Air Installations Compatible Use Zones Study for Naval Station Norfolk Chambers Field, Norfolk, Virginia

October 2009

Prepared for:

United States Department of the Navy

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UNITED STATES DEPARTMENT OF THE NAVY
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Table of Contents

Table of Contents, continued

Table of Contents, continued

List of Tables

List of Figures

Figure **Page**

Acronyms and Abbreviations

AEDT	Aircraft Events and Disturbance Tracking
AFB	Air Force Base
AGL	above ground level
AICUZ	Air Installations Compatible Use Zones
AirOps	Air Operations
AMC	Air Mobility Command
ANSI	American National Standards Institute
AODO	Assistance Operations Duty Officer
APZ	Accident Potential Zone
ASO	Airport Safety Overlay
ATC	air traffic control
BASH	Bird/Animal Aircraft Strike Hazard
BRAC	Base Realignment and Closure
CNEL	Community Noise Exposure Level
CPLO	Community Plans and Liaison Officer
CTOL	Conventional take-off/landing
CV	Carrier variant
dB	decibels
dBA	A-weighted decibels
DNL	day-night average sound level noise metric
DoD	(United States) Department of Defense
EA	environmental assessment
EIS	environmental impact statement
EMI	Electromagnetic interference
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FCLP	field carrier landing practice
FHA	Federal Highway Administration
FICON	Federal Interagency Committee on Noise
FICUN	Federal Interagency Committee on Urban Noise
GCA	Ground Control Approach
HRPDC	Hampton Roads Planning District Commission

HRRA	Hampton Roads Realtors Association
HRTPO	Hampton Roads Transportation Planning Organization
HUD	Housing and Urban Development
IFR	Instrument Flight Rules
JLUS	Joint Land Use Study
MCAS	Marine Corps Air Station
mph	miles per hour
MSA	Metropolitan Statistical Area
MSL	mean sea level
NALF	Naval Auxiliary Landing Field
NAS	Naval Air Station
Navy	United States Department of the Navy
NEPA	National Environmental Policy Act
nm	nautical mile
NS	Naval Station
OMB	(U.S.) Office of Management and Budget
OPNAVINST	Chief of Naval Operations Instruction
R-	Restricted Area
RNM	Rotorcraft Noise Model
STOVL	Short take-off/Vertical Landing
SUA	Special Use Airspace
T&E	Test and Evaluation
TDR	Transfer of Development Rights
U.S.C.	United States Code
USDOT	United States Department of Transportation
VDOT	Virginia Department of Transportation
VFR	Visual Flight Rules
W-	Warning Area

Executive Summary

ES.1 Purpose of AICUZ Study

Executive Summary

In the early 1970s, the Department of Defense (DoD) established the Air Installations Compatibility Use Zone (AICUZ) Program to balance the need for aircraft operations and community concerns over aircraft noise and accident potential. The AICUZ Program was developed in response to growing incompatible urban development (encroachment) around military airfields. The objectives of the AICUZ Program, according to the Chief of Naval Operations Instruction (OPNAVINST 11010.36C), are:

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

The original, complete AICUZ study for NS Norfolk Chambers Field was prepared and approved in 1978, and is now outdated. AICUZ studies should be updated when an air installation has a significant change in aircraft operations, a change in the type of aircraft stationed and operating at the installation, or changes in flight paths or procedures. Noise contours for NS Norfolk Chambers Field were updated in 1999 and incorporated into the 2005 Hampton Roads Joint Land Use Study (JLUS). This AICUZ study compares the 1999 noise contours (not part of an AICUZ study) to new 2009 contours that use flight operations projected out to 2015.

This AICUZ Study provides substantial background information for NS Norfolk Chambers Field to orient the reader to the type of facility it is and how it has evolved over time. This background data includes historical use of the facility as well as past, present-day and projected aircraft operations. The Study also summarizes the base's contribution to the local economy. The primary focus of the Study, however, is a presentation of updated aircraft noise contours and Accident Potential Zones (APZs) for the installation, and an evaluation of land use compatibility against those noise contours and APZs. The compatibility assessment considers both current and proposed land uses and zoning for the City of Norfolk. Lastly, this AICUZ Study provides recommendations to Navy and community planners as well as the general public on ways to promote land use compatibility that is consistent with both the goals of the AICUZ Program and the community's land use goals.

ES.2 NS Norfolk Chambers Field

Chambers Field is the airfield associated with NS Norfolk, located on Sewell's Point peninsula in the City of Norfolk. The installation is at the confluence of the James River and Chesapeake Bay and is approximately 18 miles from the Atlantic Ocean. Aircraft operating out of NS Norfolk Chambers Field also utilize other Navy installations in the Hampton Roads region of southeastern Virginia, including Naval Auxiliary Landing Field (NALF) Fentress in the City of Chesapeake, Virginia.

The mission of NS Norfolk Chambers Field is to support the operational readiness of the U.S. Atlantic Fleet, primarily by providing facilities and services to support the missions of its tenant commands. NS Norfolk is homeport to aircraft carriers, cruisers, destroyers, large amphibious ships, submarines, and various supply and logistics ships, as well as numerous fixed-wing and rotary-wing aircraft. NS Norfolk has two primary components: 1) the pier facilities that house ships, submarines, and aircraft carriers, and 2) the airfield known as Chambers Field. Chambers Field is under the command and control of the Navy Region, Mid-Atlantic Air Operations Program Manager. Chambers Field provides training and flight operations for a number of fixed-wing and helicopter squadrons with various mission requirements. Flight operations include takeoffs, landings, and touch and goes. In addition, there are minesweeper sled training operations in Willoughby Bay.

ES.3 Aircraft Operations

Aircraft that typically utilize NS Norfolk Chambers Field can be broken down into two categories fixed-wing aircraft and rotary-wing aircraft. Fixed-wing aircraft types currently or projected to utilize NS Norfolk Chambers Field include the E-2C (transitioning to the E-2D), C-2A, C-9, C-130, C-5, and

F/A-18. Rotary-wing aircraft types that are currently or projected to utilize NS Norfolk Chambers Field include the MH-60S, SH-60F/HH-60H, MH-53, and CH-46E.

The basic flight operations at NS Norfolk Chambers Field are departures, straight in/full-stop arrivals, overhead arrivals, touch-and-go operations, low approaches, low-work/hover areas, and ground control approaches (GCA). Each of these operation procedures is described in detail in Section 3.4.2 of the Study. The baseline flight operations inventory from the 1999 noise contours included 98,180 operations (including both fixed-wing and helicopters). The inventory from the 2009 AICUZ noise contours (which is based upon the projected operations in 2015) includes 43,845 fixed-wing and 96,466 helicopter operations, for a total of 140,311 annual operations, a 42% increase from operations in 1999. This includes transient aircraft that utilize NS Norfolk Chambers Field, but are not permanently based at the installation.

ES.4 Aircraft Noise

The main noise sources at NS Norfolk Chambers Field are aircraft operations and maintenance or pre-flight engine run-ups. The noise exposure from aircraft at NS Norfolk Chambers Field, as with other installations, is measured using the day-night average sound level noise metric (DNL). The DNL is depicted visually as a noise contour that connects points of equal value. The AICUZ Program generally divides noise exposure into three categories known as noise zones:

- **Noise Zone 1** (less than 65 DNL) is generally considered an area of low or no noise impact;
- **Noise Zone 2** (65 to 75 DNL) is an area of moderate impact, where some land use controls are required; and
- **Noise Zone 3** (greater than 75 DNL) is the most severely impacted area and requires the greatest degree of land use control.

A noise analysis was conducted to define noise exposure contours at NS Norfolk Chambers Field. Noise contours created from computer models are combined to 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 2009 AICUZ noise contours (which are based upon the projected operations out to 2015) were compared to the previous contours published in the Hampton Roads JLUS in 2005, referred to as the 1999 noise contours. 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. The comparison in this AICUZ for NS Norfolk Chambers Field reveals an increase in area from the 1999 noise zones, mostly occurring within the installation's property boundaries or over water. Areas off installation property and over land that appear to have an increase in noise are to the southwest of NS Norfolk Chambers Field and to the east of the installation along East Ocean Avenue.

Overall, the area covered by the noise zones (not including water or on-station acreage) increased 1,912 acres between the 1999 noise contours and the 2009 AICUZ noise contours. The majority of this, 1,198 acres (63%), was within the 60 to 65 dB DNL noise contour, which is considered part of Noise Zone 1 (areas below 65 DNL).

ES.5 Airfield Safety

While the likelihood of an aircraft mishap occurring is remote, the Navy identifies areas of accident potential to assist in land use planning. The Navy has identified Accident Potential Zones (APZs) around its runways based on historical data for aircraft mishaps. The Navy recommends certain land uses that concentrate large numbers of people – such as apartments, churches, and schools – be constructed outside the APZs.

NS Norfolk Chambers Field is a Class B runway. The components of standard APZs for Class B runways are (OPNAVINST 11010.36C) as follows Clear Zone, APZ I, and APZ II (defined in Section 5.1.2). An accident is more likely to occur in APZ I than APZ II, and is more likely to occur in the Clear Zone than in APZ I or APZ II

The comparison between 1999 APZs and 2009 AICUZ APZs show a change in their respective land area affected as follows: for the Clear Zone there was no change; for APZ I there was a decrease of 117 acres of land included with the APZ; and for APZ II there was an increase of 87 acres impacted. This equates to an overall decrease of 30 acres impacted when comparing the 1999 APZs and the 2009 AICUZ APZs (note: areas over water or on-station were not included in these acreages). The fixed-wing APZs remain essentially with the exception of a slight shift to the south for Flight Track 10D1 utilizing Runway 10/28. This change in the location and size of the APZs associated with this flight track brings the APZs into compliance with OPNAVINST 11010.36C.

ES.6 Land Use Compatibility Analysis

The 2009 AICUZ map is based off the noise zones and APZs and defines the minimum recommended acceptable area within which land use controls are needed to protect the health, safety, and welfare of those living or working near a military airfield and to preserve the defense flying mission.

The Navy has developed land use compatibility recommendations for APZs and noise zones. These recommendations, which are found in OPNAVINST 11010.36C, Air Installations Compatible Use Zones Program, are intended to serve as guidelines for placement of APZs and noise zones and for development of land uses around military air installations. The guidelines recommend that noise-sensitive land uses (e.g., houses, churches) be placed outside high-noise zones, and people-intensive uses (e.g., apartments, theaters) not be placed in APZs. Certain land uses are considered incompatible with APZs and high-noise zones, while other land uses may be considered compatible or compatible under certain conditions (compatible with restrictions).

Several incompatible land uses and major existing compatibility concerns currently exist around NS Norfolk Chambers Field. These concerns include: residential areas located in the Clear Zone and Noise Zones 2 and 3; schools and churches located in APZ I and APZ II; and several transportation-related projects that are in-process which have the potential to create land use compatibility concerns in the vicinity of NS Norfolk Chambers Field.

ES.7 Land Use Tools and Recommendations

The Federal Government, State/Regional Governments, Local Governments, Private Citizens, Business, and Real Estate Developers, along with the Navy all play an important role in the implementation of the AICUZ Study. Each role is described in Section 7. It is recommended that the AICUZ noise zones and APZs be adopted into the City of Norfolk’s land use planning and zoning process to best guide compatible development around the installation.

1 Introduction

Chapter 1

In many locations throughout the United States the military's presence is expanding both in terms of physical size and mission growth and/or expansion. Many areas have also experienced associated population growth and increased development in close proximity to a military installation, as is the case with Naval Station Norfolk Chambers Field. This growth is evident immediately outside many station fence lines as well as throughout the surrounding areas within the city of Norfolk, and the adjacent cities of Virginia Beach and Chesapeake. This growth typically takes the form of residential and commercial development. New homes are constructed in close proximity to an installation to allow both military and civilian personnel who work at a base to live near their employer. Similarly, businesses are established in proximity to these homes and the military installation to support the installation and its personnel. Because of its close proximity to the installation, some of this development may be incompatible with aircraft and other military operations that occur at the base and over time can result in nearby residents or businesses being adversely impacted. This can also result in the potential degradation of the installation's mission.

Naval Station Norfolk Chambers Field Norfolk, Virginia

The United States Department of Defense (DoD) initiated the Air Installations Compatible Use Zones (AICUZ) Program to help governmental entities and communities anticipate, identify, and promote compatible land use and development near military installations. The goal of this program is to protect military operational capabilities and to protect the health, safety, and welfare of the public by achieving compatible land-use patterns and activities in the vicinity of a military installation. The AICUZ Program recommends that noise levels, Accident Potential Zones (APZs), to be described later (Section 5), and flight clearance requirements associated with military airfield operations be incorporated into local community planning programs in order to maintain the

> The goal of the AICUZ Program is to protect military operational capabilities and the health, safety, and welfare of the public by achieving compatible land-use patterns and activities in the vicinity of a military installation.

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

This AICUZ Study has been prepared for NS Norfolk Chambers Field, Norfolk, Virginia. NS Norfolk Chambers Field encompasses approximately 3,400 acres in the Hampton Roads region of southeastern Virginia. The NS Norfolk Chambers Field runway is located in the central/eastern portion of the installation. Aircraft from NS Norfolk Chambers Field utilize surrounding airspace and ranges for training, as well as Naval Auxiliary Landing Field (NALF) Fentress, located 17 nautical miles southeast of NS Norfolk Chambers Field, for field carrier landing practices.

The original AICUZ for NS Norfolk (then named Naval Air Station [NAS] Norfolk) was approved on May 9, 1978. The noise contours and APZs associated with NS Norfolk Chambers Field were updated in 1999 and incorporated into the 2005 Hampton Roads Joint Land Use Study (JLUS). These 1999 noise contours and APZs were never incorporated into an AICUZ Study; however, since they are the most recently approved and published set of noise contours and APZs for the installation and they will be used for comparison purposes in this AICUZ Study.

An environmental assessment (EA) with an accompanying aircraft noise study was recently conducted at NS Norfolk Chambers Field for the "EA for the Transition of E-2C Hawkeye to E-2D Advanced Hawkeye." The EA was finalized in January 2009. Operational data associated with this EA effort for fixed-wing aircraft operating at NS Norfolk Chambers Field, serves as part of the operational framework for this AICUZ Study; however, this AICUZ Study also incorporates operations of rotary-wing aircraft operating at the installation, which was not covered in the EA. Section 3.4 has more details on the aircraft operations being analyzed as part of this AICUZ Study.

This 2009 AICUZ Study is an update of the 1999 noise contours and APZs. This study has been prepared in consideration of both past and expected changes in mission, aircraft, and projected operational levels that will occur within the next five to six-year planning period.

