginary Surfaces and Transition Surfaces for Class A Fixed-Wing Runways

5.2.2 Bird Aircraft Strike Hazard (BASH)

Wildlife can represent a significant hazard to flight operations. Birds, in particular, are drawn to the open, grassy areas and warm pavement of an airfield. Although most bird and animal strikes do not result in crashes, they can cause structural and mechanical damage to aircraft. Most collisions occur when the aircraft is at an elevation of less than 1,000 feet. Due to the speed of the aircraft, collisions with wildlife can happen with considerable force.

To reduce BASH, the FAA and the military recommend that land uses that attract birds be located at least 10,000 feet from the airfield. These land uses include the following:

- Waste disposal operations,
- Wastewater treatment facilities,
- Landfills,
- Golf courses,
- Wetlands;
- Dredge disposal sites,
- Seafood processing plants, and
- Storm water ponds.

Design modifications also can be used to reduce the attractiveness of these types of land uses to birds and other wildlife. The MCAS New River Environmental Affairs Department manages the air station's BASH Program and actively monitors bird and other wildlife activity.

5.2.3 Electromagnetic Interference

New generations of military aircraft are highly dependent on complex electronic systems for navigation and critical flight and mission-related functions. Consequently, care should be taken when siting any activities that create electromagnetic interference (EMI). EMI is defined by the American National Standards Institute as any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics/electrical equipment. It can be induced intentionally, as in forms of electronic warfare, or unintentionally, as a result of spurious emissions and responses (e.g., leakage from high-tension lines). In addition, EMI may be caused by atmospheric phenomena (e.g., lightning and precipitation static) and by non-telecommunication equipment (e.g., vehicles and industry machinery).

5.2.4 Lighting

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

5.2.5 Smoke, Dust, and Steam

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

6 Land Use Compatibility Analysis

This section addresses land-use compatibility within aircraft noise exposure zones and APZs by examining existing and planned land uses near MCAS New River and then identifying any land use compatibility concerns.

Management of land use outside the installation, which is critical to limiting the number of people exposed to excessive noise and the potential for accidents, is under the exclusive control of state and local governments.

6.1 Planning Authority

While MCAS New River actively maintains an AICUZ Program and provides recommendations to encourage compatible land development and prevent encroachment, it has no regulatory authority to control the development of lands outside of the installation. Local commands act only in an informational role for land use recommendations outside of the installation's boundary and hold no jurisdiction over non-military property. The Marine Corps recognizes that local governments are responsible for land use planning, zoning, and regulation of land surrounding MCAS New River. These local planning authorities are the governments of the City of Jacksonville and Onslow County. The City of Jacksonville maintains jurisdiction over land use within its municipal boundaries, and the County regulates land use for all areas within the county but outside of the city.

6.2 Existing Zoning and Land Use

6.2.1 Zoning

Zoning, which is the public regulation of land and building use, is used to regulate future land use, building height, building density, and minimum and maximum lot sizes. Generally contained within a municipality's zoning ordinance or law, zoning defines the specific land uses (e.g., residential, commercial, open space) that are allowed for a specific piece of property. In this AICUZ study, zoning is used as a predictor of future land uses surrounding the installation.

Figure 6-1 identifies the zoning and special zoning districts in the areas surrounding MCAS New River. These areas are within the City of Jacksonville and the County of Onslow and include property zoned for a mix of multi-family residential, office/light industrial, business, commercial, and agricultural uses to the north and west of the installation. Traveling south along the western boundary of the installation, along Route 17 and within Onslow County, most of the land is zoned for agricultural and light residential uses. Directly to the east of the air station is the New River, a natural waterway. Further east and directly south of the air station are MCB Camp Lejeune military lands.

Onslow County has developed and adopted as part of its zoning ordinance a Flight Path Overlay District (FPOD) for some lands neighboring the air station. The FPOD prohibits or restricts land use, development, or activities on lands under designated fixed-wing flight paths and rotary-wing landing areas in an effort to ensure compatibility between air operations and civilian development (Onslow County 2007). The FPOD applies only to designated lands within the jurisdiction of the county. The FPOD is illustrated on Figure 6-1.

With respect to the municipal zoning ordinance, the City of Jacksonville designates the air station property as a military reservation zone but has not incorporated any special zoning districts to prevent encroachment along the installation property line or under any of the flight operational areas. While no other special military land use districts exist, both the County and the City identify the need to protect the installation from encroachment and understand the need for planning partnerships with the military within their comprehensive land use plans (see Table 6-1).

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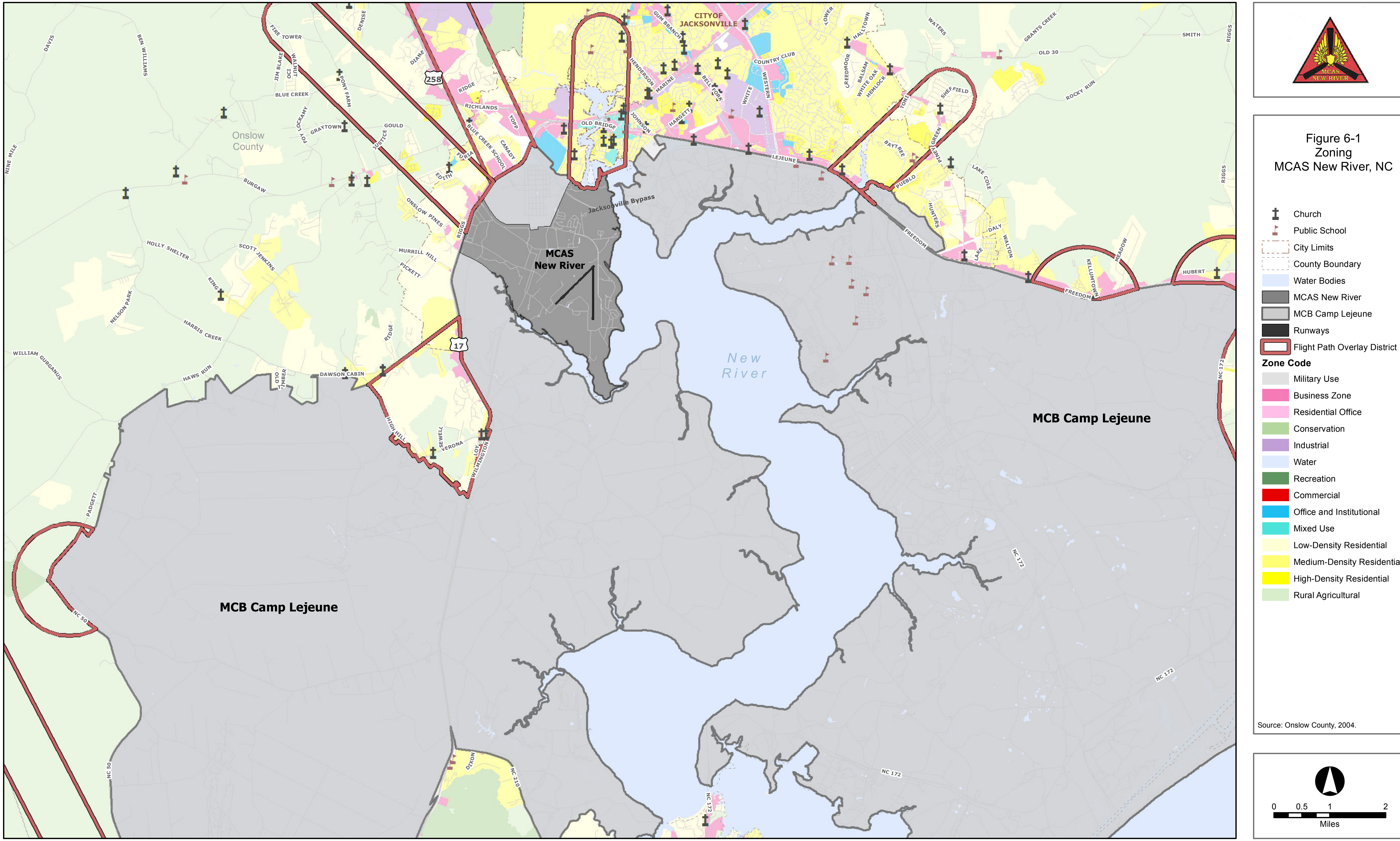

Figure 6-1
Zoning
MCAS New River, NC

Source: Onslow County, 2004.

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Table 6-1
Military Support Policies – Onslow County and the City of Jacksonville

Onslow County, Citizens Comprehensive Plan (approved April 30, 2003)
Policy 1.2: Onslow County shall encourage a pattern of development and community growth which respects the training and operational missions of area military installations, while also allowing for reasonable, appropriate uses of properties near such installations. Policy 19.1: Coordinate intergovernmental and military-community planning for land use and development, transportation, utilities, environmental management, law enforcement and public safety, education, recreation, tourism and economic development shall be encouraged. Policy 19.2: Special committees, advisory panels, educational forums, workshops, leadership seminars, community meetings, and media contacts shall be encouraged to enhance the level of community involvement and awareness of military-community issues. Policy 19.3: The County shall work proactively with the Marine Corps Base Camp Lejeune and the New River Air Station to determine those policies and actions that will strengthen the operational viability of the military while also enhancing the community at large.
City of Jacksonville, Growth Management Element Plan (July 11, 2007)
Policy 23.1: Support the long-term viability of Camp Lejeune and the New River Marine Corps Air Station ("military facilities") operations by supporting a framework for military-community partnerships and planning efforts which involve joint land use planning, facility and resource sharing and public/private economic ventures. Policy 23.2: Encourage development of an intergovernmental agreement between the City and military facilities to define land use compatibility issues and agreeing to resolve land use disputes through mutually acceptable techniques. Policy 23.3: Coordinate with the military facilities to identify off-base properties within the City under federal control that are available exclusively for military operations, housing, personnel, recreation, and similar ancillary military facilities or environmental habitat preservation. Policy 23.4: Establish long-range compatibility standards and land use regulations that preserve the military missions of Camp Lejeune and the New River Marine Corps Air Station while accommodating the growth of Jacksonville. Policy 23.5: Consider impacts on current and future military facility activities as a component of the development review process. Policy 23.6: Encourage development of an intergovernmental agreement between the City and military facilities to establish opportunities to plan for and provide public facilities and services.
Source: Onslow County 2003b; City of Jacksonville 2007

Population Growth – Onslow County
The county's population is projected to increase by approximately 15% in the next 10-year planning period.

Year	Population
2000	– 150,363
2005	– 157,327
2010	– 177,912
2015	– 208,040
2020	– 238,164

Source: North Carolina Office of State Budget and Management 2011

6.2.2 Existing Land Use

As zoning is used as a predictor of future land use, existing land use is used to identify the current use of property. Land use surrounding MCAS New River features a wide range of uses, including residential subdivisions, hotels, restaurants, professional offices, light industrial and technology parks, and retail establishments.

Figure 6-2 identifies land uses around MCAS New River. The density of development on the properties surrounding the installation's boundary ranges from low to medium. Downtown Jacksonville is located to the north of the air station and includes low- to medium-density residential and commercial buildings. To the northwest of the air station, land use is mostly comprised of light industrial buildings, surface parking lots, commercial businesses, low-density residential areas, and mobile home parks. Along the western boundary of the air station, along Route 17 and up to Bonnyman Street, the properties immediately adjacent to the installation boundary are comprised of commercial buildings. Behind these properties, further west, land use comprises low-density residential areas. Further south, along Route 17, the land is mostly undeveloped except for a few low-density residential subdivisions.

6.2.3 Future Land Use and Proposed Development

Figure 6-3 identifies growth areas and the locations of proposed future development in the areas surrounding MCAS New River. The City of Jacksonville's Growth Management Element Plan identifies much of the land immediately to the north and west of the installation as areas of potential future growth. The city's downtown area is considered to be fully built out. However, the area immediately west of the downtown area is targeted for planned growth, and the area on the western boundary of the air station has been targeted as an area of future growth.