This AICUZ Study provides background on the AICUZ Program and historical data from previous AICUZ studies and noise modeling for NS Norfolk Chambers Field (Section 1) and describes locations and features of the facility (Section 2). Section 3 discusses historical, present-day, and projected aircraft operations. Section 4 presents the updated aircraft noise contours, outlining the methodology for how the noise contours were determined, what changes have occurred, and what the future expectations are for change, as well as what measures have been implemented by the Navy to mitigate any community noise concerns. Aircraft safety issues and the development of APZs are discussed in Section 5. Section 6 evaluates the compatibility of both current and proposed land uses as provided by the City of Norfolk. Finally, Section 7 provides recommendations to Navy installation planners for promoting land use compatibility consistent with the goals of the AICUZ Program.

1.1 AICUZ Program

Encroachment is primarily any non-Navy action planned or executed which inhibits, curtails, or possesses the potential to impede the performance of Navy activities.

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

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

Noise zones and APZs, which are described in detail in Sections 4 and 5, respectively, represent and identify areas where both the air installation and local planning departments need to focus. Noise zones and APZs represent areas that are vital to the continuing operations of the air installation. Since they may extend beyond the "fence line" of the installation, presentation of the most current dimensions of noise zones and APZs through development of an updated AICUZ study to local planners is essential to fostering mutually beneficial land uses and development. It is a goal of the AICUZ Program to get the

AICUZ noise zones and APZs adopted by the local planning department in order to incorporate development criteria in areas around the base.

Along the same lines, the 2005 Hampton Roads JLUS was recently prepared for the Hampton Roads region. The 2005 Hampton Roads JLUS worked to address land use issues associated with the operation of three Navy facilities – NAS Oceana, NALF Fentress, and NS Norfolk Chambers Field – covering three cities in the Hampton Roads area – Chesapeake, Norfolk, and Virginia Beach. The analysis for NS Norfolk Chambers Field was based upon noise contours and APZs completed in 1999; thus, any changes in the dimensions of the noise zones or APZs would need to be updated in the Hampton Roads JLUS and may affect planning assumptions outlined in that report. AICUZ-related tools and recommendations will be discussed further in Section 7 of this Study.

In addition to the Navy AICUZ instruction, the Federal Aviation Administration (FAA) and DoD have developed specific instructions and guidance to encourage local communities to restrict development or land uses that could endanger aircraft in the vicinity of the airfield, including lighting (direct or reflected) that would impair pilot vision; towers, tall structures, and vegetation that penetrate navigable airspace or are constructed near the airfield; uses that generate smoke, steam, or dust; uses that attract birds, especially waterfowl; and electromagnetic interference (EMI) sources that may adversely affect aircraft communication, navigation, or other electrical systems. This is discussed in more detail in Section 5.2 – Flight Safety.

1.2 Purpose, Scope, and Authority

The purpose of the AICUZ program is to achieve compatibility between air installations and neighboring communities. OPNAVINST 11010.36C is the current Navy guidance document that governs the AICUZ Program. To satisfy the purpose of the AICUZ Program, the military installation must work with the local community to discourage incompatible development of lands adjacent to the installation. As development encroaches upon the airfield, more people are potentially exposed to noise and accident potential associated with aircraft operations. The scope of the AICUZ study includes an analysis of:

> The AICUZ Study analyzes community development trends, land use tools, and mission requirements to develop a recommended strategy for communities to prevent incompatible land development adjacent to the installation.

- Aircraft noise zones for existing conditions and future-year forecasts;
- Aircraft APZs for existing conditions and future-year forecasts;
- Land use compatibility;

- Historic and current aircraft operations;
- Noise reduction strategies; and
- Possible solutions to existing and potential incompatible land use problems.

The AICUZ Study uses an analysis of community development trends, land use tools, and mission requirements at the airfield to develop a recommended strategy for communities that prevents incompatible land development adjacent to the installation. Implementation of the AICUZ program requires cooperation between the air installation commander and the local government. The overall goal is to protect the installation's mission while simultaneously protecting and promoting the public's health, safety, and welfare.

Key documents that outline the authority for the establishment and implementation of the NS Norfolk Chambers Field AICUZ Program, as well as guidance on facility requirements, are derived from:

- DoD Instruction 4165.57, "Air Installations Compatible Use Zones," dated November 8, 1977;
- OPNAVINST 11010.36C, "Air Installations Compatible Use Zones Program," dated October 9, 2008;
- Unified Facilities Criteria 3-260-01, "Airfield and Heliport Planning and Design," dated May 19, 2006;
- Naval Facilities Engineering Command P-80.3, "Facility 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

Ensuring land use compatibility within the AICUZ is the responsibility of many organizations, including the DoD and Navy, the local naval air installation command, local planning and zoning agencies, real estate agencies, residents, developers, and builders. Military installations can make recommendations or advise the local government agencies, but the local government agencies have the planning and zoning authority to be able to preserve land use compatibility near the military installation. Cooperative action by all parties is essential to prevent land use incompatibility and hazards to the neighboring community. Table 1-1 identifies some responsibilities for various community stakeholders residing in proximity to an installation.

Table 1-1
Responsibility for Compatible Land Uses

Navy	■ Examine air mission for operation 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 an AICUZ Study. ■ Work with local governments and private citizens. ■ Monitor operations and noise complaints. ■ Update AICUZ studies, as required.
Local Government	■ Incorporate AICUZ guidelines into a comprehensive development plan and zoning ordinance. ■ Regulate height and obstruction concerns through an airport ordinance. ■ Regulate acoustical treatment in new construction. ■ Require fair disclosure in real estate for all buyers, renters, lessees, and developers.
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 builder/developers, ensure an understanding and evaluation of the AICUZ Program.
Builders/Developers	■ Develop properties in a manner that appropriately protects the health, safety, and welfare of the civilian population by constructing facilities which are compatible with aircraft operations (e.g., sound attenuation features, densities, and occupations).

1.4 Previous AICUZ Efforts and Studies

The original, complete AICUZ for NS Norfolk Chambers Field was prepared and approved in 1978

Several other noise studies have been conducted since the 1978 AICUZ. In 1997, an Aircraft Noise Study was prepared and for the F/A-18 realignment at NAS Oceana, Marine Corps Air Station (MCAS) Cherry Point, and MCAS Beaufort, and NS Norfolk Chambers Field was included as part of the analysis. In 2003, an updated noise study was prepared as a component of the "Environmental Impact Statement (EIS) for the Introduction of F/A-18 E/F (Super Hornet) Aircraft to the East Coast of the United States."

Updated noise contours and APZs were approved by the Chief of Naval Operations in 1999 but were not incorporated into an official AICUZ Study. Instead, the contours and APZs were released as part of an approved Hampton Roads AICUZ map, representing composite AICUZ maps for NS Norfolk Chambers Field; NAS Oceana (in Virginia Beach, VA) and NALF Fentress (in Chesapeake, VA).

In 2005, the Hampton Roads Planning District Commission (HRPDC) prepared the Hampton Roads JLUS. The Hampton Roads JLUS is a study that examines and makes recommendations regarding land development policy and implementation of that policy in response to the Navy's air mission in the region (including NS Norfolk Chambers Field, NALF Fentress, and NAS Oceana). Noise contours and APZs developed in 1999 were utilized for NS Norfolk Chambers Field's planning analysis in the Hampton Roads JLUS, and serve as a basis for comparison to the 2009 AICUZ noise contours and APZs developed in this AICUZ Study.

In addition, as previously discussed, a 2008 noise study was prepared as a component of the "Environmental Assessment for the Transition of E-2C Hawkeye to E-2D Advanced Hawkeye."

1.5 Changes that Require an AICUZ Update

AICUZ studies should be updated when an air installation has a significant change in aircraft operations (i.e., the number of takeoffs and landings), a change in the type of aircraft stationed and operating at the installation, or changes in flight paths or procedures.

In accordance with OPNAVINST 11010.36C, this AICUZ Study has been prepared to reflect changes in airfield operations at NS Norfolk Chambers Field since the last AICUZ, including changes in aircraft type, and to examine any reasonable projected aircraft loading changes over the next five years.

Through several internal studies looking at aircraft homebasing and anticipated operational changes, the Navy has determined there is a need to prepare and implement an updated AICUZ Study for NS Norfolk Chambers Field. This is partially a result of the identification of the need/challenge of addressing community noise exposure, APZs, and urban development around the installation. The AICUZ Study will also identify potential problem areas and offer potential recommendations to prevent further encroachment.

1.5.1 Changes in Operations Level

The operational tempo at NS Norfolk Chambers Field has fluctuated over time (see Table 1-2). The highest number of operations reported for NS Norfolk Chambers Field occurred in 1990 where there were an estimated 165,626 annual operations for the facility. The low was reached in 2007 with only 53,886 annual operations.

> Over time, the operational tempo at Chambers Field has fluctuated. Planned flight operations of approximately 44,000 fixed-wing operations and 96,500 helicopter operations are used as the basis for this AICUZ.

The fluctuation in the number of annual operations can vary due to a number of factors, including deployments, both routine and in times of conflict, as well as the movement of aircraft squadrons between air installations. An AICUZ analysis incorporates any anticipated, potential, or reasonably foreseeable changes in air installations' annual operations into the noise and safety estimates, and it is anticipated that in the coming years NS Norfolk Chambers Field will be experiencing an increased level of aircraft operations primarily from an increase in helicopters operating at the installation. Thus, planned (2015) flight operations of 43,845 fixed-wing and 96,466 helicopter operations, for a total of 140,311 annual operations are used as the basis for this AICUZ (see Section 3.4 for more details on aircraft flight operations).

Table 1-2
Yearly Comparison of Operations at NS Norfolk Chambers Field

Year	Flight Operations
1987	149,743
1988	154,388
1989	150,209
1990	165,626
1991	146,936
1992	155,973
1993	121,233
1994	99,775
1995	98,180
1996	111,909
1997	108,117
1998	119,621
1999	102,773
2000	111,665
2001	106,043
2002	67,875
2003	107,578
2004	90,126
2005	81,335
2006	65,115
2007	53,886
2008	65,798
*2015**	*140,311*

Sources: NS Norfolk Chambers Field 1999, NS Norfolk Chambers Field 2000, Himmelwright 2009

Key:
* = Projected operations.

1.5.2 Changes in Aircraft Mix

Aircraft mix at NS Norfolk Chambers Field has changed significantly since the 1978 AICUZ and the more recent 1999 modeling effort. Currently, several types of aircraft – both fixed-wing and rotary-wing - utilize NS Norfolk Chambers Field and each perform various training exercises, with numerous mission requirements.

In addition, some aircraft are currently transitioning in and out of services at the installation (i.e., the E-2C and E-2D transition). The number of H-60 aircraft will also be increasing significantly between current loading and 2015. Table 1-3 outlines the permanently-stationed aircraft operating from the NS Norfolk Chambers Field. Not represented in this table are the transient commercial aircraft that utilize the airfield, but are not permanently-stationed (i.e., F/A-18s, C-5s, C-9s, and C-130s).

Transient aircraft are aircraft that utilize the field, but are not permanently-stationed at NS Norfolk Chambers Field.

1.5.3 Changes in Flight Tracks and Procedures

There have been no notable changes that have occurred in existing flight tracks or procedures for fixed-wing aircraft at NS Norfolk Chambers Field in recent years. However, new helicopter pads and operating areas have been established along the seawall area in Willoughby Bay, with additional helicopter flight tracks added to the area north of the installation.

Table 1-3
Aircraft Types at NS Norfolk Chambers Field in 2009 and 2015 (projected)

Aircraft Type	2009	2015
Fixed Wing		
E-2C/E-2D	30	37
C-2A	14	14
C-12	3	3
Rotary Wing		
H-60	39	71
CH-46 (USMC)	13	13*
MH-53	16	25
Total	**115**	**163**

Source: Himmelwright 2009

Note:
* USMC plan is to complete decommissioning of CH-46s by 2016 and replace with MV-22 Osprey, although homebase location(s) have not been determined.

See Section 3.4.2 for specific flight tracks flown at NS Norfolk Chambers Field for both fixed-wing and rotary-wing aircraft. Historic modifications to flight operation procedures associated with noise abatement are discussed in Section 4.4, Noise Abatement/Flight Procedures.

2 Naval Station Norfolk Chambers Field

Chapter 2

2.1 Location

Chambers Field is the airfield associated with NS Norfolk, located on Sewell's Point peninsula in the City of Norfolk. The installation is at the confluence of the James River and Chesapeake Bay and approximately 18 miles from the Atlantic Ocean (see Figure 2-1). Aircraft operating out of NS Norfolk Chambers Field also utilize other Navy installations in the Hampton Roads region of southeastern Virginia, including NALF Fentress in the City of Chesapeake, Virginia.

2.2 Mission

The mission of NS Norfolk Chambers Field is to support the operational readiness of the U.S. Atlantic Fleet, primarily by providing facilities and services to support the missions of its tenant commands. NS Norfolk is homeport to aircraft carriers, cruisers, destroyers, large amphibious ships, submarines, and various supply and logistics ships, C-2, C-12 and E-2 fixed-wing aircraft, as well as SH-60, MH-60, CH-46, and MH-53 helicopters. NS Norfolk has two primary components: 1) the pier facilities that house ships, submarines, and aircraft carriers, and 2) the airfield known as Chambers Field. NS Norfolk Chambers Field is under the command and control of the Navy Region, Mid-Atlantic Air Operations Program Manager. NS Norfolk Chambers Field provides training and flight operations for a number of fixed-wing and helicopter squadrons with various mission requirements. Flight operations include takeoffs, landings, and touch and goes. In addition, there are minesweeper sled training operations in Willoughby Bay.

NS Norfolk Chambers Field is also home to the United States Air Force's Air Mobility Command (AMC) Passenger and Air Cargo Terminal located on the south side of the airfield. AMC's mission is to provide global air mobility to support war efforts and humanitarian missions in the U.S. and abroad. AMC is the largest customer on the airfield, moving in excess of 10,000 passengers and 1,500 to 2,500 tons of cargo per month for military missions worldwide.

2.3 History

NAS Norfolk was commissioned in 1918 at the forefront of Naval aviation and has supported transport, surveillance, and attack aircraft through its history. In the 1940s, NAS Norfolk was growing significantly and the operational area was expanded into Willoughby Bay to support additional air operations. In 1973, the E-2C Hawkeye was introduced to the fleet and stationed at NAS Norfolk. In 1998, NAS Norfolk was disestablished as part of the consolidation of several Naval facilities and functions in the Hampton Roads region. The airfield facility formerly belonging to NAS Norfolk was renamed NS Norfolk Chambers Field.