In addition to targeted growth areas, numerous residential subdivisions are being developed or planned along the western boundary of MCAS New River. Table 6-2 identifies some of the proposed subdivisions within the vicinity of the air station. Figure 6-3 also identifies the location of these developments.

Table 6-2
Proposed Residential Subdivisions

Figure 6-3 Identifier	Year Proposed	Subdivision Name	Proposed Number of Residential Units
1	2005	Kanton Hills Section I	63
2	2006	Dawson Place Sections I and III	170
3	2006	Liberty Hills Section	26
4	2006	Magnolia Grove	90
5	2006	Sewell Fields (located in FPOD)	29
6	2006	Fieldstone at Haws Run	182
7	2007	Thompson Farms	105
8	2007	Grizzly Acres	14

Source: Sizemore 2007

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\L:\Buffalo\New_River\Maps\MXD\Draft_AICUZ\January_2009\Figure 4-1 2009 Noise Contours Rev01.mxd

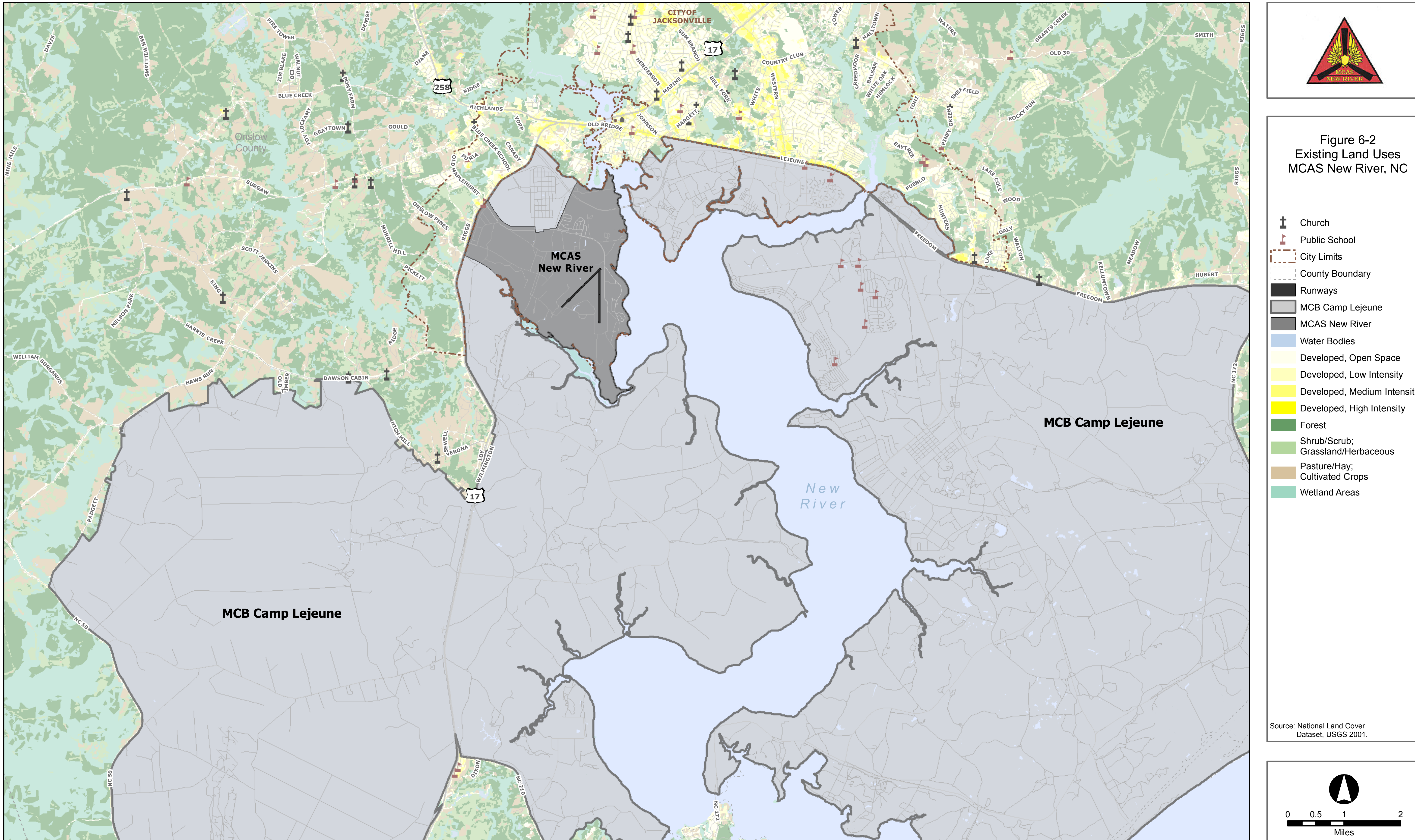

Figure 6-2
Existing Land Uses
MCAS New River, NC

Source: National Land Cover Dataset, USGS 2001.

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\L:\Buffalo\New_River\Maps\MXD\Draft_AICUZ\January_2009\Figure 4-1 2009 Noise Contours Rev01.mxd

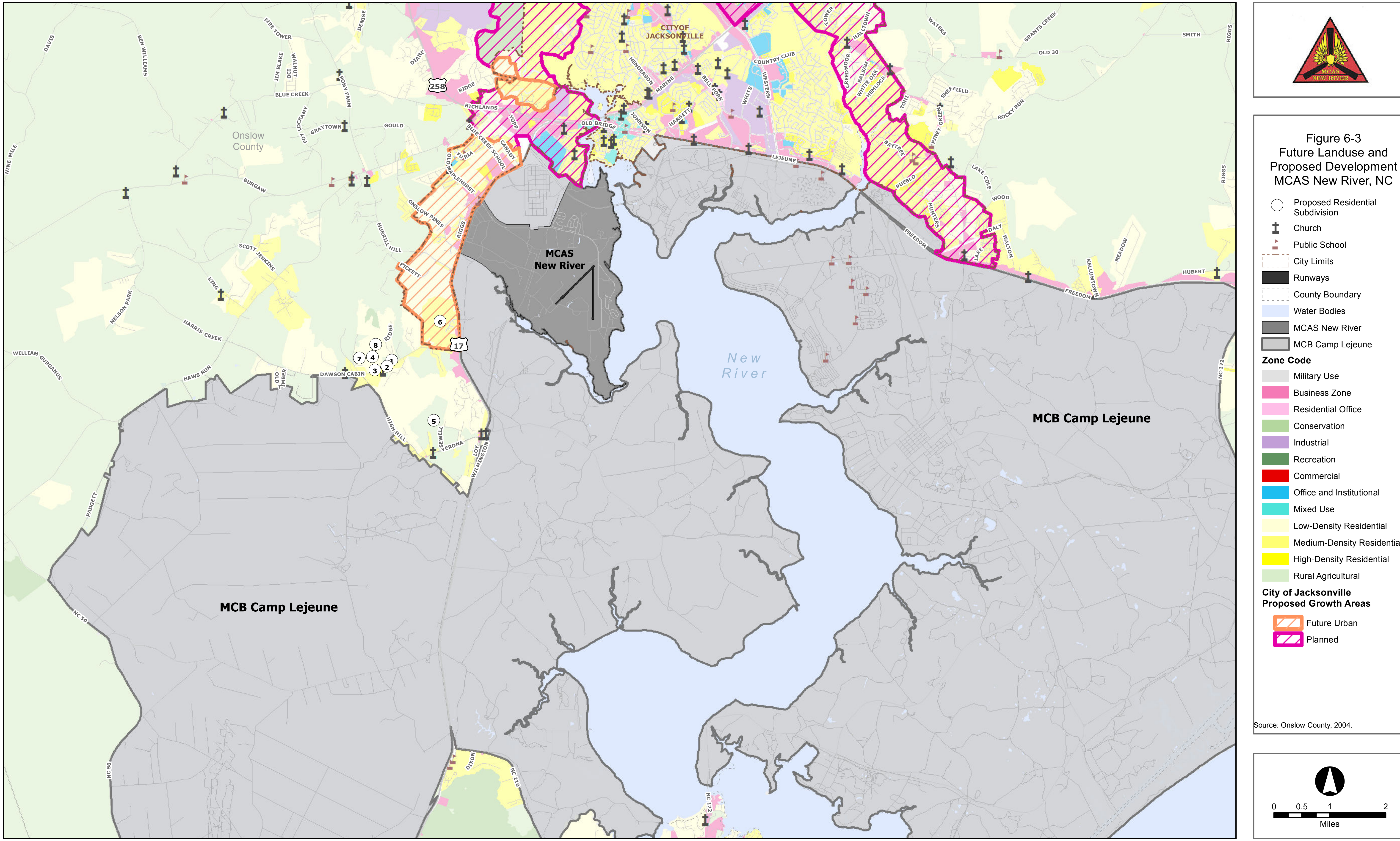

Figure 6-3
Future Landuse and Proposed Development
MCAS New River, NC

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6.3 AICUZ Composite Map

The 2011 AICUZ composite map (and information derived from the map) is the fundamental tool necessary for implementing the AICUZ Program. The AICUZ composite map is defined as the area contained within the noise zones and APZs. The AICUZ composite map identifies the recommended minimum acceptable 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 defense flying mission. In order to provide long-term protection from encroachment, local governments are encouraged to provide additional land use controls for properties outside the AICUZ composite based on local economic and social concerns. The 2011 AICUZ composite map is provided on Figure 6-4.

6.4 Land-Use Compatibility Guidelines and Classifications

The U.S. Marine Corps has developed land-use compatibility guidelines for noise zones and APZs. These recommendations, which are found in OPNAVINST 11010.36C/MCO 11010.16, Air Installations Compatible Use Zones Program, are intended to serve as guidelines for placement of noise zones and APZs and for development of land uses around military air installations (U.S. Navy 2008). The guidelines assume noise-sensitive land uses (e.g., houses, churches, schools) will be placed outside high-noise zones, and people-intensive uses (e.g., apartments, theaters) will not be placed in APZs. Certain land uses are considered incompatible with high-noise zones and APZs, while other land uses may be considered compatible. The land-use compatibility analysis conducted for MCAS New River was based on the Marine Corps' land-use compatibility recommendations, which are presented in Appendix A. In addition, Table 6-3 shows existing generalized land-use classifications and the associated land-use compatibility with each land use designation for noise zones and APZs.

Table 6-3
Land Use Classifications and Compatibility Guidelines

	Land Use Compatibility with Noise Zone (DNL)						Land Use Compatibility with APZs		
	Noise Zone 1		Noise Zone 2		Noise Zone 3				
	<55	55-64	65-69	70-74	75-79	>80	Clear Zone	APZ I	APZ II
Single-unit, detached (residential)									(1)
Apartment, walk-up (residential)									
Public Assembly									
Educational Services			(2)	(2)					
Business Services				(2)	(2)				(3)
Parks								(4)	(4)

Source: Adapted from OPNAVINST 11010.36C

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

(1) = Maximum density of1-2 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 of 0.22 in APZ II
(4) = Facilities must be low intensity.

Key:
Compatible
Incompatible

6.5 Compatibility Concerns at MCAS New River

The AICUZ Program provides a means to promote land use compatibility around MCAS New River. Based on this AICUZ study and an analysis of the noise exposure contours and APZs, zoning and land use areas of potential concern can be identified and recommendations can be made to protect the health and safety of the public and the military's flying mission.

The 2011 AICUZ composite map is almost entirely located within the boundaries of MCAS New River and MCB Camp Lejeune. No major compatibility concerns have been identified through this analysis. However, three arms of the 60 to 64 DNL (2,572 acres) and 65 to 69 DNL (22 acres) noise contours extend over the western, northeastern, and southern property lines of MCAS New River and MCB Camp Lejeune. The three arms are illustrated on Figure 6-5 and are identified as:

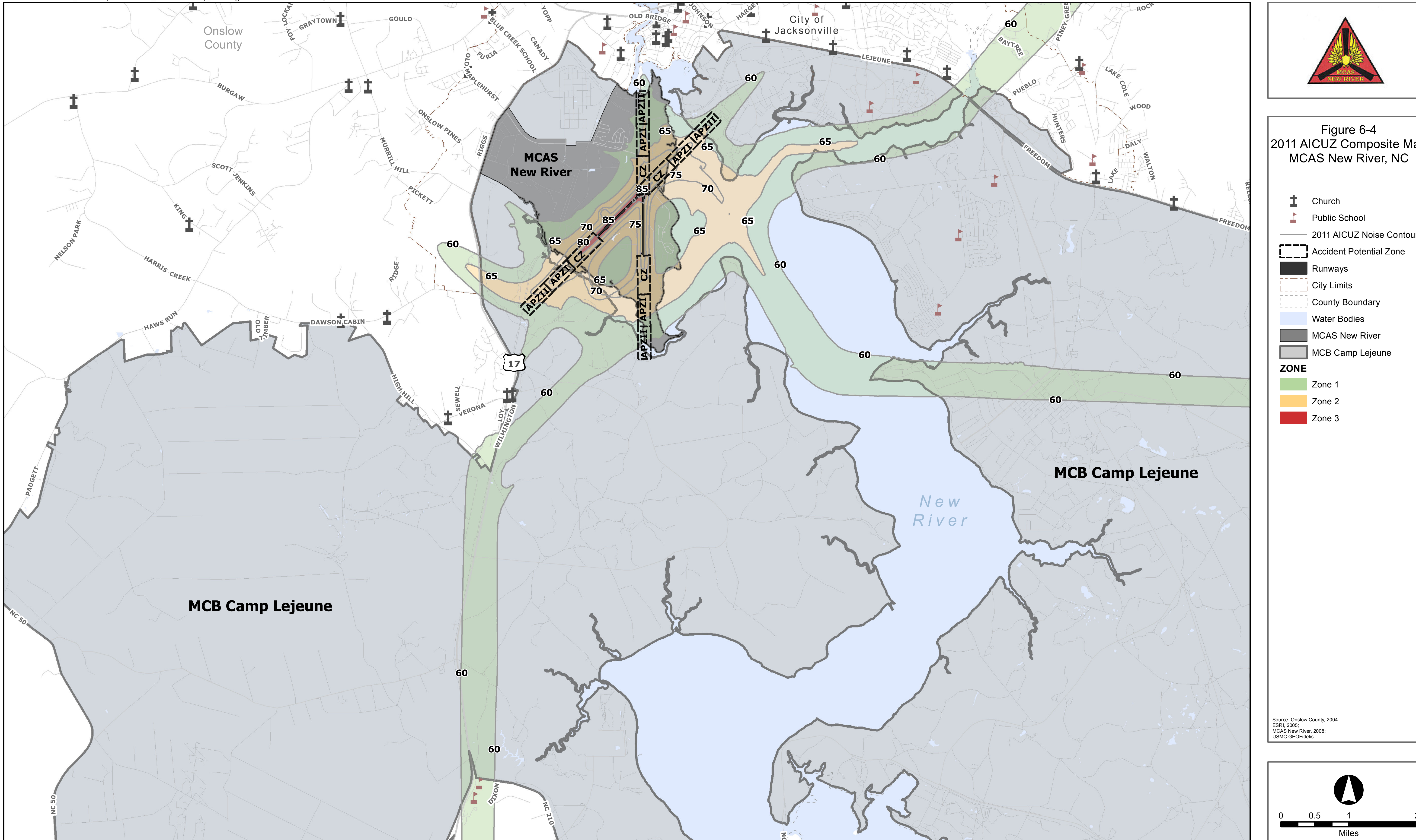

Figure 6-4
2011 AICUZ Composite Map
MCAS New River, NC

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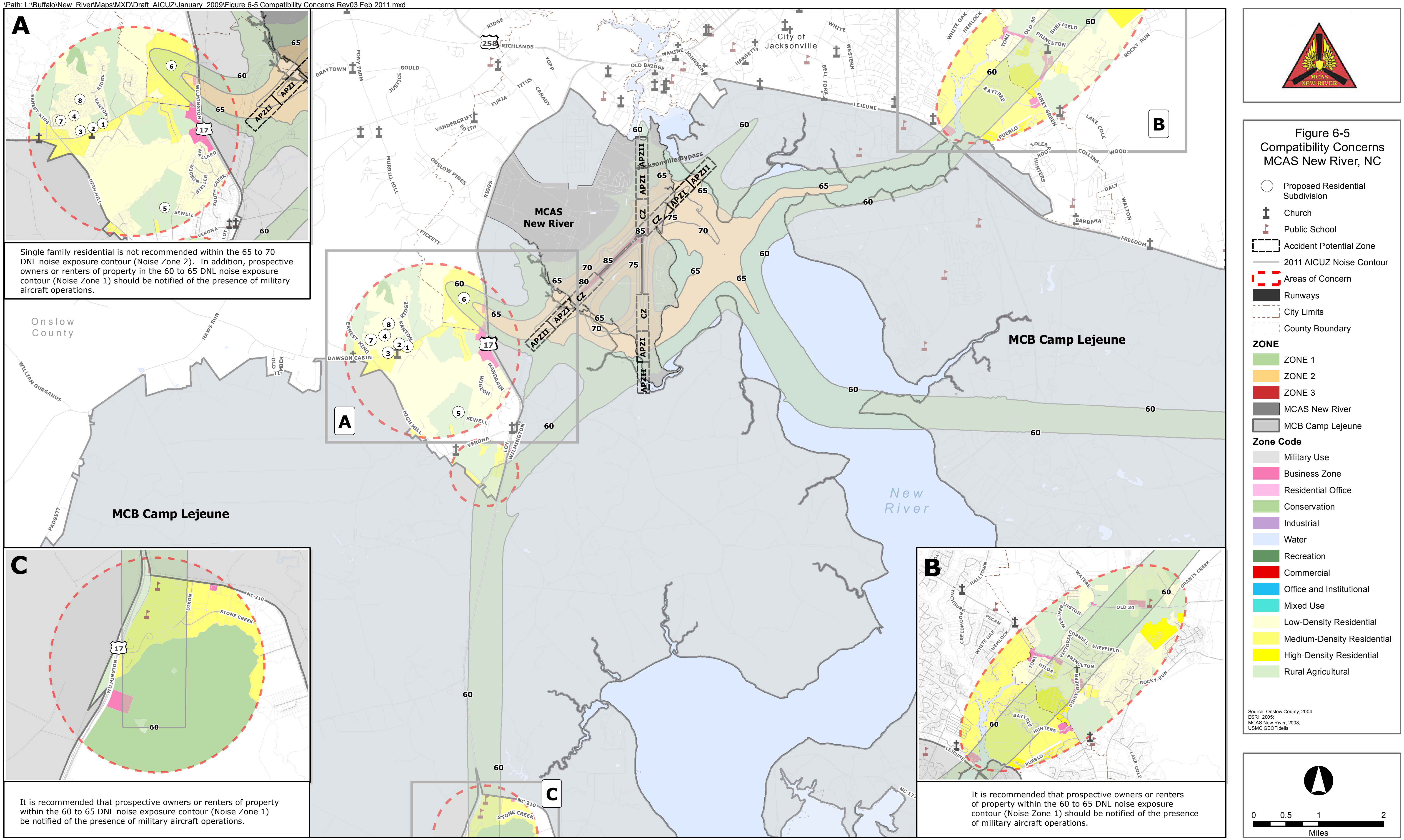
Figure 6-5
Compatibility Concerns
MCAS New River, NC
Proposed Residential Subdivision
Church
Public School
Accident Potential Zone
2011 AICUZ Noise Contour
Areas of Concern
Runways
City Limits
County Boundary
ZONE
ZONE 1
ZONE 2
ZONE 3
MCAS New River
MCB Camp Lejeune
Zone Code
Military Use
Business Zone
Residential Office
Conservation
Industrial
Water
Recreation
Commercial
Office and Institutional
Mixed Use
Low-Density Residential
Medium-Density Residential
High-Density Residential
Rural Agricultural
Source: Onslow County, 2004
ESRI, 2005;
MCAS New River, 2008;
USMC GEOFidelis
0 0.5 1 2
Miles
MCAS New River
MCB Camp Lejeune
City of Jacksonville
Onslow County
New River
A
B
C
Single family residential is not recommended within the 65 to 70 DNL noise exposure contour (Noise Zone 2). In addition, prospective owners or renters of property in the 60 to 65 DNL noise exposure contour (Noise Zone 1) should be notified of the presence of military aircraft operations.
It is recommended that prospective owners or renters of property within the 60 to 65 DNL noise exposure contour (Noise Zone 1) be notified of the presence of military aircraft operations.
It is recommended that prospective owners or renters of property within the 60 to 65 DNL noise exposure contour (Noise Zone 1) should be notified of the presence of military aircraft operations.

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- **Point A -** includes segments of the 60 to 64 DNL (Noise Zone 1) and 65 to 69 DNL (Noise Zone 2) noise contours that extend over the western edge of the air station property line, above Dawson Cabin Road, in an area that is zoned for residential and business land uses. The area is also heavily targeted for future residential development (Fieldstone at Haws Run). Residential development within the 60 to 64 DNL noise contour (Noise Zone 1) is compatible with the AICUZ Program. However, residential land uses are not recommended or compatible within the 65 to 69 DNL noise zone (a portion of Noise Zone 2). Business land uses are compatible within both Noise Zone 1 and 2. Under the AICUZ Program, it is recommended that owners or renters of property within the 60 to 64 DNL noise zone (Noise Zone 1) be notified of the presence of military aircraft operations.

- **Point B** – includes segments of the 60 to 64 DNL (Noise Zone 1) noise zone that extends over the northeastern boundary of MCB Camp Lejeune, over Piney Green Road, south of Race Track Road in an area zoned for residential, business, and agricultural land uses. Residential development within the 60 to 64 DNL noise zone (Noise Zone 1) is compatible with the AICUZ Program. Business and agricultural land uses are also compatible within Noise Zone 1. Under the AICUZ Program, it is recommended that owners or renters of property within the 60 to 64 DNL noise zone (Noise Zone 1) be notified of the presence of military aircraft operations.

- **Point C** – includes segments of the 60 to 64 DNL (Noise Zone 1) noise zone that extends over the southern boundary of MCB Camp Lejeune, in the vicinity of Dixon School Road. The area is zoned for residential, business, and agricultural land uses. Two public schools (Dixon Middle School and Dixon High School) are also located within this area. Residential, business, and agricultural land uses within the 60 to 64 DNL noise zone (Noise Zone 1) are compatible with the AICUZ Program. In addition, educational services (schools) are also compatible land uses within Noise Zone 1. Under the AICUZ Program, it is recommended that owners or renters of property within the 60 to 64 DNL noise exposure zone (Noise Zone 1) be notified of the presence of military aircraft operations.

MCAS New River's APZs, including clear zones, are also mostly located within the boundaries of MCAS New River and MCB Camp Lejeune. The only exception is a 2.9-acre area located at the northern tip of Runway 19's APZ II. This small area is located over the New River, which is a naturally occurring water body and thus a compatible use for APZ II.

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7 AICUZ Recommendations and Strategies

The goal of the AICUZ Program is to prevent land-use incompatibility, implement the AICUZ study recommendations, protect public health and safety, and safeguard the military's flying mission. Implementing the AICUZ Program at the local level and preventing incompatible land development is the responsibility of many, including the U.S. Marine Corps and Navy, local governments, private citizens, real estate professionals, and land use developers.