NS Norfolk's mission is to support the operational readiness of the U.S. Atlantic Fleet, primarily by providing facilities and services to support the missions of its tenant commands.

2.4 Operational Areas

2.4.1 NS Norfolk Chambers Field

Figure 2-2 provides a depiction of NS Norfolk Chambers Field. Chambers Field has a single runway configuration for fixed-wing operations. The single runway is identified as runway 10/28 and is 8,369 feet long and 200 feet wide. Runways are numbered according to their magnetic heading for aircraft on approach or departure. For example, on runway 10/28, the numbers 10 and 28 signify this runway is most closely aligned with a compass heading of 100 and 280 degrees, respectively.

For helicopter operations, NS Norfolk Chambers Field currently is operating out of two main areas – the LF area and SP area, with some operations occurring on helipads on taxiways (taxiway B [Bravo] and taxiway G [Golf]). However, plans are in place (and the basis for analysis in this AICUZ Study) such that by 2015, NS Norfolk Chambers Field will have four separate operating areas: a pad on taxiway B, four pads along the seawall in the SP area, Runway 09/27 at the heliport in LF area, and a new pad in the V area. In addition to these operating areas, a pad on taxiway G will be used for Combat Ordnance Loading referred to as the CALA (see Figure 2-2).

Naval Station Norfolk (Chambers Field)

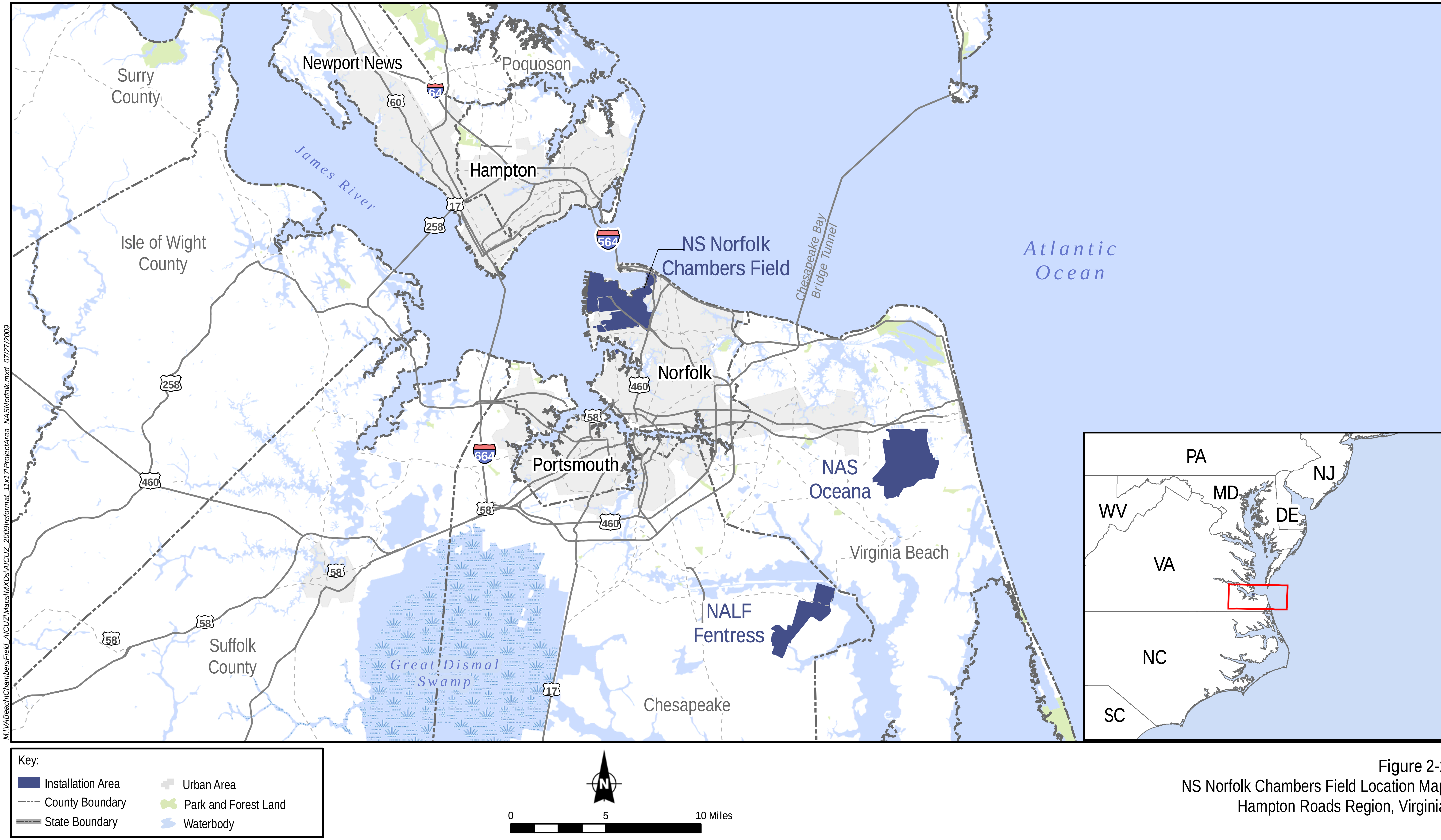


Figure 2-1
NS Norfolk Chambers Field Location Map
Hampton Roads Region, Virginia

NS Norfolk Chambers Field Airfield

Key:
- Ground Runup Location
- Runway / Helicopter Pad

LF - Landing Field
LP - Land Plane Area
SP - Sea Plane Area

0 0.5 1 Mile

Figure 2-2
NS Norfolk Chambers Field Airfield Map
Norfolk, Virginia

The airfield consists of approximately 603,000 square feet of parking apron space, 15 aircraft hangars, along with a variety of weapons storage facilities, fuel storage areas, and general maintenance/storage warehouses. The airfield elevation is 15 feet above mean sea level (MSL) and there are taxiways throughout the installation of varying widths.

2.5 Local Economic Impacts and Population Growth

Naval Station Norfolk is a major employer and contributor to the local economy employing over 96,000 military and civilians.

Similar to other areas where major military bases are located, NS Norfolk (including Chambers Field) has a significant impact on the economy in the Norfolk area and the greater Hampton Roads region. The jobs associated with NS Norfolk and its tenants, the salaries paid to its workers, and the spending associated with both the workers and the facility ripple through the entire region's economy. The installation contributes directly to the economic development of the surrounding communities through increased demand for local goods and services and increased household spending by service members, military retirees, and civilian employees. NS Norfolk, the largest naval base in the world, is important to the Commonwealth of Virginia and local economies accounting for thousands of jobs and contributing billions of dollars in economic activity and tax revenue. The DoD's expenditures and obligations in Norfolk in 2006 totaled $5,787,800,000 (Media General Operations, Inc. 2008). This includes active and inactive duty military pay, military retirement and disability payments, civilian pay, and procurements. As a result, the military creates a stable and consistent source of employment and tax revenue for the local economy. The location of NS Norfolk with respect to the Hampton Roads region is illustrated in Figure 2-1.

Although ship operations are the primary activity at the installation, jobs associated with supporting the air station's air operations mission at Chambers Field represents a major activity that contributes to local employment and economic benefits to the City of Norfolk and the surrounding communities in Hampton Roads. In 2008, it was estimated that NS Norfolk (including both air operations activities and ship activities) employed a workforce of approximately 84,000 active-duty military personnel and 12,000 civilian personnel (Media General Operations, Inc. 2008).

The population of Norfolk has increased slightly, following a sharp decline between 1990 and 2000. The estimated population of 235,092 in 2008 is up from 234,452 in 2000 (2-percent increase), but down from 262,175 in 1990 (9-percent decrease). The Hampton Roads Planning District Commission (HRPDC) estimates that the City's population will increase slightly by 2034. The population of the entire Hampton Roads region has also been increasing. The 2008 population estimate (1,644, 903) is a 5-percent increase from 2000 and a 15-percent increase from 1990. HRPDC estimates the regional population will exceed two million by 2034 resulting from increased port and defense-related industries (see Table 2-1).

Table 2-1
Population of Municipalities in the Vicinity of NS Norfolk Chambers Field
Norfolk, Virginia

Population Area	1990	2000	2008	2034	% Growth 2000-2007	% Growth 2007- 2034
City of Norfolk	257,675	234,452	235,092	240,400	<1%	3%
Hampton Roads MSA (VA/NC)	1,445,543	1,555,700	1,644,903	2,080,600	5%	21%

Source: HRPDC 2009

Note: Hampton Roads MSA consists of Virginia Beach, Norfolk, and Newport News.

Key:
MSA = Metropolitan Statistical Area.
VA/NC = Virginia/North Carolina.

Although the population of the City of Norfolk has remained relatively constant, the population of the Hampton Roads Metropolitan Statistical Area (MSA) has been growing and is projected to continue to grow significantly in the coming decades. This regional- level growth may not directly impact NS Norfolk in terms of new developments around the installation that are incompatible with aircraft operations, however it has the potential to impact the installation through the establishment of newly constructed infrastructure to support the growing regional population base. This could include upgrading or expansion of the region's transportation systems, for example. A discussion of local and regional compatibility issues is provided in Section 6 of this Study.

3 Aircraft Operations

Chapter 3

NS Norfolk Chambers Field conducts both aircraft flight operations and aircraft ground engine maintenance "run-up" operations in specific locations.

This section discusses the types of aircraft stationed at NS Norfolk Chambers Field, the number of operations conducted by these aircraft and the flight tracks used to conduct the operations, as well as transient aircraft that utilize the airfield.

3.1 Aircraft Types

Aircraft that typically utilize NS Norfolk Chambers Field are described in the following subsections. They include fixed-wing and rotary-wing aircraft stationed at NS Norfolk Chambers Field, as well as fixed-wing aircraft transient to NS Norfolk Chambers Field. Commercial aircraft also occasionally utilized the airfield; however, it is infrequent and the type of aircraft varies and they are not described in this section.

3.1.1 Fixed – Wing Aircraft

A fixed-wing aircraft is an aircraft whose lift is generated not by wing motion relative to the aircraft, but by forward motion through the air. The term is used to distinguish from rotary-wing aircraft (i.e., helicopters).

3.1.1.1 Fixed – Wing Aircraft Stationed at NS Norfolk Chambers Field

E-2C Hawkeye. The E-2C Hawkeye is the Navy's all-weather, aircraft carrier-based tactical airborne warning and control system platform. It provides all-weather airborne early warning and command and control functions for the carrier battle group. Additional missions include surface surveillance coordination, strike and interceptor control, search and rescue guidance and communications relay. The E-2C is scheduled to be replaced at

NS Norfolk Chambers Field by the E-2D beginning in 2011 and completing in 2022. There are currently 30 E-2C aircraft stationed at NS Norfolk Chambers Field.

E-2D Advanced Hawkeye. The E-2D Advanced Hawkeye, using the E-2C Hawkeye 2000 configuration as a baseline, is slated to feature a state-of-the art radar that will provide advance warning of approaching enemy surface units, cruise missiles, and aircraft, to vector interceptors or strike aircraft to attack. It will also provide area surveillance, communications relay, search and rescue coordination, and air traffic control. The E-2D Advanced Hawkeye will fundamentally differ from its E-2C Hawkeye predecessor. While the aircraft's outward appearance remains nearly identical (beyond the upgrade to a new, more efficient 8-bladed propeller), the mission system will be completely redesigned to accommodate new radar, antenna, workstations, and displays, as well as a cockpit layout that includes a fourth mission-operator station in addition to the three in the rear of the aircraft. There are currently no E-2D aircraft stationed at NS Norfolk Chambers Field, but by 2015, it is anticipated that E-2Ds will number 37 at the installation after transition is complete.

C-2A Greyhound. The C-2A Greyhound is a T-6 turboprop twin-engine, cargo aircraft designed to land on aircraft carriers. The aircraft is capable of carrying a mix of 10,000 pounds of high-priority cargo and passengers (up to 26 passengers or 20 litter patients). The aircraft is capable of carrying jet engines, dropping special forces or delivering the mail, and can air drop supplies and personnel from a carrier-launch aircraft due to its open-ramp flight capabilities. The C-2A aircraft are assigned to Fleet Logistics Support Squadrons, serving carriers from NS Norfolk Chambers Field, VA. There are currently 14 C-2A aircraft stationed at NS Norfolk Chambers Field.

3.1.1.2 Fixed – Wing Transient Aircraft that Utilize NS Norfolk Chambers Field

A transient aircraft is an aircraft that utilizes NS Norfolk Chambers Field for training missions but is not permanently stationed there.

C-9. The McDonnell Douglas C-9 is a twin jet engine fixed-wing aircraft that is used for medical evacuations, passenger transportation, and special missions. The aircraft is powered by two Pratt & Whitney JT8D-9A engines. The C-9 is 119.3 feet long with a height of 27.4 feet and a maximum gross take-off weight of 114,000 pounds. The range of the aircraft is approximately 2,600 nautical miles with a maximum airspeed of Mach 0.84. It has a flight ceiling of 37,000 feet. There are currently no C-9 aircraft stationed at NS Norfolk Chambers Field; however, C-9 aircraft frequently utilize NS Norfolk Chambers Field on a transient basis.

C-130 Hercules. The C-130 Hercules primarily performs the intra-theatre portion of the airlift mission. It is a four-engine turboprop aircraft whose multi-role, multi-mission includes tactical tanker/transport, aerial refueling, aerial delivery of troops and cargo, emergency re-supply, emergency medevac, tactical insert of combat troops and equipment, and evacuation missions. Although there are no C-130 aircraft stationed at NS Norfolk Chambers Field, these aircraft utilize the airfield as transient aircraft.

C-5 Galaxy. The C-5 Galaxy is a large military transport jet aircraft that provides strategic heavy airlift over intercontinental distances. It operates at NS Norfolk Chambers Field in support of the Air Force's local airlift mission. The C-5 Galaxy is a large military transport jet aircraft that provides strategic heavy airlift over intercontinental distances. It operates at NS Norfolk Chambers Field in support of the Air Force's local airlift mission. It is the military's largest aircraft in operation and supports deployment and supply of combat and support forces. Although there are no C-5 aircraft stationed at NS Norfolk Chambers Field, these aircraft utilize the airfield as transient aircraft.