MCAS New River and local government agencies with planning and zoning authority share the responsibility for preserving land-use compatibility near the air station. However, cooperative action by all involved parties is essential to prevent land-use incompatibility, implement the AICUZ study recommendations, protect public health and safety, and safeguard the military flying mission.

This section provides a series of recommendations and strategies that can be used by the installation, local government officials, planners, community members, and others to implement the AICUZ Program. The goal is to encourage local, state, and federal governments to coordinate their encroachment prevention efforts and to implement appropriate land use regulations and other actions to prevent incompatible development around military airfields and to mitigate noise impacts.

7.1 AICUZ Recommendations and Implementation

The following recommendations have been made to facilitate implementation of MCAS New River's AICUZ Program, minimize the impact of aircraft operations on the community, and prevent encroachment.

7.1.1 MCAS New River

Release AICUZ Study to the Public

This AICUZ study will be released to local and state governments and provided to community groups. The AICUZ Program is the installation's defining statement regarding the impact of missions on the surrounding community. In addition, information about the AICUZ Program will be posted on MCAS New River's public Web site (http://www.newriver.usmc.mil/).

Operational Alternatives

Operations will be continually reviewed to identify new operational changes in an effort to reduce noise impacts from aircraft operations and enhance public safety.

Off-station developments that can affect operational integrity include:

- Capital improvement projects
- Building code changes
- Comprehensive plan and zoning changes
- Community facility construction
- Approvals for subdivisions and site plans
- Transportation and infrastructure improvement projects

Cooperate in the Land Use Planning Process

MCAS New River will continue to work with and encourage cooperative land use planning between the installation, the City of Jacksonville, and Onslow County so that future community growth and development are compatible with military air operations. In addition, the installation will encourage local governments to incorporate the AICUZ recommendations identified in Section 7.1.2.

MCAS New River will also continue to monitor proposed development beyond the AICUZ noise contours, APZs, and the installation property, and, if needed, present any concerns on proposed development in the appropriate local forums. Although the emphasis of the AICUZ Program is on the areas within the AICUZ composite map, MCAS New River will, when appropriate, comment on land use issues outside of the air stations boundary that might impact operations. Development that occurs up to the air station's boundary could prevent mission changes or expansion in the future. Records of important discussions with and before local officials will be maintained.

Community Plans & Liaison Officer

MCAS New River will continue to maintain a Community Plans & Liaison Officer (CP&LO) to assist in the implementation of the AICUZ Program and act as spokesperson for the Command in AICUZ matters that involve the community. The CP&LO's responsibilities include working with and ensuring accurate and consistent responses to the public regarding the AICUZ Program.

Community Outreach

Successful implementation of the AICUZ Program depends on a close working relationship between the installation and community leaders. Efforts will be made to implement the AICUZ Program at the local level, including coordinating with federal, state, and local officials to maintain public awareness of the AICUZ Program and encourage land use that is compatible with aircraft operations. In addition, opportunities to build partnerships with the surrounding community to protect land around MCAS New River will be encouraged.

Outreach activities should continually inform local governments, realtors, developers, citizen groups, and the general public on the following:

- The AICUZ Program,
- The requirements of military aviation,
- Air installation operations,
- The efforts underway and planned to reduce noise and ensure compatible development, and
- The local Command's position on specific land use issues.

MCAS New River representatives will continue to take every opportunity to work with and share information with the community on the AICUZ Program, including meeting with and making presentations to local governments, particularly the planning and zoning agencies.

AICUZ Education Programs

A local AICUZ education program will be developed to educate community decision makers, including local planning commissions, city councils, county legislatures, government councils, and other interested parties. Materials for the program may include videos, poster boards, an electronic or slide presentation, and fact sheets. The program would provide an opportunity to inform individuals or groups who make land use decisions (e.g., regarding infrastructure siting, schools, and zoning changes) on AICUZ issues, the installation's contribution to the local economy, and the need for responsible land use planning.

In addition, installation personnel are encouraged to attend Chief of Naval Operations (CNO) -sponsored AICUZ seminars to increase their awareness of current trends and techniques for AICUZ Program development and implementation.

Continue to Maintain Noise Complaint Hotline

MCAS New River will continue to collect, document, and research noise complaints. All noise complaints are investigated by the MCAS New River Operations staff, and corrective actions are taken, as appropriate. Noise complaint procedures for MCAS New River are established in the installation's Air Operations Manual. All complaints will be collected in a standard format for plotting locations in a spatial database for future planning use. Recording these complaints can help to:

- Provide land use planning information for local governments,
- Determine which operational flight tracks may be responsible for the noise complaint and at what time most complaints occur, and
- Provide valuable information for real estate transactions.

On-Station Implementation

Development strategies and capital improvement projects at MCAS New River will be consistent with the recommendations/guidelines contained within this AICUZ study.

7.1.2 Local and State Governments

Communication

While it is MCAS New River's responsibility to inform and educate community decision makers about the AICUZ Program, community decision makers should continue to actively inform and seek input from MCAS New River regarding land use decisions that potentially could affect the operational integrity of the installation. Local governments should share information regarding proposed major developments within their jurisdiction and of developments in the vicinity of the installation.

To communicate with the public, local government Web sites should provide a link to the MCAS New River Web site (http://www.newriver.usmc.mil/) for information on aircraft operations and the MCAS New River AICUZ Program.

Adopt AICUZ Study Recommendations

Local governments are encouraged to adopt and implement all or parts of the AICUZ study, including amending their comprehensive plan and zoning ordinances to be consistent with the AICUZ composite map and recommended compatible land uses. The study is the installation's defining statement regarding the impact of the installation on the surrounding community. The AICUZ Program is intended to support local government land use planning programs and processes by providing scientifically based technical information on military activities.

Land use plans should consider:

- Accident potential zones (APZs)
- Noise zones
- Military training routes
- Transportation needs
- Open space conservation
- Population growth

Regulate Land Uses within Identified Noise Zones and APZs

Encroachment is mostly a conflict between military and civilian land uses. To minimize these impacts, local planning tools can be used to encourage compatible development and discourage incompatible development around the installation's fence line or under any of the flight operational areas. A comprehensive zoning map amendment designed to prevent encroachment can be one of the strongest tools available to local governments to synchronize the plan's land use recommendations with the zoning code and official zoning map.

Sound Insulation
Exterior noise can have a significant impact on human activity, health, and safety. Noise may be isolated and reduced in homes and working environments through the application of standard construction techniques that selectively increase the insulating quality of the exterior of occupied structures.

Local Development Review

Local governments should invite a representative of the installation to participate on the local development review staff team as a way to integrate the military's missions with the local government's planning and development review processes. The military is a major stakeholder in the community, and its input is needed if decision makers are to consider the full impact of a development proposal on all stakeholders. The review process presents an opportunity for a military representative to work with a local government's development review team to identify issues and opportunities associated with the development application.

Capital Improvement

Capital improvements projects, such as potable water lines, sewage transmission lines, road paving and/or improvements, new right-of-way acquisition, and schools can be used to direct growth and types of growth toward areas compatible with the AICUZ Program. It is recommended all capital improvement projects in proximity to the installation be evaluated and reviewed for potential direct and indirect impacts with installation operations.

Building Codes

Local building codes should be reviewed and/or modified to incorporate sound insulation requirements in building codes for new construction and renovation projects located within high noise zones. Although this tool will not prevent incompatible development, building codes can ensure compatibility to the greatest extent practicable. Recommended sound insulation techniques can be found in the Department of the Navy's *Guidelines for Sound Insulation of Residences Exposed to Aircraft Operations, April 2005*. These guidelines are available online at http://www.wyle.com/services/arc/documentlibrary/federalandlocalguidanceonoise.html.

Real Estate Disclosure

Local governments should consider requiring that an AICUZ-specific disclosure be completed for all real estate transactions. Real estate disclosures allow prospective buyers, lessees, or renters of property in the vicinity of military operation areas to make informed decisions regarding the purchase or lease of property. The purpose is to protect the seller, real estate agent, buyer, local jurisdiction, and military. Disclosure of the 2011 AICUZ composite map is a very important tool in informing the community about expected impacts of aviation noise and location of airfield safety zones, subsequently reducing frustration and anti-airport criticism by those who were not adequately informed prior to purchase of properties within impact areas. Where a local jurisdiction may not have the authority to require real estate disclosure, State legislation may be required.

Public Land Acquisition and Purchase/Transfer of Development Rights Programs

Land acquisition programs and purchase/transfer of property development rights programs should be reviewed to determine whether they can be used in support of the AICUZ Program.

7.1.3 Private Citizens/Real Estate Professionals/Lending Institutions/Developers

Private Citizens

Private citizens can help meet the goals of the AICUZ Program by becoming informed about the AICUZ Program at MCAS New River 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.

Real Estate Professionals

To help implement the AICUZ Program, real estate professionals should:

- To the greatest extent possible, make prospective purchasers, renters, or lessees aware of the potential magnitude of noise exposures they may experience;
- Provide written disclosure to prospective purchasers, renters, or lessees when a property is located within an APZ or noise zone; and
- Provide an AICUZ brochure or other AICUZ information to prospective purchasers, renters, or lessees.

Lending Institutions

Lending institutions can limit financing for real estate purchases or construction incompatible with the AICUZ Program by restricting or prohibiting mortgage and/or other types of loans.

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

Builders and Developers

Properties should be developed in a manner that appropriately protects building occupants (e.g., by construction of structures that are compatible with aircraft operations).

7.2 Federal Tools and Programs to Prevent Encroachment

In addition to the specific recommendations mentioned above, the following planning tools are available to help prevent encroachment.

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 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, which is more limited in scope than an EIS. The environmental review process represents a procedure for incorporating the elements of the AICUZ into the planning review process.

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

As a result of the Intergovernmental Cooperation Act of 1968, the U.S. Office of Management and Budget (formally the Bureau of the 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.

U.S. General Services Administration (GSA) Federal Management Circular 75-2

This circular allows the base 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 the base.

Housing and Urban Development (HUD) Circular 1390.2

Approvals of mortgage loans from the Federal Housing Administration are subject to requirements of this HUD circular. The circular sets forth a discretionary policy to withhold funds for housing projects when noise exposure exceeds prescribed levels. Residential construction may be permitted within the 65 DNL noise contour, provided sound attenuation is accomplished. However, the added construction expense of noise attenuation may make siting in these noise exposure areas financially less attractive. Because the HUD policy is discretionary, variances may also be permitted, depending on regional interpretation and local conditions. HUD also has a policy that prohibits funding for projects in clear zones and APZs unless the project is compatible with the AICUZ land use guidelines.

DoN Encroachment Partnering Program

Title 10, U.S.C. § 2684a authorizes the Secretary of Defense or the Secretary of a military department to enter into agreements with an eligible entity or entities to address the use or development of real property in the vicinity of, or ecologically related to, a military installation or military airspace, to limit encroachment or 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 Agreements provide for an eligible entity to acquire fee title, or a lesser interest, in land for the purpose of limiting encroachment on the mission of a military installation and/or to preserve habitat off the installation to relieve current or anticipated environmental restrictions that might interfere with military operations or training on the installation. DoN can share the real estate acquisition costs for projects that support the fee simple, or acquisition of a conservation or other restrictive easement for such property. The eligible entity negotiates and acquires the real estate interest from a voluntary seller. The eligible entity must transfer the agreed upon restrictive easement interest to the United States of America upon request of the Secretary.

Encroachment Control Program

In addition to the Joint Land Use Study and the AICUZ Study, an installation can develop an Encroachment Control Program (ECP). The ECP is implemented at the installation level with the purpose of identifying and managing encroachment issues. An ECP includes the following activities:

- Assignment of personnel to monitor encroachment issues.