F/A-18 Hornet/Super Hornet. The F/A-18 Hornet is an all-weather fighter and attack aircraft. The F/A–18 is a multi-role attack and fighter aircraft. The Hornet is highly capable across a full mission spectrum. It provides fighter escort, reconnaissance, close air support, air defense suppression, and day/night precision strike. The F/A-18 E/F Super Hornet is the Navy's newest operational multi-mission tactical aircraft. It is designed to complement and eventually supplant the F/A-18 A-D carrier-based aircraft. It is a single- and two-seat, twin engine, multi-mission fighter/attack (air-to-air and air-to-ground capable) aircraft that can operate from either aircraft carriers or land bases. Although there are no F/A-18 aircraft stationed at NS Norfolk Chambers Field, these aircraft utilize the airfield as transient aircraft.

3.1.2 Rotary – Wing Aircraft

> **A rotary wing** aircraft is an aircraft, as the helicopter, which is partly or wholly sustained in the air by lifting surfaces (rotors) revolving around a vertical axis

MH-60S Knighthawk. The MH-60S evolved from the U.S. Army Sikorsky-built UH-60A Black Hawk helicopter. The MH-60S is a new addition to the Navy’s fleet of combat helicopters, and its primary missions are vertical replenishment, combat logistics, and search and rescue. The MH-60S has an internal payload of 5,500 pounds and external payload of 8,000 pounds. It is also capable of operating in all-weather conditions and during the day or night. There are currently 39 H-60 aircraft (mix of variants) stationed at NS Norfolk Chambers Field, which is anticipated to increase significantly by 2015 to approximately 71 total aircraft, which will all be the MH-60S variant.

MH-53E Sea Dragon. The MH-53E Sea Dragon is the largest helicopter in the U.S. military inventory, and is powered by three turbine engines. It is primarily used to conduct Airborne Mine Countermeasures (AMCM), with a secondary mission of shipboard delivery. AMCM missions include mine sweeping and ancillary spotting, mine neutralization, floating mine destruction and surface towing of small craft and ships, with additional capabilities include air-to-air refueling, hover in-flight refueling, search and rescue and external cargo transport operations. The helicopter has the ability to perform Vertical Onboard Delivery as well as transportation of 55 troops or a 16-ton payload 50 nautical miles or a 10-ton payload 500 nautical miles. There are currently 16 MH-53E aircraft stationed at NS Norfolk Chambers Field, which is anticipated to increase to approximately 25 aircraft by 2015.

CH-46E Sea Knight (Phrog). The Sea Knight, or "Phrog," is used primarily during cargo and troop transport. The tandem-rotor design of the Sea Knight permits increased agility and superior handling qualities in strong relative winds from all directions, allowing, in particular, rapid direction changes during low-airspeed maneuvering. With a maximum lift capability of 6,000 pounds, the CH-46E is considered a medium-lift helicopter. There are currently 13 CH-46E aircraft stationed at NS Norfolk Chambers Field; however, the Marine Corps plans to decommission these aircraft by 2016.

3.2 Major Tenants and Squadron Organization

3.2.1 Major Tenants

NS Norfolk is the largest naval station in the world, and as such, has numerous major tenants on station.

NS Norfolk is the largest single Naval Station in the world, and includes extensive basing of both ships and aircraft.

- Air Mobility Command (AMC)
- Aircraft Intermediate Maintenance Department (AIMD)
- Naval Munitions Command (NMC) (Sewells Point Detachment)
- Commander, Navy Region Mid-Atlantic (CNRMA)
- Commander, Naval Air Forces U.S. Atlantic Fleet (AIRLANT)
- Commander, Naval Operations (CNO)
- Commander, Naval Surface Force, U.S. Atlantic Fleet (SURFLANT)
- Commander, Navy Installations (CNI)
- Commander, Second Fleet (COMSECONDFLT)
- Commander, Submarine Force, U.S. Atlantic Fleet (SUBLANT)

- Defense Commissary Agency (DeCA)
- Defense Distribution Depot Norfolk, Virginia (DDNV)
- Fleet and Industrial Supply Center (FISC)
- Naval Atlantic Meteorology and Oceanography (NAVLANTMETOC)
- Naval Air Forces, U.S. Atlantic Fleet (NAVAIR)
- Naval Computer and Telecommunications Area Master Station, Atlantic (NCTAMSLANT)
- Navy Exchange (NEX)
- Navy Family Services Center, Norfolk (FFSC)
- Naval Facilities Engineering Command, Mid-Atlantic (NAVFAC MIDLANT)
- Sealift Logistics, Atlantic (SEALOGLANT)
- Space and Naval Warfare Systems Command (SPAWAR)
- Special Warfare (SPECWAR)

From an air operations perspective, AIRLANT and AMC comprise the major tenants at NS Norfolk Chambers Field and are responsible for the fixed-wing and rotary-wing aircraft operating at the airfield. AIRLANT is the senior command for all aviation assets employed by the Atlantic Fleet. AIRLANT provides operationally ready air squadrons and aircraft carriers to the Atlantic Fleet. AIRLANT is responsible for training of all Atlantic Fleet squadrons and carrier crews and for outfitting and maintenance of their aircraft and ships.

AMC’s mission is to provide global air mobility to support war efforts and humanitarian purposes in the U.S. and abroad. AMC is the largest customer on the airfield, moving 15,000 passengers and 1,500 to 2,500 tons of cargo per month, and is the largest AMC in the United States.

3.2.2 Squadron Organization

NS Norfolk Chambers Field is home to the Commander, Helicopter Tactical Wing and Commander, Airborne Early Warning Wing of the U.S. Atlantic Fleet. In addition, Naval Air Reserve squadrons (HCS-4, VAW-78, and VR-56) and a Marine Air Reserve squadron (MAG-49) are located at the installation. The Air Operations detachment maintains C-12 aircraft stationed at NS Norfolk Chambers Field.

3.3 Airspace

The use of airspace over NS Norfolk Chambers Field is dictated by the FAA National Airspace System (Figure 3-1). This system is designed to ensure the safe, orderly, and efficient flow of commercial, private, and military aircraft. NS Norfolk Chambers Field is located within Class D airspace, which encompasses an area within a 4.3-nautical-mile (nm) radius of the center of NS Norfolk that extends upward to, but not including, 2,000 feet above ground level (AGL). Norfolk International Airport's Class C Airspace overlies the southeastern portion of NS Norfolk Chambers Field's Class D Airspace.

The main Air Traffic Control (ATC) tower located to the south of Runway 10/28 (in LP area) at NS Norfolk Chambers Field directs traffic within the Class D airspace entering, exiting, or taxiing at the airfield. In addition, a separate air traffic control tower is located in the LF area specifically for helicopter operations.

NS Norfolk Chambers Field's operational areas include several Special Use Airspace (SUA) areas. SUA in the region primarily includes Restricted Areas (R-) and Warning Areas (W-) (see Figure 3-1). NS Norfolk Chambers Field SUA includes:

- Restricted Area R-6606. Located off shore to the east of NS Norfolk Chambers Field.
- Warning Areas W-50A/B/C, W-72A/B, and W-386. Located off shore to the east of NS Norfolk Chambers Field.

3.4 Aircraft Operations

The Navy conducts **aircraft run-up operations** to test aircraft engines at high power levels to ensure their proper operation.

Aircraft operations conducted at NS Norfolk Chambers Field include flight arrivals, departures, pattern work and low-level activities (i.e., hovers) and aircraft run-up operations.

3.4.1 Pre-Flight and Maintenance Run-Up Operations

Pre-flight and maintenance run-up (sometimes referred to as turn-up) operations that take place at NS Norfolk Chambers Field are associated primarily with the E-2 and C-2 fixed-wing aircraft, as well as the MH-60, MH-53, and CH-46 helicopters. The areas where these run-ups are conducted are depicted in Figure 2-2. For fixed-wing aircraft, the pre-flight run-up operations take place on the active runway prior to brake release and typically last 5 seconds at 100% power. For helicopters, run-up operations are grouped into four basic categories: Hover Checks, Pre-flight, Maintenance Checks, and Hot Pit

Refueling. Based on the type of run-up, they are conducted at the appropriate location on the airfield (i.e., hot pit refueling run-ups are conducted in the hot pit area).

3.4.2 Flight Operations

A "flight operation" refers to anytime an aircraft crosses over the runway threshold at an airfield. The takeoff and landing may be part of a training maneuver (or pattern) associated with the runway or may be associated with a departure or arrival of an aircraft to or from defense-related, special-use airspace. Certain flight operations are conducted as patterns (e.g., touch-and-go). Departures and arrivals each count as one operation and a pattern counts as two. Basic flight operations at NS Norfolk Chambers Field are:

The **runway threshold** is a line perpendicular to the runway centerline designating the beginning of that portion of a runway usable for landing.

- **Departure.** An aircraft taking off to a local training area, a non-local training area, or as part of a training maneuver (e.g., touch-and-go).
- **Straight-In/Full-Stop Arrival.** An aircraft lines up with 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 (152 meters) 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.
- **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 actually is counted as two operations--the landing is counted as one operation and the takeoff is counted as another.
- **Low Approach.** An approach to a runway when the pilot does not make contact with the runway.
- **Low-Work/Hover Areas.** Events at these locations typically last 15 minutes (low-work) or 20 minutes (hovers) in specific areas of the airfield in which the pilot does not make contact with the runway.
- **Ground Control Approach (GCA).** A radar or "talk down" approach directed from the ground by Air Traffic Controllers (ATC) personnel. ATC personnel provide pilots with verbal course and glide slope information, allowing them to make an instrument approach during inclement weather.

Special Use Airspace

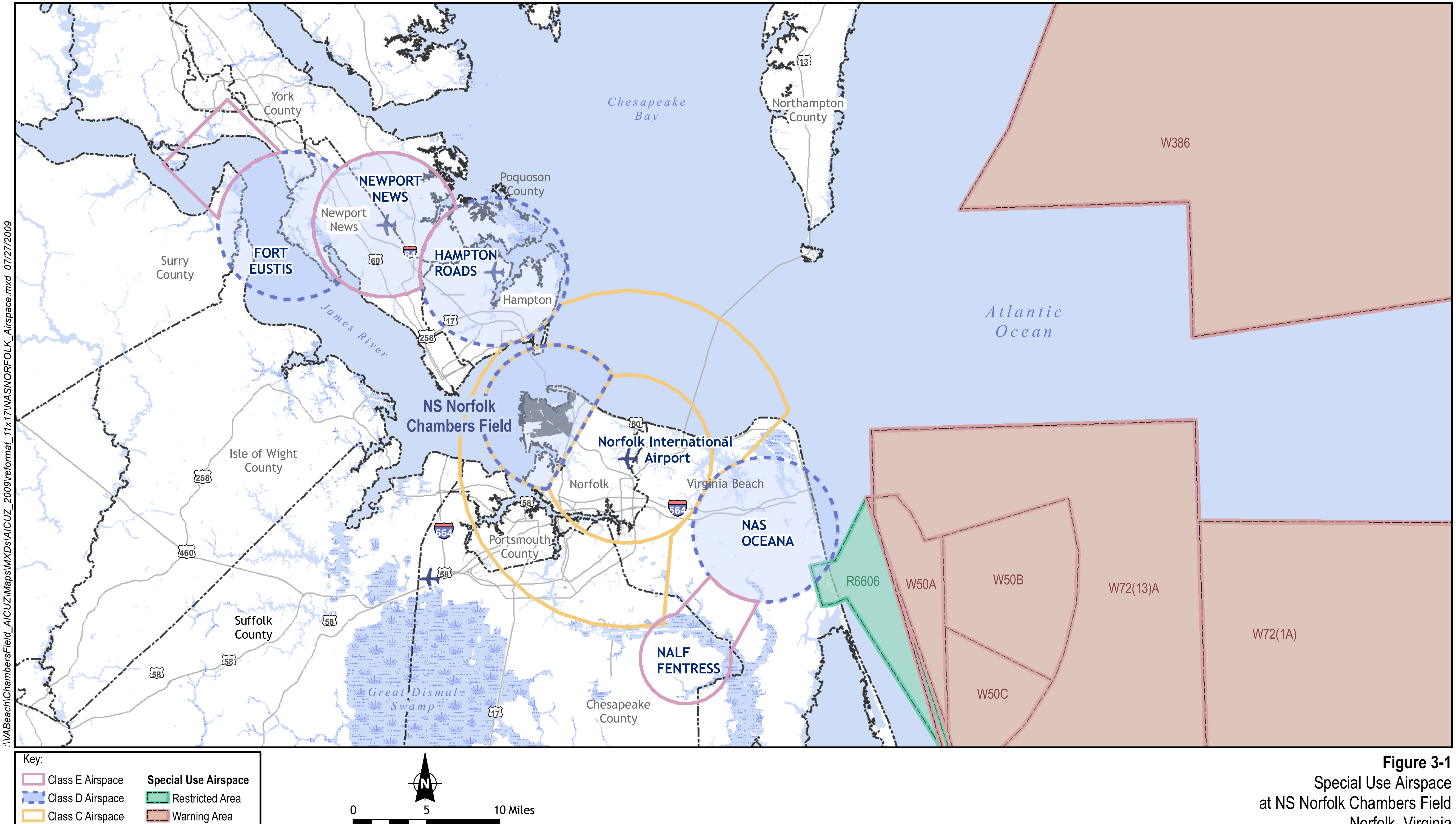


Figure 3-1
Special Use Airspace
at NS Norfolk Chambers Field
Norfolk, Virginia

3.4.2.1 NS Norfolk Chambers Field Operations

The number of annual operations projected for NS Norfolk Chambers Field as part of the noise study conducted for this AICUZ is shown in Table 3-1. The total number of projected fixed-wing operations is 43,845 and the total number of helicopter operations is 96,466, for a total of 140,311 in the year 2015, which is the year this Study is projecting to. The baseline flight operations inventory used for comparison in this AICUZ was from the 1999 noise contours and totaled 98,180 operations (including both fixed-wing and helicopters).

Based on the data in Table 3-1, calculations show that the E-2C/E-2D and the MH-60 aircraft represent the greatest percentage of operations, 22.6% and 56.5% respectively. Also included in the analysis are different aircraft types that either operate at NS Norfolk Chambers Field or may serve as surrogates for typical aircraft that utilize the airfield.

3.4.3 Runway and Flight Track Utilization

Aircraft approaching or departing from the air stations are assigned specific routes or flight tracks. The designated runways or helipads for the airfield are identified in Section 2.4. Flight tracks are represented as single lines, but flights vary due to aircraft performance, pilot technique, and weather conditions, such that the actual flight track is a band, often one-half to several miles wide. The flight tracks shown in this AICUZ Study are idealized representations. Predominant arrival, departure, and pattern flight tracks for both fixed-wing and rotary-wing aircraft at NS Norfolk Chambers Field are shown on Figures 3-2 through 3-7.