- Maintain an open dialogue with local officials concerning on- and off-station activities.
- Maintain a dialogue among on-station staff to identify potential encroachment threats.
- Maintain a directory of key agencies and individuals that have responsibilities for planning, reviewing, and approving land use and development.
- Provide representation, as appropriate, at meetings or hearings and provide input on topics of Marine Corps interest.
- Maintain files of all relevant on-station and community planning documents (e.g., tax maps, zoning plans, master plans, etc.).
- Provide appropriate advance notice to surrounding communities of Marine Corps operations which are anticipated to draw complaints.
- Provide information on the installations encroachment concerns and prevention measures to tenant organizations.

More information about the ECP can be found in Marine Corps Order 11011.22B, Encroachment Control (U.S. Marine Corps 2010a).

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Appendix A

Land-Use Compatibility Recommendations

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Table A-1
Land-Use Compatibility Recommendations – Noise Zones

		Suggested Land Use Compatibility						
		Noise Zone 1 (DNL)		Noise Zone 2 (DNL)		Noise Zone 3 (DNL)		
SLUCM No.	**Land Use**	**<55**	**55-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
10	**Residential**							
11	Household units	Y	Y[1]	N[1]	N[1]	N	N	N
11.11	Single units, detached	Y	Y[1]	N[1]	N[1]	N	N	N
11.12	Single units, semi-detached	Y	Y[1]	N[1]	N[1]	N	N	N
11.13	Single units, attached row	Y	Y[1]	N[1]	N[1]	N	N	N
11.21	Two units, side by side	Y	Y[1]	N[1]	N[1]	N	N	N
11.22	Two units, one above the other	Y	Y[1]	N[1]	N[1]	N	N	N
11.31	Apartments, walk up	Y	Y[1]	N[1]	N[1]	N	N	N
11.32	Apartments, elevator	Y	Y[1]	N[1]	N[1]	N	N	N
12	Group quarters	Y	Y[1]	N[1]	N[1]	N	N	N
13	Residential hotels	Y	Y[1]	N[1]	N[1]	N	N	N
14	Mobile home parks or courts	Y	Y[1]	N	N	N	N	N
15	Transient lodgings	Y	Y[1]	N[1]	N[1]	N[1]	N	N
16	Other residential	Y	Y[1]	N[1]	N[1]	N	N	N
20	**Manufacturing[3]**							
21	Food and kindred products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
22	Textile mill products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
23	Apparel and other finished products made from fabrics, leather, and similar materials; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
24	Lumber and wood products (except furniture); manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
25	Furniture and fixtures; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
26	Paper and allied products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
27	Printing, publishing, and allied industries	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
28	Chemicals and allied products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
29	Petroleum refining and related industries	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
31	Rubber and misc. plastic products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
32	Stone, clay, and glass products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
33	Primary metal products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
34	Fabricated metal products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
35	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks	Y	Y	Y	25	30	N	N
39	Miscellaneous manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
40	**Transportation, Communication, and Utilities[3,6]**							
41	Railroad, rapid rail transit, and street railway transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
42	Motor vehicle transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
43	Aircraft transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
44	Marine craft transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N

Table A-1
Land-Use Compatibility Recommendations – Noise Zones

SLUCM No.	Land Use	Suggested Land Use Compatibility						
		Noise Zone 1 (DNL)		Noise Zone 2 (DNL)		Noise Zone 3 (DNL)		
		<55	55-64	65-69	70-74	75-79	80-84	85+
45	Highway and street right-of-way	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
46	Automobile parking	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
47	Communication	Y	Y	Y	25[5]	30[5]	N	N
48	Utilities	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
48.5	Solid waste disposal (landfills, incineration, etc.)							
49	Other transportation, communication, and utilities	Y	Y	Y	25[5]	30[5]	N	N
50	**Trade**							
51	Wholesale trade	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
52	Retail trade – building materials, hardware, and farm equipment	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
53	Retail trade – shopping centers	Y	Y	Y	25	30	N	N
54	Retail trade – food	Y	Y	Y	25	30	N	N
55	Retail trade – automotive, marine craft, aircraft, and accessories	Y	Y	Y	25	30	N	N
56	Retail trade – apparel and accessories	Y	Y	Y	25	30	N	N
57	Retail trade – furniture, home furnishings, and equipment	Y	Y	Y	25	30	N	N
58	Retail trade – eating and drinking establishments	Y	Y	Y	25	30	N	N
59	Other retail trade	Y	Y	Y	25	30	N	N
60	**Services**							
61	Finance, insurance, and real estate services	Y	Y	Y	25	30	N	N
62	Personal services	Y	Y	Y	25	30	N	N
62.4	Cemeteries	Y	Y	Y	Y[2]	Y[3]	Y[4,11]	Y[6,11]
63	Business services	Y	Y	Y	25	30	N	N
63.7	Warehousing and storage services	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
64	Repair services	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
65	Professional services	Y	Y	Y	25	30	N	N
65.1	Hospitals, other medical facilities	Y	Y[1]	25	30	N	N	N
65.16	Nursing homes	Y	Y	N[1]	N[1]	N	N	N
66	Contract construction services	Y	Y	Y	25	30	N	N
67	Governmental services	Y	Y[1]	Y[1]	25	30	N	N
68	Educational services	Y	Y[1]	25	30	N	N	N
69	Miscellaneous services	Y	Y	Y	25	30	N	N
70	**Cultural, Entertainment, and Recreational**							
71	Cultural activities (including churches)	Y	Y[1]	25	30	N	N	N
71.2	Nature exhibits	Y	Y[1]	Y[1]	N	N	N	N
72	Public assembly	Y	Y[1]	Y	N	N	N	N
72.1	Auditoriums, concert halls	Y	Y	25	30	N	N	N
72.11	Outdoor music shells, amphitheaters	Y	Y[1]	N	N	N	N	N
72.2	Outdoor sports arenas, spectator sports	Y	Y	Y[7]	Y[7]	N	N	N
73	Amusements	Y	Y	Y	Y	N	N	N
74	Recreational activities (including golf courses, riding stables, water recreation)	Y	Y[1]	Y[1]	25	30	N	N

Table A-1
Land-Use Compatibility Recommendations – Noise Zones

SLUCM No.	Land Use	Suggested Land Use Compatibility						
		Noise Zone 1 (DNL)		Noise Zone 2 (DNL)		Noise Zone 3 (DNL)		
		<55	55-64	65-69	70-74	75-79	80-84	85+
75	Resorts and group camps	Y	Y[1]	Y[1]	Y[1]	N	N	N
76	Parks	Y	Y[1]	Y[1]	Y[1]	N	N	N
79	Other cultural, entertainment, and recreational	Y	Y[1]	Y[1]	Y[1]	N	N	N
80	**Resource Production and Extraction**							
81	Agriculture (except livestock)	Y	Y	Y[8]	Y[9]	Y[10]	Y[10,11]	Y[10,11]
81.5	Livestock farming	Y	Y	Y[8]	Y[9]	N	N	N
81.7	Animal breeding	Y	Y	Y[8]	Y[9]	N	N	N
82	Agricultural-related activities	Y	Y	Y[8]	Y[9]	Y[10]	Y[10,11]	Y[10,11]
83	Forestry activities	Y	Y	Y[8]	Y[9]	Y[10]	Y[10,11]	Y[10,11]
84	Fishing activities	Y	Y	Y	Y	Y	Y	Y
85	Mining activities	Y	Y	Y	Y	Y	Y	Y
89	Other resource production and extraction	Y	Y	Y	Y	Y	Y	Y

Source: Department of the Navy 2008

Key:

25, 30, or 35 = The numbers refer to NLR levels. Land Use and related structures generally compatible however, measures to achieve NLR or 25, 30, or 35 must be incorporated into design and construction of structures. However, measures to achieve an overall noise reduction do not necessarily solve noise difficulties outside the structure and additional evaluation is warranted. Also, see notes indicated by superscripts where they appear with one of these numbers.
CNEL = Community Noise Equivalent Level (normally within a very small decibel difference of DNL).
DNL = Day Night Average Sound Level.
Ldn = Mathematical symbol for DNL.
N (No) = Land Use and related structures are not compatible and should be prohibited.
NLR (Noise Reduction Level) = NLR (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.
N^x (No with exceptions) = The land use and related structures are generally incompatible. However, see note(s) indicated by superscript.
SLUCM = Standard Land Use Coding Manual, U.S. Department of Transportation.
Y (Yes) = Land Use and related structures compatible without restrictions.
Y^x (Yes with restrictions) = The land use and related structures are generally compatible. However, see note(s) indicated by superscript.

Notes:

1 General

a. Although local conditions regarding the need for housing may require residential use in these zones, residential use is discouraged in DNL 65 to 69 and strongly discouraged in DNL 70 to 74. The absence of viable alternative development options should be determined and an evaluation should be conducted locally prior to local 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 these uses must be allowed measures to achieve and outdoor to indoor NLR of at least 25 Decibels (dB) in DNL 65 to 69 and NLR of 30 dB in DNL 70 to 74 should be incorporated into building codes and be in individual approvals; for transient housing a NLR of at least 35 dB should be incorporated in DNL 75 to 79.

c. Normal permanent construction can be expected to provide a 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 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 noise exposure NLR particularly from ground level sources. Measures that reduce noise at a site should be used wherever practical in preference to measures that only protect interior spaces.

2 Measures to achieve NLR of 2-5 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or

Table A-1
Land-Use Compatibility Recommendations – Noise Zones

SLUCM No.	Land Use	Suggested Land Use Compatibility						
		Noise Zone 1 (DNL)		Noise Zone 2 (DNL)		Noise Zone 3 (DNL)		
		<55	55-64	65-69	70-74	75-79	80-84	85+

where the normal noise level is low.
3 Measures to achieve 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.
4 Measures to achieve 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.
5 If project or proposed development is noise sensitive, use indicated NLR; if not, land use is compatible without NLR.
6 No buildings.
7 Land use compatible provided special sound reinforcement systems are installed.
8 Residential buildings require a NLR of 25
9 Residential buildings require a NLR of 30.
10 Residential buildings not permitted.
11 Land use not recommended, but if community decides use is necessary, hearing protection devices should be worn.

Table A-2
Land-Use Compatibility Recommendations - APZs

SLUCM No.	Land Use	Suggested Land Use Compatibility[1]			
		Clear Zone	APZ I	APZ II	Density
10	**Residential**				
11	Household units				
11.11	Single units, detached	N	N	Y[2]	Max. density of 1-2 Du/Ac
11.12	Single units, semi-detached	N	N	N	
11.13	Single units, attached row	N	N	N	
11.21	Two units, side by side	N	N	N	
11.22	Two units, one above the other	N	N	N	
11.31	Apartments, walk up	N	N	N	
11.32	Apartments, elevator	N	N	N	
12	Group quarters	N	N	N	
13	Residential hotels	N	N	N	
14	Mobile home parks or courts	N	N	N	
15	Transient lodgings	N	N	N	
16	Other residential	N	N	N	
20	**Manufacturing[3]**				
21	Food and kindred products; manufacturing	N	N	Y	Max. FAR of 0.56 in APZ II
22	Textile mill products; manufacturing	N	N	Y	Max. FAR of 0.56 in APZ II
23	Apparel and other finished products made from fabrics, leather, and similar materials; manufacturing	N	N	N	
24	Lumber and wood products (except furniture); manufacturing	N	Y	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
25	Furniture and fixtures; manufacturing	N	Y	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
26	Paper and allied products; manufacturing	N	Y	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
27	Printing, publishing, and allied industries	N	Y	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
28	Chemicals and allied products; manufacturing	N	N	N	
29	Petroleum refining and related industries	N	N	N	
31	Rubber and misc. plastic products; manufacturing	N	N	N	
32	Stone, clay, and glass products; manufacturing	N	N	Y	Max. FAR of 0.56 in APZ II
33	Primary metal products; manufacturing	N	N	Y	Max. FAR of 0.56 in APZ II
34	Fabricated metal products; manufacturing	N	N	Y	Max. FAR of 0.56 in APZ II
35	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks	N	N	N	
39	Miscellaneous manufacturing	N	Y	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
40	**Transportation, Communication, and Utilities[4,5]**				
41	Railroad, rapid rail transit, and street railway transportation	N	Y[5]	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
42	Motor vehicle transportation	N	Y[5]	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
43	Aircraft transportation	N	Y[5]	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
44	Marine craft transportation	N	Y[5]	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
45	Highway and street right-of-way	N	Y[5]	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
46	Automobile parking	N	Y[5]	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II

Table A-2
Land-Use Compatibility Recommendations - APZs

SLUCM No.	Land Use	Suggested Land Use Compatibility[1]			
		Clear Zone	APZ I	APZ II	Density
47	Communication	N	Y[5]	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
48	Utilities	N	Y[5]	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
48.5	Solid waste disposal (landfills, incineration, etc.)	N	N	N	
49	Other transportation, communication, and utilities	N	Y[5]	Y	See Note 5 below.
50	**Trade**				
51	Wholesale trade	N	Y	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II
52	Retail trade – building materials, hardware, and farm equipment	N	Y	Y	See Note 6 below.
53	Retail trade[7] – shopping centers, home improvement stores, discount clubs, electronic superstores	N	N	Y	Max. FAR of 0.16 in APZ II
54	Retail trade – food	N	N	Y	Max. FAR of 0.24 in APZ II
55	Retail trade – automotive, marine craft, aircraft, and accessories	N	Y	Y	Max. FAR of 0.14 in APZ I and 0.28 in APZ II
56	Retail trade – apparel and accessories	N	N	Y	Max. FAR of 0.28 in APZ II
57	Retail trade – furniture, home furnishings, and equipment	N	N	Y	Max. FAR of 0.28 in APZ II
58	Retail trade – eating and drinking establishments	N	N	N	
59	Other retail trade	N	N	Y	Max. FAR of 0.16 in APZ II
60	**Services**				
61	Finance, insurance, and real estate services	N	N	Y	Max. FAR of 0.22 for "General Office/Office Park" in APZ II
62	Personal services	N	N	Y	Office uses only. Max. FAR of 0.22 in APZ II
62.4	Cemeteries	N	Y[9]	Y[9]	
63	Business services	N	Y	Y	Max. FAR of 0.22 in APZ II
63.7	Warehousing and storage services	N	Y	Y	Max. FAR of 1.0 in APZ I and 2.0 in APZ II
64	Repair services	N	N	Y	Max. FAR of 0.11 in APZ I and 0.22 in APZ II
65	Professional services	N	N	Y	Max. FAR of 0.22 in APZ II
65.1	Hospitals, other medical facilities	N	N	N	
65.16	Nursing homes	N	N	N	
66	Contract construction services	N	Y	Y	Max. FAR of 0.11 in APZ I and 0.22 in APZ II
67	Governmental services	N	N	Y	Max. FAR of 0.24 in APZ II
68	Educational services	N	N	N	
69	Miscellaneous services	N	N	Y	Max. FAR of 0.22 in APZ II
70	**Cultural, Entertainment, and Recreational**				
71	Cultural activities (including churches)	N	N	N	
71.2	Nature exhibits	N	Y[10]	Y[10]	
72	Public assembly	N	N	N	
72.1	Auditoriums, concert halls	N	N	N	
72.11	Outdoor music shells, amphitheaters	N	N	N	
72.2	Outdoor sports arenas, spectator sports	N	N	N	
73	Amusements (fairgrounds, miniature golf, driving ranges, amusement parks, etc.)	N	N	Y	

Table A-2
Land-Use Compatibility Recommendations - APZs

SLUCM No.	Land Use	Suggested Land Use Compatibility[1] Clear Zone	APZ I	APZ II	Density
74	Recreational activities (including golf courses, riding stables, water recreation)	N	Y[10]	Y[10]	Max. FAR of 0.11 in APZ I and 0.22 in APZ II
75	Resorts and group camps	N	N	N	
76	Parks	N	Y[10]	Y[10]	Max. FAR of 0.11 in APZ I and 0.22 in APZ II
79	Other cultural, entertainment, and recreational	N	Y[9]	Y[9]	Max. FAR of 0.11 in APZ I and 0.22 in APZ II
80	**Resource Production and Extraction**				
81	Agriculture (except livestock)	Y[4]	Y[11]	Y[11]	
81.5	Livestock farming	N	Y[11,12]	Y[11,12]	
81.7	Animal breeding	N	Y[11,12]	Y[11,12]	
82	Agricultural-related activities	N	Y[11]	Y[11]	Max. FAR of 0.28 in APZ I and 0.56 in APZ II - no activity which produces smoke, glare, or involves explosives
83	Forestry activities [13]	N	Y	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II - no activity which produces smoke, glare, or involves explosives
84	Fishing activities [14]	N[14]	Y	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II - no activity which produces smoke, glare, or involves explosives
85	Mining activities	N	Y	Y	Max. FAR of 0.28 in APZ I and 0.56 in APZ II - no activity which produces smoke, glare, or involves explosives
89	Other resource production and extraction	N	Y	Y	Max. FAR of 0.28 APZ I and 0.56 in APZ II - no activity which produces smoke, glare, or involves explosives
90	**Other**				
91	Undeveloped Land	Y	Y	Y	
93	Water Areas	N[15]	N[15]	N[15]	

Source: Adapted from Department of the Navy 2008

Key:

Du/Ac (Dwelling Units per Acre) = This metric is customarily used to measure residential densities.
FAR (Floor Area Ratio) = A floor area ratio is the ratio between the square feet of the floor area of the building and the site area. It is customarily used to measure non-residential intensities.
N (No) = Land use and related structures are not compatible and should be prohibited.
N[x] (No with exceptions) = The land use and related structures are generally incompatible. However, see note(s) indicated by superscript(s).
SLUCM = Standard Land Use Coding Manual, U.S. Department of Transportation.
Y (Yes) = Land Use and related structures compatible without restrictions.
Y[x] (Yes with restrictions) = The land use and related structures are generally compatible. However, see note(s) indicated by superscript(s).

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 FARs are provided as a guide to density in some categories. In general, land use restrictions which limit commercial, services, or.industria1 buildings or structure occupants to 25 per acre in APZ I, and 50 per acre in APZ I1 are the range of occupancy levels, including employees, considered to be low density. Outside events should normally be

Table A-2
Land-Use Compatibility Recommendations - APZs

SLUCM No.	Land Use	Suggested Land Use Compatibility[1]			
		Clear Zone	APZ I	APZ II	Density

limited to assemblies of not more that 25 people per acre in APZ I, and Maximum (Max.) assemblies of 50 people per acre in APZ 11.

2 The suggested Max. density for detached single-family housing is one to two 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 percent 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 to pilots.

4 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 UFC 3-260-01, Airfield and Heliport Planning and Design" dated 10 November 2001 for specific design details.

5 No passenger terminals and no major above ground transmission lines in APZ I.

6 Within SLUCM Code 52, Max. FARs for lumber yards (SLUCM Code 521) are 0.20 in APZ-I and 0.40 in APZ-11. For hardware/paint and farm equipment stores, SLUCM Code 525, the Max. FARs are 0.12 in APZ-I and 0.24 in APZ-11.

7 A shopping center is an integrated group of commercial establishments that is planned, developed, owned, or managed as a unit. Shopping center types include strip, neighborhood, community, regional, and super regional facilities anchored by small businesses, supermarket or drug store, discount retailer, department store, or several department stores, respectively. Included in this category are such uses as big box discount clubs, home improvement superstores, office supply superstores, and electronics superstores. The Max. recommended FAR for SLUCM 53 should be applied to the gross leasable area of the shopping center rather than attempting to use other recommended FARs listed in Table 2 under "Retail" or "Trade."

8 Low-intensity off ice uses only. Accessory uses such meeting places, auditoriums, etc., are not recommended.

9 No chapels are allowed within APZ I or APZ 11.

10 Facilities must be low intensity, and provide no tot lots, etc. Facilities such as clubhouses, meeting places, auditoriums, large classes, etc. are not recommended.

11 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.

12 Includes feedlots and intensive animal husbandry.

13 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.

14 Controlled hunting and fishing may be permitted for the purpose of wildlife management.

15 Naturally occurring water features (e.g., rivers, lakes, streams, wetlands) are compatible.

Appendix B

Discussion of Noise and Its Effect on the Environment

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B.1 Basics of Sound

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

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

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

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

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

60 dB + 60 dB = 63

dB, and 80 dB +

80 dB = 83 dB.

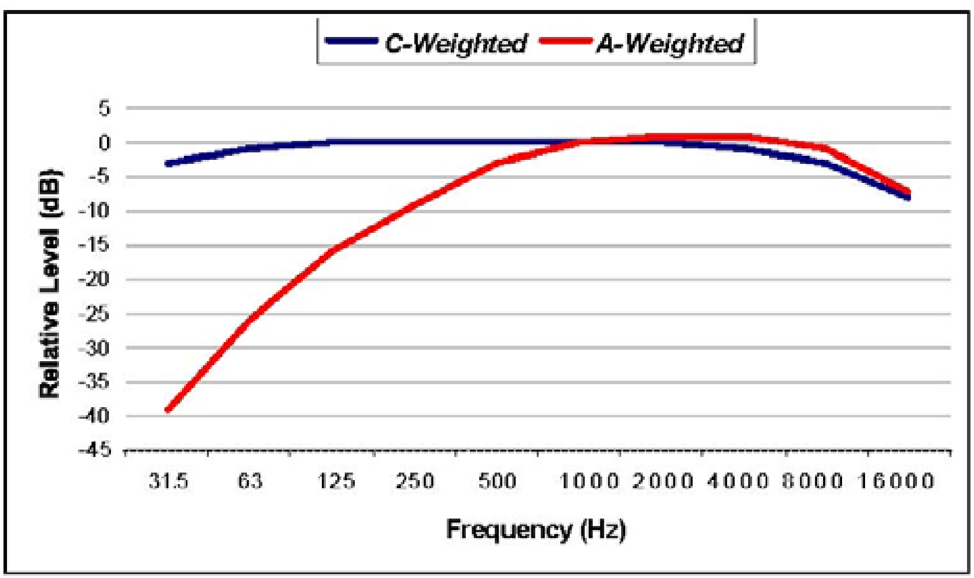
Second, the total sound level produced by two sounds of different levels is usually only slightly more than the higher of the two. For example:

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 intensity 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 (below approximately 500 Hz and above approximately 10,000 Hz) to approximate the human ear's lower sensitivities to those frequencies. C-weighting is nearly flat throughout the range of audible frequencies, hardly de- emphasizing the low frequency sound while approximating the human ear's sensitivity to higher intensity sounds. The two curves shown in Figure B-1 are also the most adequate to quantify environmental noises.



Source: ANSI S1.4 -1983 "Specification of Sound Level Meters"

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

B.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 45-50 dB (U.S. Environmental Protection Agency 1978).