As discussed in Section 3.4.1, flight operations include departure, straight-in arrival, overhead break arrival, touch-and-go, low approach, low work/hover, and GCA operations. Abbreviations for the some of these flight operations (low work/hover operations do not have flight tracks) include:

- **Departure – D**
- **Straight-In Arrival – A**
- **Overhead Break Arrival – O**
- **Touch-and-Go Pattern – T**
- **GCA Pattern – G**

Table 3-1
Planned Annual Flight Operations at NS Norfolk Chambers Field (2015)[1]

Aircraft Type	Departure			Arrival/Overhead Arrival			Touch and Go[2]			GCA[2]			Total		
	7:00 AM - 10:00 PM	10:00 PM - 7:00 AM	Total	7:00 AM - 10:00 PM	10:00 PM - 7:00 AM	Total	7:00 AM - 10:00 PM	10:00 PM - 7:00 AM	Total	7:00 AM - 10:00 PM	10:00 PM - 7:00 AM	Total	7:00 AM - 10:00 PM	10:00 PM - 7:00 AM	Total
Fixed-Wing															
E-2C/E-2D	4,575	436	5,010	4,244	766	5,010	14,512	2,989	17,501	3,859	364	4,222	27,190	4,554	31,744
C-9 (jet cargo transport)	3,153	489	3,642	3,156	486	3,642	0	0	0	0	0	0	6,309	975	7,283
C-5 (heavy jet cargo transport)	271	42	312	271	42	312	0	0	0	0	0	0	542	83	625
C-130 (prop transport)	999	154	1,152	999	154	1,152	0	0	0	0	0	0	1,997	307	2,305
F/A-18 (fighter jet)	818	126	944	818	126	945	0	0	0	0	0	0	1,637	252	1,889
Subtotal Fixed-Wing	**9,815**	**1,245**	**11,061**	**9,487**	**1,574**	**11,061**	**14,512**	**2,989**	**17,501**	**3,859**	**364**	**4,222**	**37,674**	**6,171**	**43,845**
Rotary-Wing															
MH-60	9,101	4,898	13,998	9,101	4,898	13,998	24,267	13,064	37,331	9,100	4,900	14,000	51,568	27,760	79,328
MH-53	2,124	1,143	3,267	2,124	1,143	3,267	0	0	0	2,124	1,144	3,268	6,372	3,430	9,802
CH-46[3]	1,581	57	1,638	1,581	57	1,638	3,635	0	3,635	424	0	424	7,222	114	7,336
Subtotal Rotary-Wing	**12,806**	**6,098**	**18,904**	**12,806**	**6,098**	**18,904**	**27,902**	**13,064**	**40,966**	**11,649**	**6,044**	**17,692**	**65,162**	**31,304**	**96,466**
TOTAL	**22,621**	**7,343**	**29,964**	**22,293**	**7,672**	**29,965**	**42,414**	**16,053**	**58,467**	**15,507**	**6,407**	**21,915**	**102,836**	**37,475**	**140,311**

Source: BRRC 2009

Notes:

1 Transient aircraft that utilize NS Norfolk Chambers Field, but are by definition not stationed at the airfield, are included in the numbers in this table (i.e., F/A-18s)

2 Counted as two operations.

3 The United States Marine Corps Reserves are evaluating replacement of their CH-46 squadrons with MV-22 Osprey aircraft. Homebasing locations have not been determined; thus, the MV-22 were not evaluated in this AICUZ Study.

The flight operations at NS Norfolk Chambers Field are conducted on Runway 10/28 for fixed-wing and in one of several helicopter operating areas, including the LF area, SP area, Bravo pad, V pad, and CALA pad.

Section 2.4 provided a discussion and explanation of runway names. Individual flight track IDs are labeled according to the runway used, flight operation being conducted, and numerical sequence when multiple flight tracks are present. Example flight track IDs for NS Norfolk Chambers Field are provided inthe following bullets and are color-coded for example purposes only (i.e., the “28” in the first flight track example in red corresponds to the first red sub-bullet that defines it as meaning Runway 28, the blue “A” stands for arrival, and the green “1” is the flight track sequence).

- NS Norfolk Chambers Field Flight Track ID: **28A1**
  - Runway/Helipad: 28
  - Flight Operation: Arrival
  - Flight Track Sequence Number: 1
- NS Norfolk Chambers Field Flight Track ID: **SP2D4**
  - Runway/Helipad: SP2
  - Flight Operation: Departure
  - Flight Track Sequence Number: 4

3.5 Inter-Facility Operations

NS Norfolk Chambers Field is in close proximity to several other Navy and DoD installations. Transient aircraft often utilize NS Norfolk Chambers Field. In addition, aircraft stationed at NS Norfolk Chambers Field also utilize other Navy installations in the region, including NALF Fentress for field carrier landing practice (FCLP) work. This AICUZ Study only takes into account aircraft operating at NS Norfolk Chambers Field and arriving, departing, or doing pattern work at the airfield facilities located at the installation.

Fixed - Wing Arrival Flight Tracks

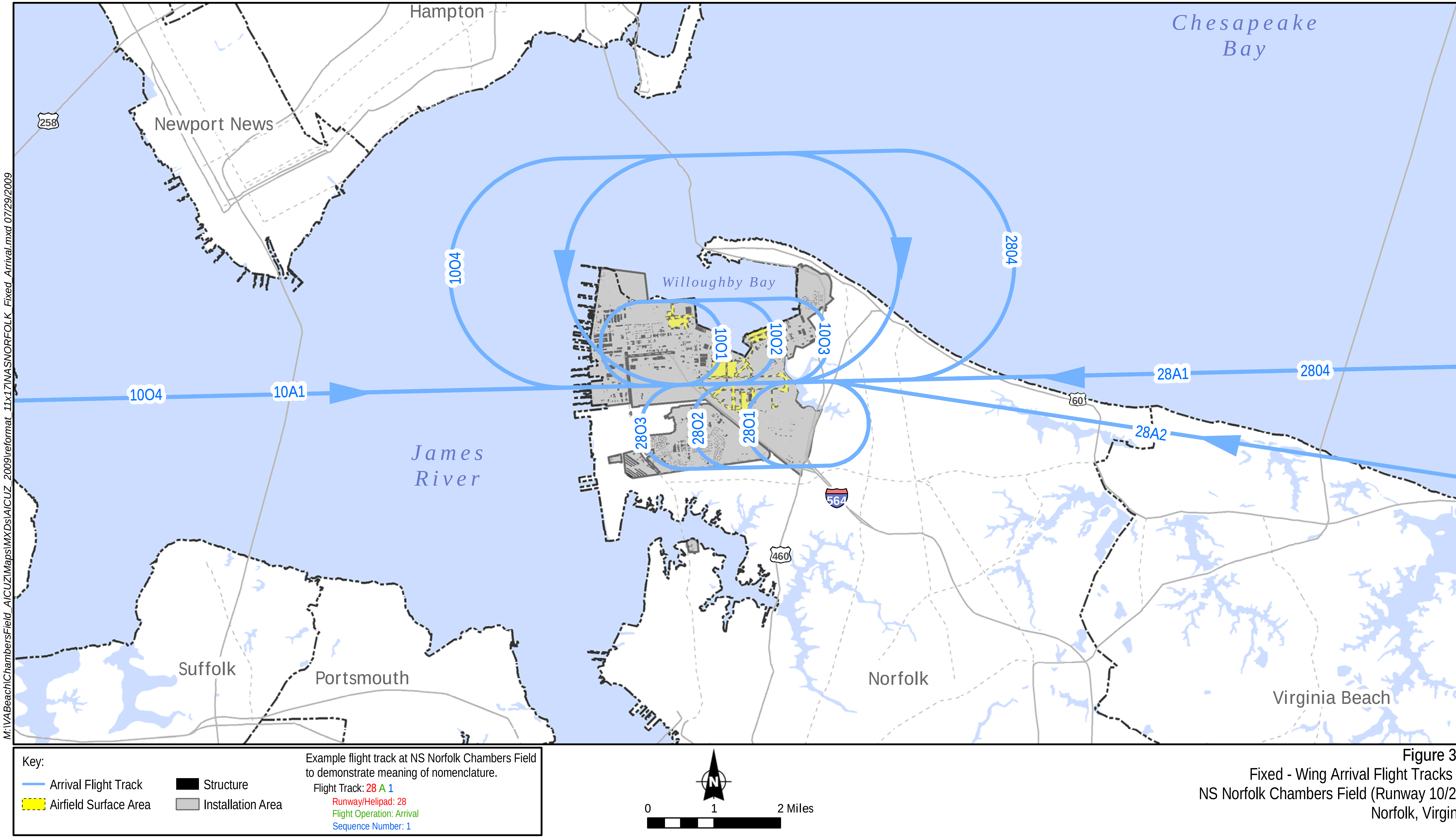


Figure 3-2
Fixed - Wing Arrival Flight Tracks at
NS Norfolk Chambers Field (Runway 10/28)
Norfolk, Virginia

Fixed - Wing Departure Flight Tracks

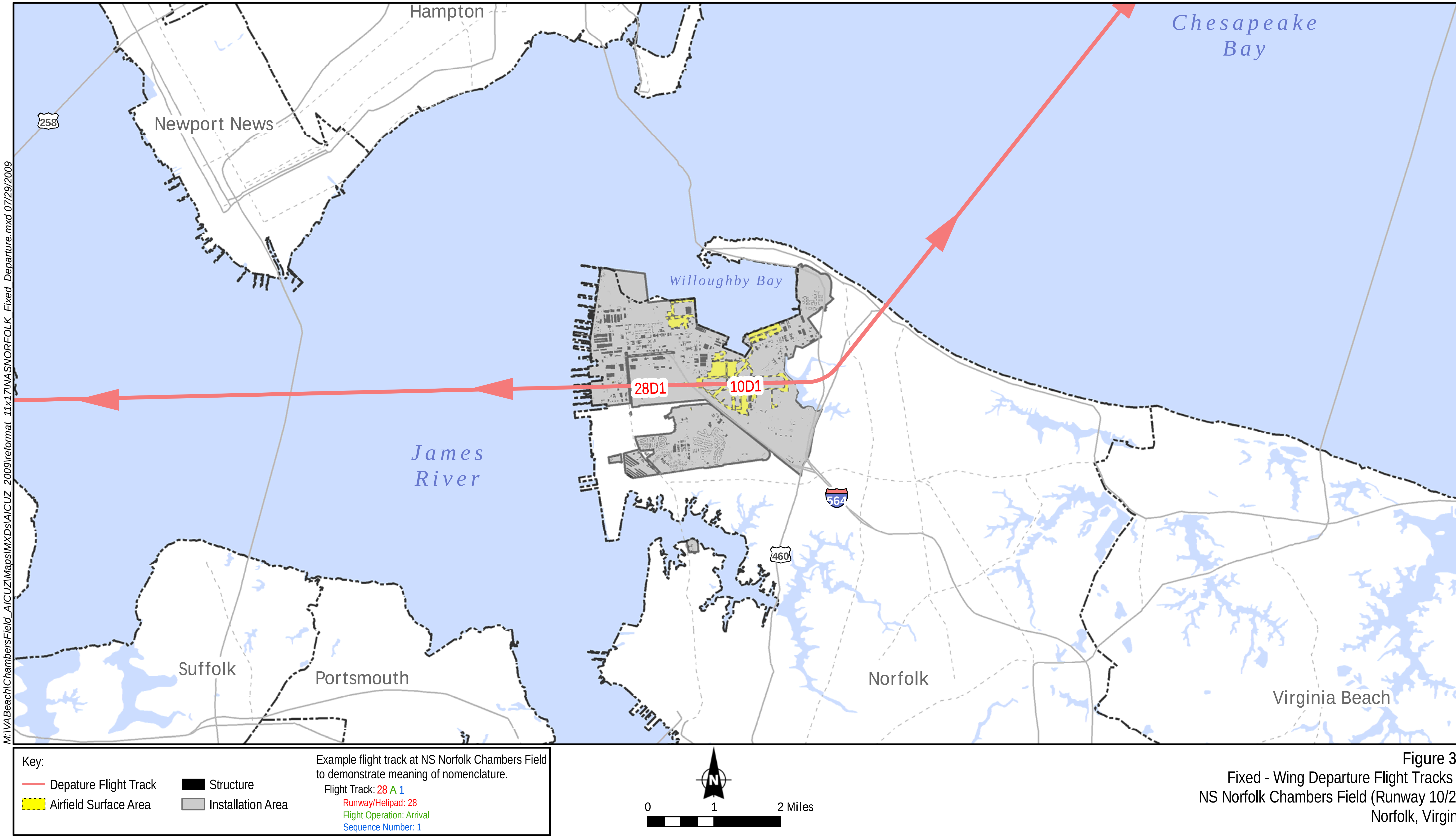
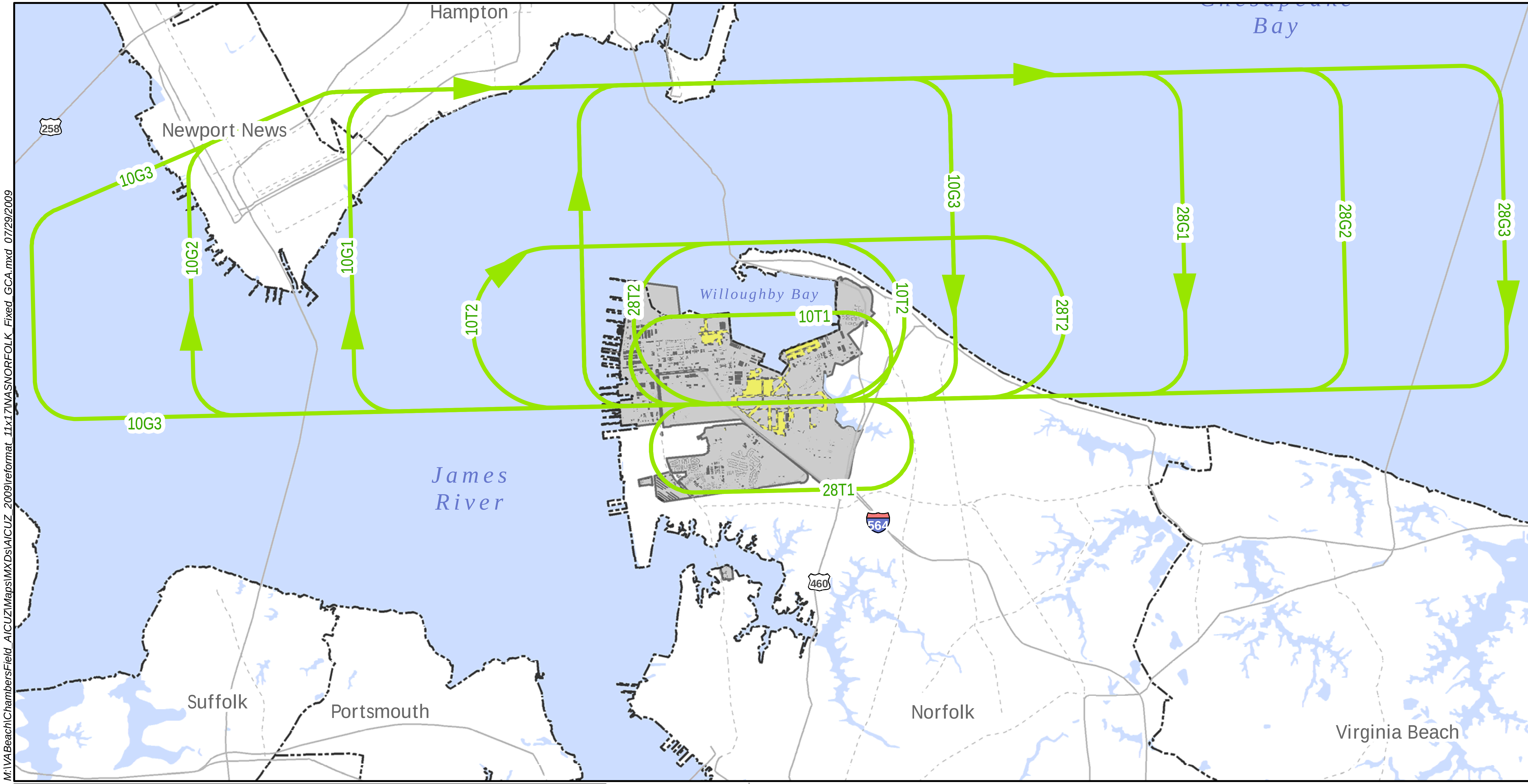