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

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

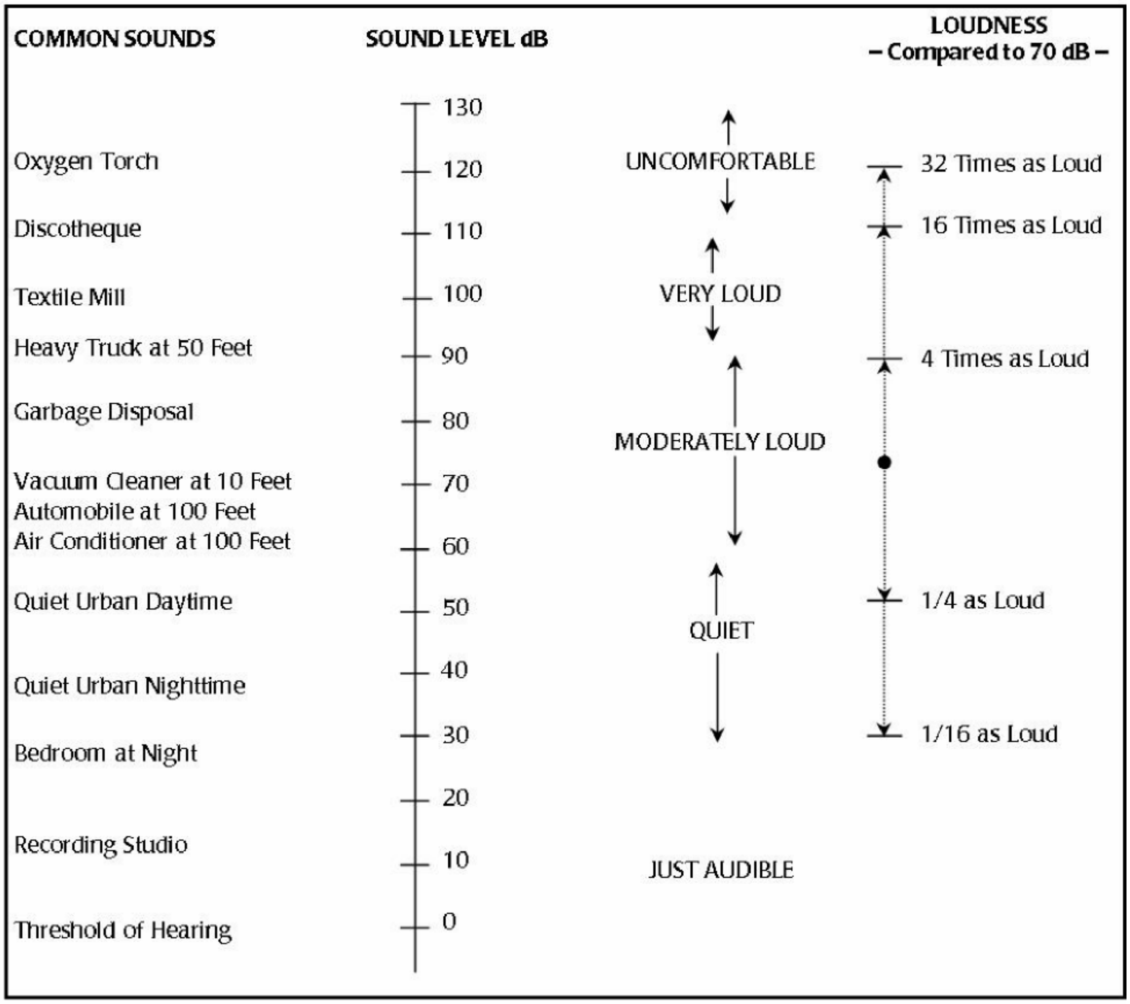
C-weighted Sound Level

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

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

<u>Impulsive Sound:</u> 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 (American National Standards Institute 1996).

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



Source: *Handbook of Noise Control*, C.M. Harris, Editor, McGraw-Hill Book Co., 1979, and FICAN 1992.

Figure B-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.

B.2 Noise Metrics

As used in environmental noise analyses, a metric refers to the unit or quantity that quantitatively measures the effect of noise on the environment. To quantify these effects, the Department of Defense and the Federal Aviation Administration use three noise-measuring techniques, or metrics: first, a measure of the highest sound level occurring during an individual aircraft overflight (single event); second, a combination of the maximum level of that single event with its duration; and third, a description of the noise environment based on the cumulative flight and engine maintenance activity. Single noise events can be described with Sound Exposure Level or Maximum Sound Level. Another measure of instantaneous level is the Peak Sound Pressure Level. The cumulative energy noise metric used is the Day/Night Average Sound Level. Metrics related to DNL include the Onset-Rate Adjusted Day/Night Average Sound Level, and the Equivalent Sound Level. In the state of California, it is mandated that average noise be described in terms of Community Noise Equivalent Level (State of California 1990). CNEL represents the Day/Evening/Night average noise exposure, calculated over a 24-hour period. Metrics and their uses are described below.

B.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.

B.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.

B.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 $_{Lmax}$ because an individual overflight takes seconds and the maximum sound level $_{(Lmax)}$ occurs instantaneously. SEL represents the best metric to compare noise levels from overflights.

B.2.4 Day-Night Average Sound Level (DNL) and Community Noise Equivalent Level (CNEL)

Day-Night Average Sound Level and Community Noise Equivalent Level are composite metrics that account for 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.

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 quantifies the total sound energy received. While it is normalized as an average, it represents all of the sound energy, and is therefore a cumulative measure.

The 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. For some military airbases, where operations are not necessarily consistent from day to day, a common practice is to compute a 24-hour DNL or CNEL based on an average busy day, 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., longterm annoyance), and particularly aircraft noise effects. In general, scientific studies and social surveys have found a high correlation between the percentages of groups of people highly annoyed and the level of average noise exposure measured in DNL (U.S. Environmental Protection Agency 1978 and Schultz 1978). The correlation from Schultz's original 1978 study is shown in Figure B-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.

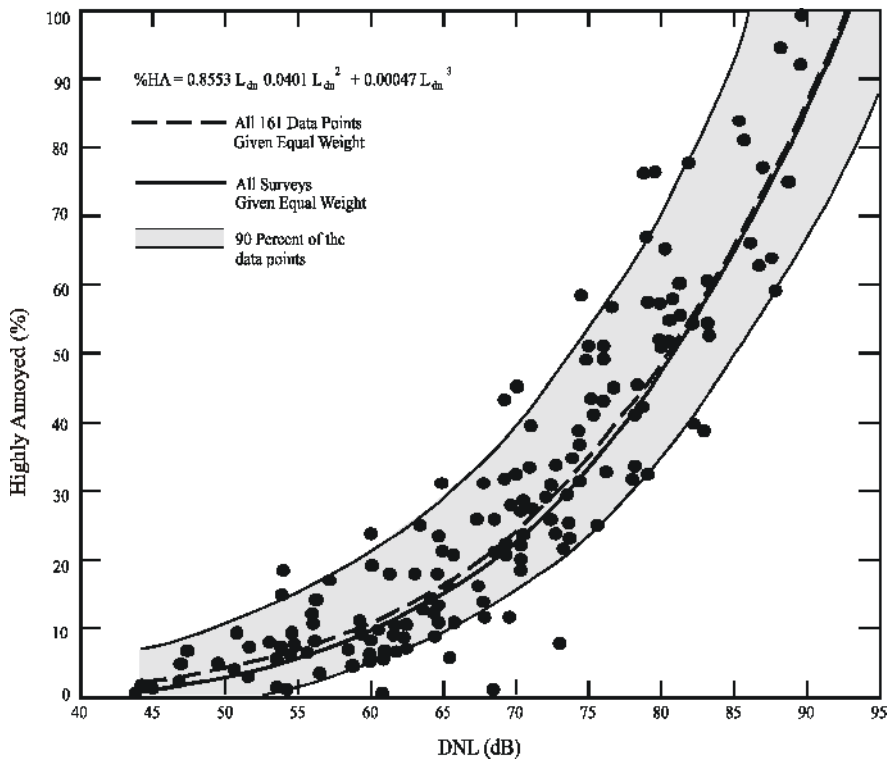


Figure B-3. Community Surveys of Noise Annoyance

A more recent study has reaffirmed this relationship (Fidell, et al. 1991). Figure B-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.

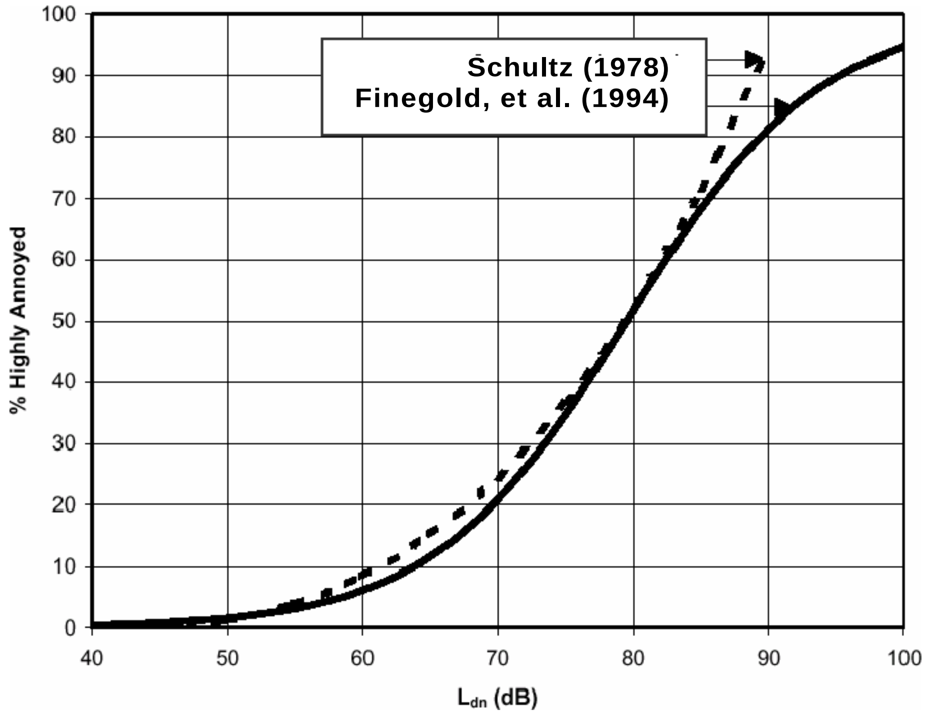


Figure B-4. Response of Communities to Noise; Comparison of Original (Schultz, 1978) and Current (Finegold, et al. 1994) Curve Fits

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.

B.2.5 Equivalent Sound Level (L_{eq})

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

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

B.2.6 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 Sound Exposure Level (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 MTR. 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 SEL_r instead of SEL. This monthly average is denoted L_{dnmr}. If onset rate adjusted DNL is computed over a period other than a month, it would be designated L_{dnr} and the period must be specified. In the state of California, a variant of the L_{dnmr} includes a penalty for evening operations (7 p.m. to 10 p.m.) and is denoted $CNEL_{mr}$.

B.3 Noise Effects

B.3.1 Annoyance

The primary effect of aircraft noise on exposed communities is one of long-term annoyance. Noise annoyance is defined by the 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 nonacoustic 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.

B.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).

Indoor speech interference can be expressed as a percentage of sentence intelligibility among two people speaking in relaxed conversation approximately 3 feet apart in a typical living room or bedroom (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 the 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.

B.3.3 Sleep Interference

Sleep interference is another source of annoyance and potential health concern associated with aircraft noise. Because of the intermittent nature and content of aircraft noise, it is more disturbing than continuous noise of equal energy. Given that quality sleep is requisite for good health, repeated occurrences of sleep interference could have an effect on overall health.

Sleep interference may be measured in either of two ways. "Arousal" represents actual awakening from sleep, while a change in "sleep stage" represents a shift from one of four sleep stages to another stage of lighter sleep without actual awakening. In general, arousal requires a somewhat higher noise level than does a change in sleep stage.

Sleep is not a continuous, uniform condition but a complex series of states through which the brain progresses in a cyclical pattern. Arousal from sleep is a function of a number of factors that include age, sex, sleep stage, noise level, frequency of noise occurrences, noise quality, and pre-sleep activity. Because individuals differ in their physiology, behavior, habitation, and ability to adapt to noise, few studies have attempted to establish noise criterion levels for sleep disturbance.

Lukas (1978) concluded the following with regard to human sleep response to noise:

- Children 5 to 8 years of age are generally unaffected by noise during sleep.
- Older people are more sensitive to sleep disturbance than younger people. Women are more sensitive to noise than men, in general.

- There is a wide variation in the sensitivity of individuals to noise even within the same age group.
- Sleep arousal is directly proportional to the sound intensity of aircraft flyover. While there have been several studies conducted to assess the effect of aircraft noise on sleep, none have produced quantitative dose-response relationships in terms of noise exposure level, DNL, and sleep disturbance. Noise-sleep disturbance relationships have been developed based on single-event noise exposure.

An analysis sponsored by the U.S. Air Force summarized 21 published studies concerning the effects of noise on sleep (Pearsons, et al. 1989). The analysis concluded that a lack of reliable studies in homes, combined with large differences among the results from the various laboratory studies, did not permit development of an acceptably accurate assessment procedure. The noise events used in the laboratory studies and in contrived in-home studies were presented at much higher rates of occurrence than would normally be experienced in the home. None of the laboratory studies were of sufficiently long duration to determine any effects of habituation, such as that which would occur under normal community conditions.

A study of the effects of nighttime noise exposure on the in-home sleep of residents near one military airbase, near one civil airport, and in several households with negligible nighttime aircraft noise exposure, revealed SEL as the best noise metric predicting noise-related awakenings. It also determined that out of 930 subject nights, the average spontaneous (not noise-related) awakenings per night was 2.07 compared to the average number of noise-related awakenings per night of 0.24 (Fidell, et al. 1994). Additionally, a 1995 analysis of sleep disturbance studies conducted both in the laboratory environment and in the field (in the sleeping quarters of homes) showed that when measuring awakening to noise, a 10 dB increase in SEL was associated with only an 8 percent increase in the probability of awakening in the laboratory studies, but only a 1 percent increase in the field (Pearsons, et al. 1995). Pearsons, et al. (1995), reported that even SEL values as high as 85 dB produced no awakenings or arousals in at least one study. This observation suggests a strong influence of habituation on susceptibility to noise-induced sleep disturbance. A 1984 study (Kryter 1984) indicates that an indoor SEL of 65 dB or lower should awaken less than 5 percent of exposed individuals.

Nevertheless, some guidance is available in judging sleep interference. The EPA identified an indoor DNL of 45 dB as necessary to protect against sleep interference (U.S. Environmental Protection Agency 1978). Assuming a very conservative structural noise insulation of 20 dB for typical dwelling units, this corresponds to an outdoor day-night average sound level of 65 dB to minimize sleep interference.

In 1997, the Federal Interagency Committee on Aviation Noise (FICAN) adopted an interim guideline for sleep awakening prediction. The new curve, based on studies in England (Ollerhead, et al. 1992) and at two U.S. airports (Los Angeles International and Denver International), concluded that the incidence of sleep awakening from aircraft noise was less than identified in a 1992 study (Federal Interagency Committee On Noise 1992). Using indoor single-event noise levels represented by SEL, potential sleep awakening can be predicted using the curve presented in Figure B-5. Typically, homes in the United States provide 15 dB of sound attenuation with windows open and 25 dB with windows closed and air conditioning operating. Hence, the outdoor SEL of 107 dB would be 92 dB indoors with windows open and 82 dB indoors with windows closed and air conditioning operating.

Using Figure B-5, the potential sleep awakening would be 15% with windows open and 10% with windows closed in the above example.

The new FICAN curve does not address habituation over time by sleeping subjects and is applicable only to adult populations. Nevertheless, this curve provides a reasonable guideline for assessing sleep awakening. It is conservative, representing the upper envelope of field study results.

The FICAN curve shown in Figure B-5 represents awakenings from single events. To date, no exact quantitative dose-response relationship exists for noise-related sleep interference from multiple events; yet, based on studies conducted to date and the USEPA guideline of a 45 DNL to protect sleep interference, useful ways to assess sleep interference have emerged. If homes are conservatively estimated to have a 20-dB noise insulation, an average of 65 DNL would produce an indoor level of 45 DNL and would form a reasonable guideline for evaluating sleep interference. This also corresponds well to the general guideline for assessing speech interference. Annoyance that may result from sleep disturbance is accounted for in the calculation of DNL, which includes a 10-dB penalty for each sortie

B.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.

B.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

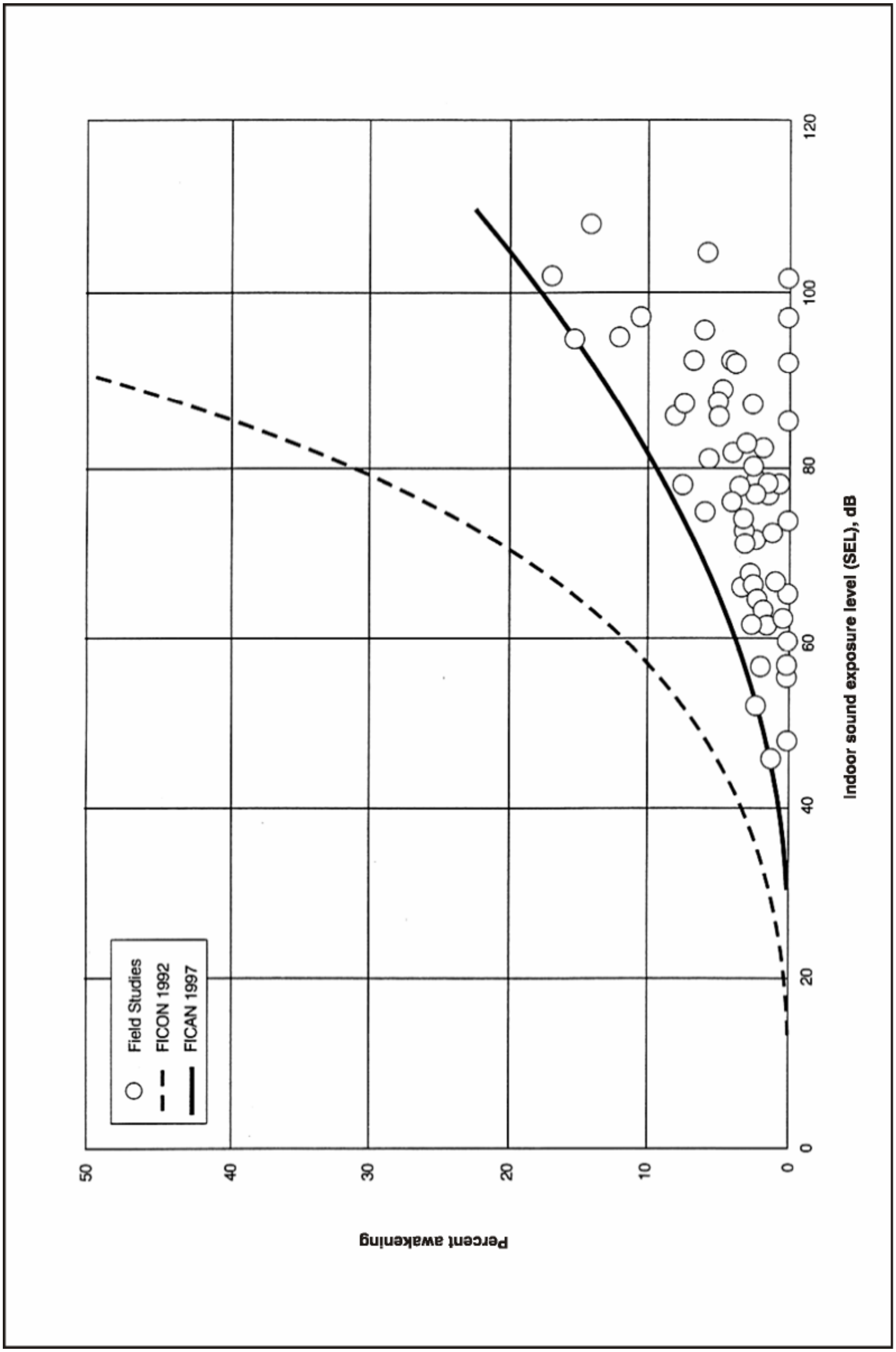


Figure B-5. Recommended Sleep Disturbance Dose-Response Relationship

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 (LA)() 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 LA)(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).

B.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.

B.3.7 Noise Effects on Children

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

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

B.3.7.1 Effects on Learning and Cognitive Abilities

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

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

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

Specifically, elementary school children attending schools near New York City's two airports demonstrated lower reading scores than children living farther away from the flight paths (Green, et al. 1982). Researchers have found that tasks involving central processing and language comprehension (such as reading, attention, problem solving, and memory) appear to be the most affected by noise (Evans and Lepore 1993; Hygge 1994; and Evans, et al. 1995). It has been demonstrated that chronic exposure of first- and second-grade children to aircraft noise can result in reading deficits and impaired speech perception (i.e., the ability to hear common, low-frequency [vowel] sounds but not high frequencies [consonants] in speech) (Evans and Maxwell 1997).

The Evans and Maxwell (1997) study found that chronic exposure to aircraft noise resulted in reading deficits and impaired speech perception for first- and second-grade children. Other studies found that children residing near the Los Angeles International Airport had more difficulty solving cognitive problems and did not perform as well as children from quieter schools in puzzle-solving and attentiveness (Bronzaft 1997; Cohen, et al. 1980). Children attending elementary schools in high aircraft noise areas near London's Heathrow Airport demonstrated poorer reading comprehension and selective cognitive impairments (Haines, et al. 2001a, b). Similarly, a study conducted by Hygge (1994) found that students exposed to aircraft noise (76 dBA) scored 20% lower on recall ability tests than students exposed to ambient noise (42-44 dBA). Similar studies involving the testing of attention, memory, and reading comprehension of schoolchildren located near airports showed that their tests exhibited reduced performance results compared to those of similar groups of children who were located in quieter environments (Evans, et al. 1995; Haines, et al. 1998). The Haines and Stansfeld study indicated that there may be some long-term effects associated with exposure, as one-year follow-up testing still demonstrated lowered scores for children in higher noise schools (Haines et al., 2001a and 2001b). In contrast, a study conducted by Hygge, et al. (2002) found that although children living near the old Munich airport scored lower in standardized reading and long-term memory tests than a control group, their performance on the same tests was equal to that of the control group once the airport was closed.

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).

B.3.7.2 Health Effects

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

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

Although the literature appears limited, 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).

B.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 is vital to understanding the long-term effects of noise on wildlife. Questions regarding the effects (if any) on predator-prey interactions, reproductive success, and intra-inter specific behavior patterns remain.

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

A great deal of research was conducted in the 1960's and 1970's on the effects of aircraft noise on the public and the potential for adverse ecological impacts. These studies were largely completed in response to the increase in air travel and as a result of the introduction of supersonic jet aircraft. According to 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.

B.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).

B.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).

B.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. 1991).

B.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.

B.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.

B.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).

B.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 1991; 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.

B.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.

B.3.8.4 Summary

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

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

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

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

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

B.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 commercial value of the property near airports; both ideas were supported by Crowley (1978). Ultimately, Newman and Beattie summarized that while an effect of noise was observed, noise is only one of the many factors that is part of a decision to move close to, or away from, an airport, but which is sometimes considered an advantage due to increased opportunities for employment or ready access to the airport itself. With all the issues associated with determining property values, their reviews found that decreases in property values usually range from 0.5 to 2 percent per decibel increase of cumulative noise exposure.

More recently Fidell et al (1996) studied the influences of aircraft noise on actual sale prices of residential properties in the vicinity of two military facilities and found that equations developed for one area to predict residential sale prices in areas unaffected by aircraft noise worked equally well when applied to predicting sale prices of homes in areas with aircraft noise in excess of 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.

B.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.

B.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.

B.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.

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