Figure 3-3
Fixed - Wing Departure Flight Tracks at
NS Norfolk Chambers Field (Runway 10/28)
Norfolk, Virginia

Fixed - Wing Pattern (GCA\Touch-and-Go) Flight Tracks



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Key:
- Pattern (GCA/Touch-and-Go) Flight Tracks
- Airfield Surface Area
- Structure
- Installation Area

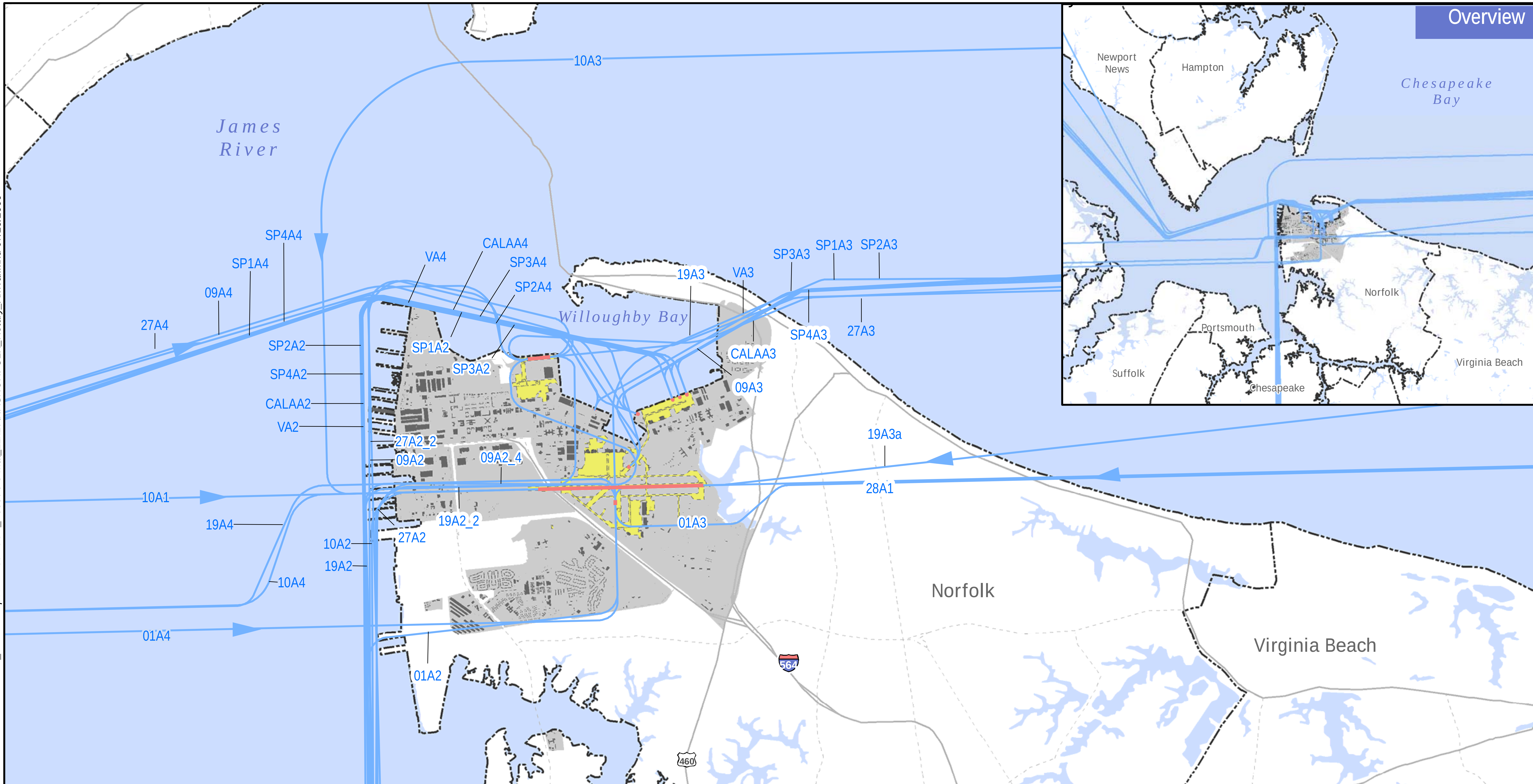
Example flight track at NS Norfolk Chambers Field to demonstrate meaning of nomenclature.
Flight Track: 28 A 1
Runway/Helipad: 28
Flight Operation: Arrival
Sequence Number: 1

N

0 1 2 Miles

Figure 3-4
Fixed - Wing Pattern (GCA\Touch-and-Go) Flight Tracks at NS Norfolk Chambers Field (Runway 10/28)
Norfolk, Virginia

Rotary - Wing Arrival Flight Tracks



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Key:

- Helicopter Operation Areas
- Rotary-Wing Arrival Flight Track
- Airfield Surface Area
- Structure
- Installation Area

Example flight track at NS Norfolk Chambers Field to demonstrate meaning of nomenclature.

Flight Track: 28 A 1

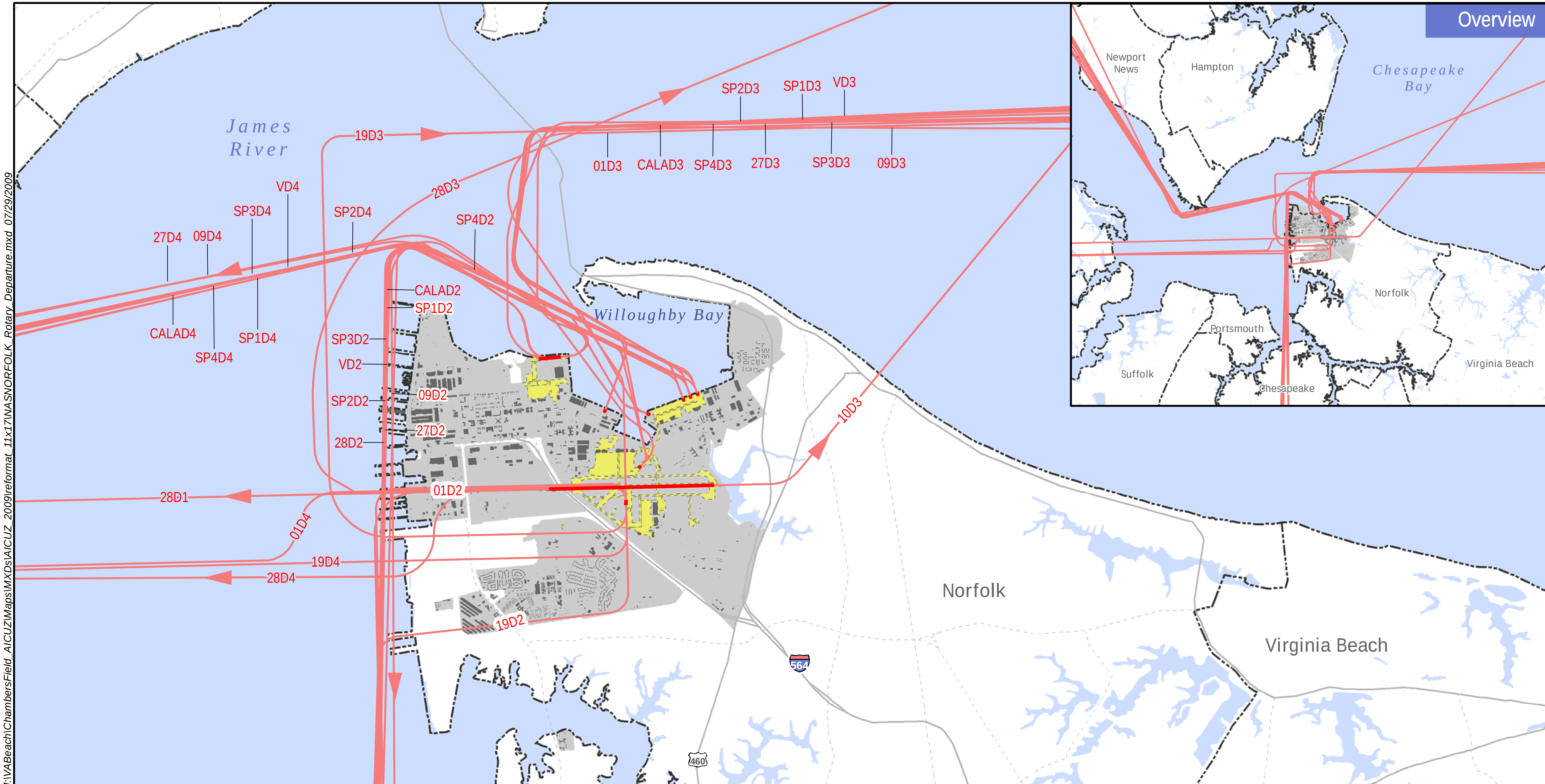
Runway/Helipad: 28

Flight Operation: Arrival

Sequence Number: 1

Figure 3-5
Rotary - Wing Arrival Flight Tracks
at NS Norfolk Chambers Field
Norfolk, Virginia

Rotary - Wing Departure Flight Tracks



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Key:

- Helicopter Operation Area
- Rotary-Wing Departure Flight Track
- Airfield Surface Area
- Structure
- Installation Area

Example flight track at NS Norfolk Chambers Field to demonstrate meaning of nomenclature.

Flight Track: 28 A 1
Runway/Helipad: 28
Flight Operation: Arrival
Sequence Number: 1

Figure 3-6
Rotary - Wing Departure Flight Tracks
at NS Norfolk Chambers Field
Norfolk, Virginia

Rotary - Wing Pattern (GCA\Touch-and-Go) Flight Tracks

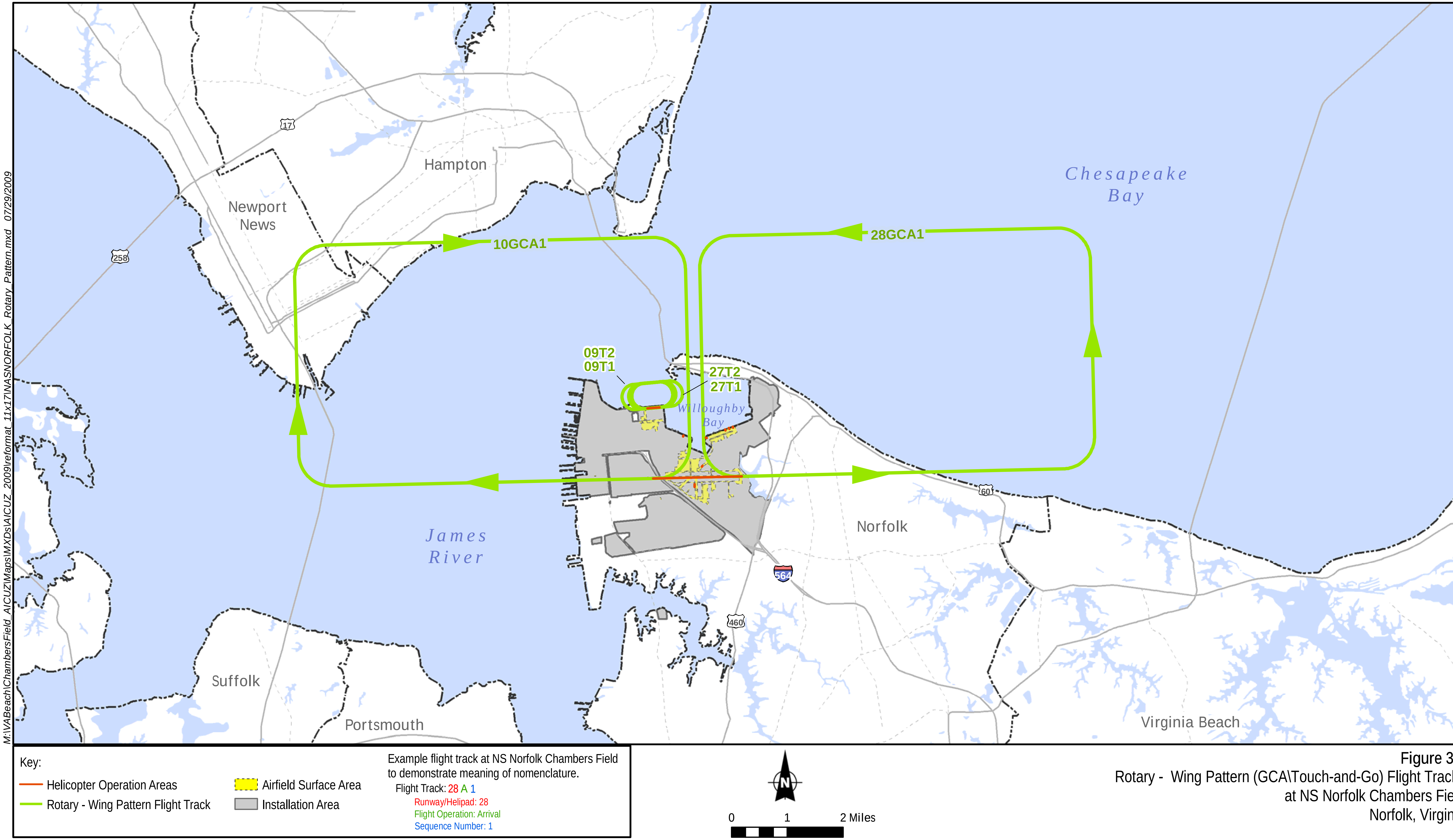


Figure 3-7
Rotary - Wing Pattern (GCA\Touch-and-Go) Flight Tracks
at NS Norfolk Chambers Field
Norfolk, Virginia

4 Aircraft Noise

The impact of aircraft noise is a critical factor in planning future land use near air facilities. Because the noise from aircraft operations significantly impacts areas surrounding an installation, NS Norfolk Chambers Field has defined certain areas as high noise zones under the AICUZ Program. This section discusses noise associated with aircraft operations at NS Norfolk Chambers Field, including average noise levels, noise complaints, noise abatement/flight procedures, and noise contours.

Chapter 4

4.1 What is Sound/Noise?

Sound is vibrations in the air, which can be generated by a multitude of sources. Some of the potential sources of noise include roadway traffic, land use activities, railway activities, and aircraft operations. Noise occurs when the sound is judged to be unwanted. Generally, sound becomes noise to a listener when it interferes with normal activities. For further discussion of noise and its effect on people and the environment, the Navy developed a detailed noise analysis that explains noise and noise exposure issues in great detail and is included as Appendix A.

Noise exposure at NS Norfolk Chambers Field is measured using the day-night average sound level noise metric (DNL).

In this document, all sound or noise levels are measured in A-weighted decibels (dBA), which represent sound pressure adjusted to the range of human hearing with an intensity greater than the barely audible sound. This is set at 0 dB. Normal speech has a sound level of approximately 60 to 65 dBA. Generally, a sound level above 120 dBA will begin to provide discomfort to a listener (Berglund and Lindvall 1995), and the threshold of pain is 140 dBA.

Typical A-weighted Sound Levels and Common Sounds

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

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

The noise exposure from aircraft at NS Norfolk Chambers Field, as with other 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 the Community Noise Exposure Level [CNEL]). DNL averages the sound energy from aircraft operations at a location over a 24-hour period. DNL also adds an additional 10 decibels to events occurring between 10:00 p.m. to 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.

By combining factors most noticeable about noise annoyance—maximum noise levels, duration, and the number of events over a 24-hour period—DNL provides a single measure of overall noise impact. Scientific studies and social surveys conducted to evaluate community annoyance to all types of environmental noise have found DNL to be the best correlation to community annoyance (FICUN 1980, U.S. Environmental Protection Agency [EPA] 1982, American National Standards Institute [ANSI] 1990, Federal Interagency Committee on Noise [FICON] 1992).

Although DNL provides a single measure of overall noise impact, it does not provide specific information on the number of noise events or the individual sound levels that occur during the day. For example, a day-night average sound level of 65 dBA could result from a few noisy events or a large number of quieter events.

The DNL is depicted visually as a noise contour that connects points of equal value. The noise contours in this document are depicted in 5-dBA increments. The AICUZ Program generally divides noise exposure into three categories known as noise zones:

- **Noise Zone 1:** Less than 65 DNL;
- **Noise Zone 2:** 65 to 75 DNL; and
- **Noise Zone 3:** Greater than 75 DNL.

Noise Zone 1 (less than 65 DNL) is generally considered an area of low or no noise impact. Noise Zone 2 (65 to 75 DNL) is an

For land use planning purposes, noise zones are grouped into three noise zones:

Noise Zone 1 (less than 65 DNL) generally considered an area of low or no noise impact.

Noise Zone 2 (65 to 75 DNL) is an area of moderate impact, where some land use controls are required.

Noise Zone 3 (greater than 75 DNL) is the most severely impacted area and requires the greatest degree of land use control.

area of moderate impact, where some land use controls are required. Noise Zone 3 (greater than 75 DNL) is the most severely impacted area and requires the greatest degree of land use control.

4.2 Airfield Noise Sources

The main sources of noise at airfields are flight operations or pre-flight and/or maintenance run-ups. Computer models are used to develop noise 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 pre-flight and maintenance run-ups;
- Terrain;
- Surface type; and
- Environmental data (temperature and humidity).

4.3 Noise Complaints

In general, 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 a 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.

As with most airports, NS Norfolk Chambers Field receives noise complaints, typically numbering between 15 and 20 per year. As would be expected, the complaints normally rise in the warmer weather months when windows are opened and people are outside their homes.

Table 4-1
Subjective Response to Noise

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

Noise complaints originating from operations at NS Norfolk Chambers Field are handled through representatives in the Operations Center. The public is able to call in a noise concern to the installation (757/322-3429) where the Assistant Operations Duty Officer (AODO) records the specifics of the caller's concern in a noise complaint form (i.e., date, time, location). The noise complaint form is then passed to the NS Norfolk Chambers Field Airfield Manager who conducts an investigation and may place a follow-up call to the complainant, if warranted, and then files the noise concern appropriately. A copy of the noise complaint form is also sent to NAS Oceana as part of a joint filing system.

4.4 Noise Abatement at NS Norfolk Chambers Field

The following are operational noise abatement procedures that have been adopted at NS Norfolk Chambers Field:

NS Norfolk Chambers Field is proactive with respect to **noise abatement** and is committed to minimizing noise impacts without compromising operational and safety requirements.

NS Norfolk Chambers Field

- Pilots following approved and published flight patterns consistently and without deviation, provides the best possible solution for noise abatement. All aircraft personnel at NS Norfolk Chambers Field will comply with these procedures whenever possible, consistent with safety of flight.

Hours

- Noise abatement hours are established from 11:00PM – 7:00AM Sunday night through Saturday morning and from 11:00PM Saturday night until 1:00PM Sunday afternoon. During these times, the following restrictions apply:

  (1) Landings and takeoffs at the airfield are restricted to those necessary for operational or training flights.
  (2) Touch-and-go landings and low approaches are prohibited.
  (3) Maintenance engine/aircraft turn-ups are prohibited unless necessary for operational or training flights.
  (4) Afterburner takeoffs are prohibited unless necessary for operational or training flights.

Engine Run-up/Turn-up Areas

- When Runway 28 is in use at NS Norfolk Chambers Field, pilots will perform run-ups on the northeast taxiway prior to taxiing to Runway 28. This will mitigate noise impacts from run-ups at the end of Runway 28 (near Merrimack Park) prior to takeoff.

- When performing engine run-ups at the approach end of Runway 28, pilots should exercise caution in directing the prop or jet blast due to the close proximity of Patrol Road.

NS Norfolk Chambers Field is continuously evaluating noise abatement procedures and implements any changes as part of the on-going process. For example, to reduce noise impacts to areas south of the airfield, when E-2s are operating on Runway 28 using left-hand traffic flow, they are required to climb to 500-feet prior to initiating their crossing turn.

4.5 Noise Contours

The Navy utilizes two **computerized noise models** to project noise contours for NS Norfolk Chambers Field – **NOISEMAP (fixed-wing) and RNM (rotary-wing).**

In support of this AICUZ Study, a noise analysis was conducted to define noise exposure contours at NS Norfolk Chambers Field. The Navy utilized two computer models to determine noise exposure. These were NOISEMAP, a widely accepted computer model that projects noise impacts around military airfields for fixed-wing aircraft and Rotorcraft Noise Model (RNM), which provides a more accurate analysis of the unique noise impacts associated with rotary-wing aircraft. Both NOISEMAP and RNM calculate DNL contours resulting from aircraft operations using such variables as power settings, aircraft model and type, maximum sound levels, and duration and flight profiles for a given airfield. The noise contours from the two computer models are then combined to 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) and are organized into three noise zones for land use planning purposes - Noise Zone 1 (less than 65 DNL), Noise Zone 2 (65 to 75 DNL), and Noise Zone 3 (greater than 75 DNL).

Calculated noise contours do not represent exact measurements. Noise levels inside a contour may be similar to those outside a contour line. If the contour lines are close together, the change in noise level is greater. If the lines are far apart, the change in noise level is gradual.

4.5.1 2009 AICUZ Noise Contours for NS Norfolk Chambers Field

The AICUZ process calls for evaluation of existing aircraft operations as well as any future aircraft operational changes that can be reasonably predicted for the air station. Prospective flight operations, including noise associated with new helicopter pad and run-up locations, were modeled as part of the 2009 noise contours.

Prospective flight operations at NS Norfolk Chambers Field that were modeled as part of the 2009 noise contours include the transition of the E-2C to the E-2D and the introduction of new models of the MH-60 aircraft (and associated increase aircraft loading at NS Norfolk Chambers Field).

The 2009 AICUZ noise contours for NS Norfolk Chambers Field are shown in Figure 4-1. The noise contours are centered on aircraft activities along Runway 10/28 and the various helicopter pad areas along the northern portion of the installation. The noise contours extend outside of the installation's boundaries in several areas, including to west and north over water (James River and Willoughby Bay), to the south west over a land area just outside the installation's property, and to the east over a large portion of land including several neighborhoods, which will be discussed further in Section 6.

Figure 4-2 shows DNL contours for NS Norfolk Chambers Field with the inclusion of a color gradient applied to the various noise zones. The figure illustrates that the noise from the air station does not stop at the 60dB DNL contour line. It extends beyond 60dB down to the less than 45dB DNL level and beyond.

4.5.2 Comparison of 1999 (2005 JLUS) and 2009 AICUZ Noise Contours

This section compares the 2009 AICUZ noise contours (which are based upon the projected operations out to 2015) to the contours contained in the Hampton Roads JLUS, referred to as the 1999 noise contours. 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.

The comparison of the 1999 noise contours and the 2009 AICUZ noise contours at NS Norfolk Chambers Field reveals an increase in area from the 1999 noise zones (see Figure 4-3), mostly occurring within the installation's property boundaries or over water. Areas off installation property and over land that appear to have an increase in noise are to the southwest of NS Norfolk Chambers Field and to the east of the installation along East Ocean Avenue.

2009 AICUZ Noise Contours

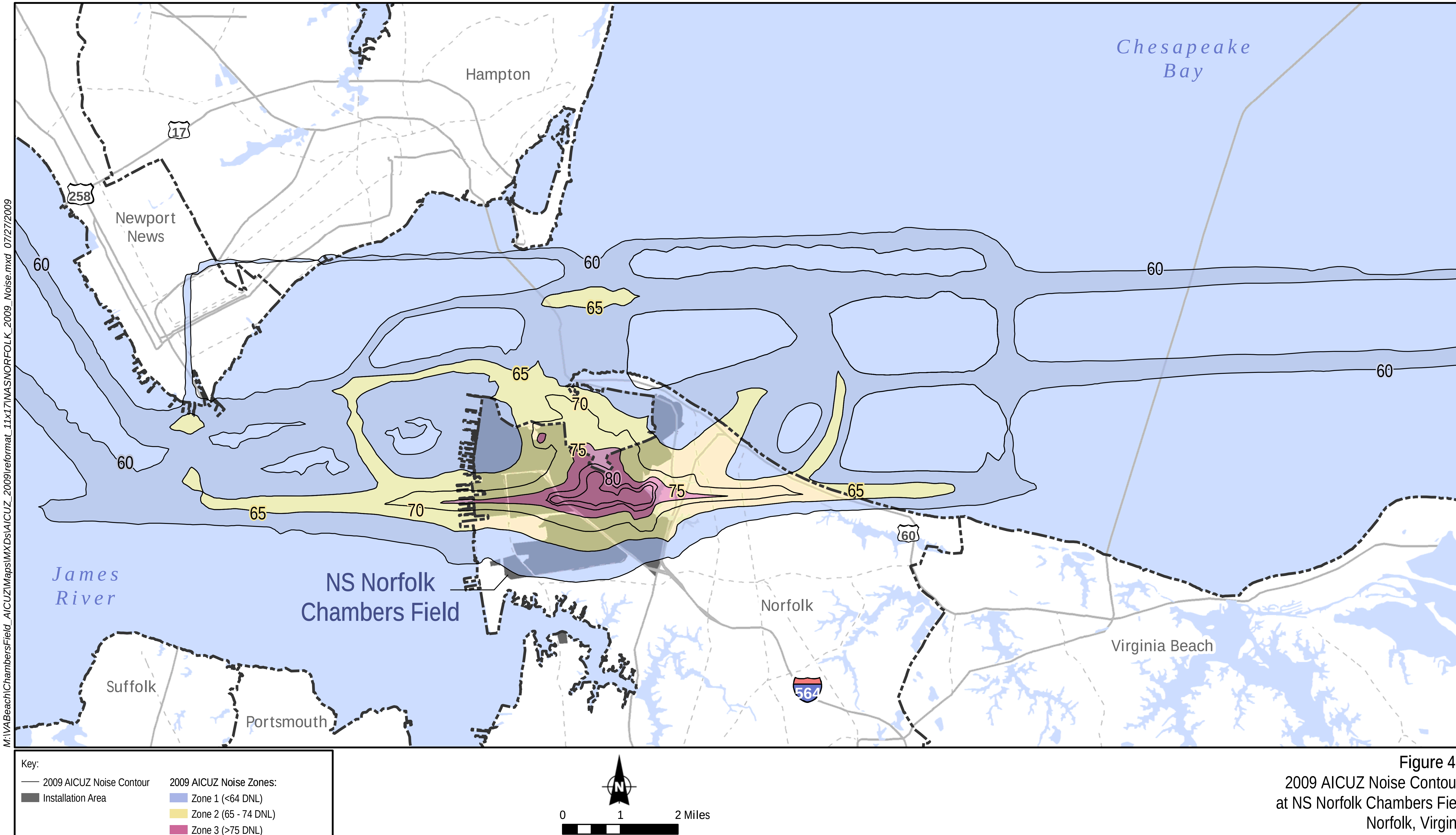
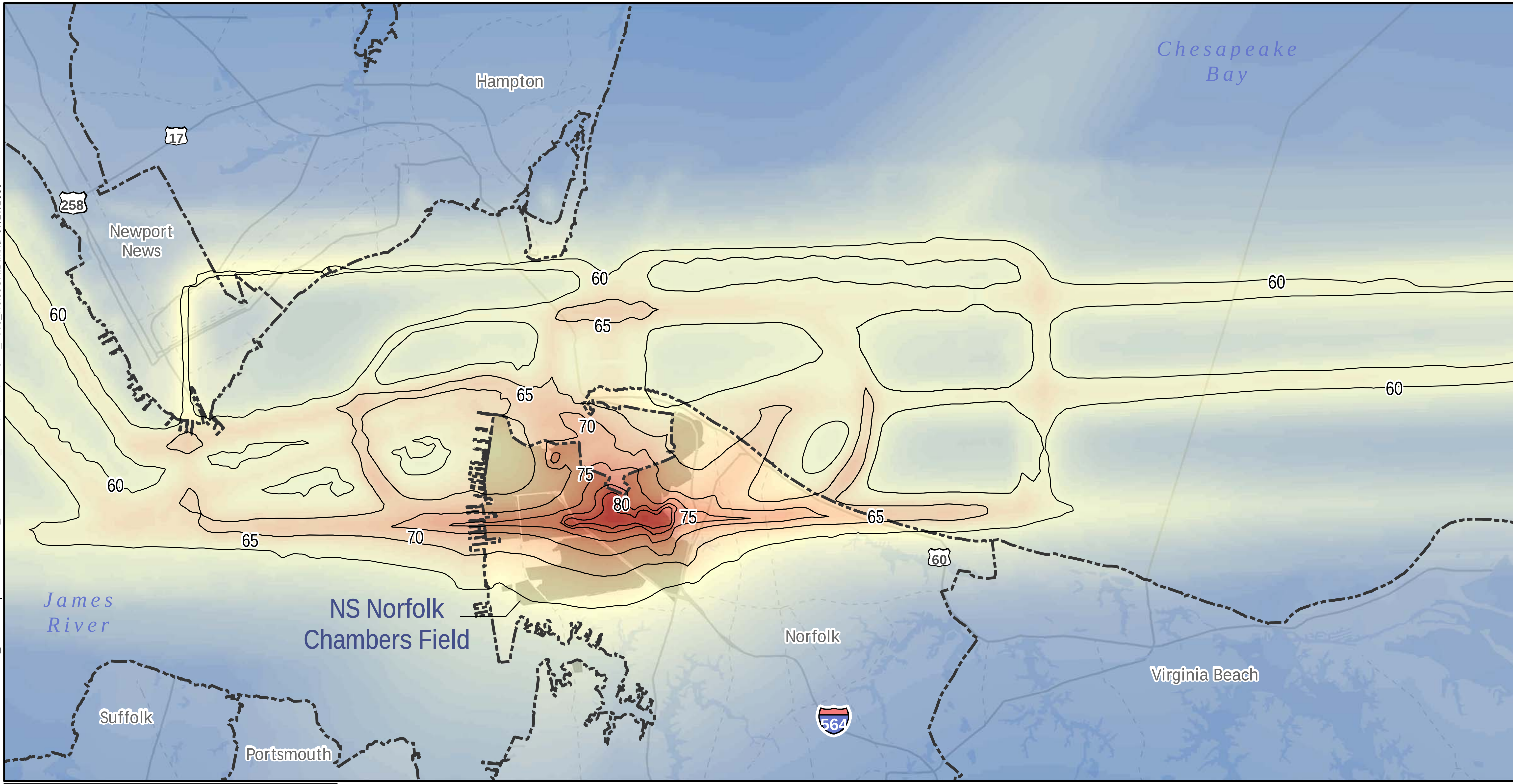


Figure 4-1
2009 AICUZ Noise Contours
at NS Norfolk Chambers Field
Norfolk, Virginia

2009 AICUZ Noise Contours and Graduated Noise Propagation



Key:
2009 AICUZ Noise Contour
Installation Area
DNL Value (dB)
High : 88
Low : 31

N
0 1 2 Miles

Figure 4-2
2009 AICUZ Noise Contours and
Graduated Noise Propagation
at NS Norfolk Chambers Field
Norfolk, Virginia

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Comparison of 1999 and 2009 AICUZ Noise Contours

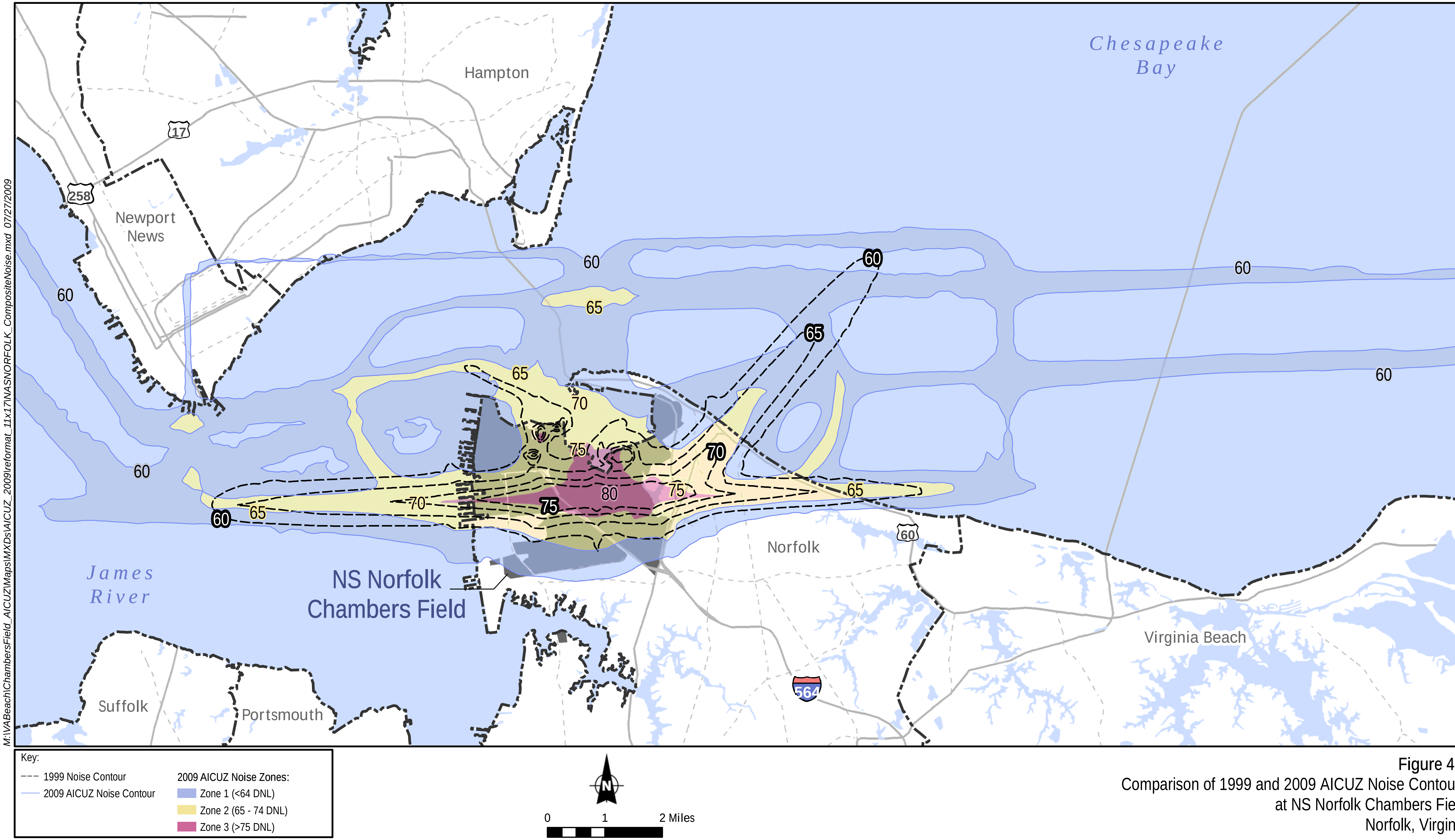


Figure 4-3
Comparison of 1999 and 2009 AICUZ Noise Contours
at NS Norfolk Chambers Field
Norfolk, Virginia

Overall, the area covered by the noise zones (not including water or on-station acreage) increased 1,912 acres between the 1999 noise contours and the 2009 AICUZ noise contours, as shown in Table 4-2. The majority of this, 1,198 acres (63%), was within the 60 to 65 dB DNL noise contour, which is considered part of Noise Zone 1 (areas below 65 DNL).

Table 4-2
Areas within Noise Contours (DNL)
(1999 and 2009)
NS Norfolk Chambers Field

Noise Contour (DNL)	Total Land Area[1]		
	1999 AICUZ Noise Contours (acres)	2009 AICUZ Noise Contours (acres)	Change in Area of Noise Contours (acres)
60-65 DNL	1,060	2,258	1,198
65-70 DNL	770	1,424	654
70-75 DNL	388	455	67
75 + DNL	182	175	-7
Total Area	**2,400**	**4,312**	**1,912**

Note:
[1] Does not include on-station acreage or any area over water.

The increase in the size of the noise contour from 1999 to 2009 can be attributed to several factors. First, based upon the anticipated increase in aircraft activity at NS Norfolk Chambers Field, a higher number of annual aircraft operations were modeled for the 2009 AICUZ noise contours. Second, many of the airframes have been replaced with newer models since the 1999 noise contours were modeled. These newer aircraft oftentimes generate more noise per operation than their predecessors. Finally, the 1999 noise contours for rotary-wing aircraft were modeled using NOISEMAP, because RNM was not available at the time. For the 2009 AICUZ noise contours, RNM was utilized to model the rotary-wing aircraft, which is a more accurate model for determining noise exposure, and may have resulted in larger contours in the northern area where helicopter operations dominate the noise environment (along the GCA pattern for helicopters).

5 Airfield Safety

The United States Department of the Navy (Navy) identifies airfield safety issues for all of its airfields. These safety issues include accident potential and hazards within the airfield vicinity.

Hazards are defined as anything that obstructs or interferes with an aircraft and its arrivals, departures, pilot vision, communications, or aircraft electronics. Hazards are defined as anything that obstructs or interferes with an aircraft and its arrivals, departures, pilot vision, communications, or aircraft electronics. NS Norfolk Chambers Field also occasionally conducts armed aircraft operations, which underscores safety at the installation as a paramount issue.

The Navy also identifies Accident Potential Zones (APZs) around its runways based on historical data for aircraft mishaps. While the likelihood of an aircraft mishap occurring is remote, the Navy identifies APZs to assist in land use planning. The Navy recommends certain land uses that concentrate large numbers of people – such as apartments, churches, and schools – be constructed outside the APZs.

In addition, the FAA and the military have defined flight safety zones (imaginary surfaces) below aircraft arrival and departure flight tracks and surrounding the airfield. For the safety of the aircraft, the heights of structures and vegetation are restricted in these zones. The flight safety zones are designed to minimize the potential harm if a mishap does occur.

Other hazards to flight safety that should be avoided in the airfield vicinity include:

- Uses that would attract birds, especially waterfowl (i.e., landfills or water features);
- Lighting (direct or reflected) that would impair pilot vision;
- Uses that would generate smoke, steam, or dust; and

- Electromagnetic interference (EMI) with aircraft communication, navigation, or other electrical systems.

5.1 Accident Potential Zones

5.1.1 Aircraft Mishaps

In the 1970s, recognizing the need to identify areas of accident potential, the military conducted studies of historic accident and operations data throughout the military. The study showed that most aircraft mishaps occur on or near the runway or along the centerline of the runway, diminishing in likelihood with distance. Based on the study, the DoD has identified APZs as areas where an aircraft accident is most likely to occur (if one was to occur); however, the APZs do not reflect the probability of an accident. APZs follow departure, arrival, and pattern flight tracks and are based upon analysis of historical data.

The most severe category for aircraft mishaps is a Class A mishap. This is an accident in which the total cost of damage to property or aircraft exceeds $1 million, an aircraft is destroyed or missing, or any fatality or permanent total disability results from the direct involvement of naval aircraft.

There have been five (5) Class A mishaps at NS Norfolk Chambers field in the past 20 years, none of which resulted in more than minor injuries and there were no fatalities associated with these mishaps, in addition, all five occurred on or near the fixed-wing/rotary-wing operating areas on the air station (Naval Safety Center 2009).

5.1.2 Fixed-wing APZ Configurations and Areas

Clear Zones and APZs are areas in the vicinity of airfield runways where an aircraft mishap is most likely to occur. While the likelihood of a mishap is remote, the Navy recommends land uses within APZs are low-density to ensure the maximum protection of public health and property. The DoD uses two classes of fixed-wing runways (Class A and Class B) for the purpose of defining APZs. A Class A runway is intended primarily for small light aircraft whereas a Class B runway can accommodate heavy aircraft and/or have the potential for development to heavy aircraft use. NS Norfolk Chambers Field is a Class B runway.

The components of standard APZs for Class B runways are defined (OPNAVINST 11010.36C) as follows:

- **Clear Zone.** The Clear Zone is a trapezoidal area lying immediately beyond the end of the runway and outward along the extended runway centerline for a distance of 3,000 feet. The Clear Zone measures 1,500 feet in width at the runway threshold and 2,284 feet in width at the outer edge. The Clear Zone is required for all active runways and should remain undeveloped.

- **APZ I.** APZ I is the rectangular area beyond the Clear Zone which still has a measurable potential for aircraft accidents relative to the Clear Zone. APZ I is provided under flight tracks which experience 5,000 or more annual operations (departures or approaches). APZ I is typically 3,000 feet in width and 5,000 feet in length and may be rectangular or curved to conform to the shape of the predominant flight track.

- **APZ II.** APZ II is the rectangular area beyond APZ I (or the Clear Zone if APZ I is not used), which 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. The dimensions of APZ II are typically 3,000 feet in width and 7,000 feet in length and, as with APZ I, may be curved to correspond with the predominant flight track.

The components of standard APZs for Class B runways are identified in Figure 5-1.

An accident is more likely to occur in APZ I than APZ II, and is more likely to occur in the Clear Zone than in APZ I or APZ II. An APZ II area is designated whenever APZ I is required. APZs extend from the end of the runway, but apply to the predominant arrival and departure flight tracks used by the aircraft. Therefore, if an airfield has more than one predominant flight track to or from the runway, APZs can extend in the direction of each flight track (see Figure 5-1).

Within the Clear Zone, most uses are incompatible with military aircraft operations. For this reason, the Navy's policy is to acquire sufficient real property interests in land within the Clear Zone to ensure incompatible development does not occur. Within APZ I and APZ II, a variety of land uses are compatible; however, people-intensive uses (e.g., schools and apartments) should be restricted because of the greater risk in these areas. When events resulting in threats to the operational integrity from incompatible development (encroachment) occur, and when local communities are unwilling or unable to take the necessary steps to combat the encroachment threat via their own land use and zoning authority, consideration will be given by the Navy for land acquisition, with priority to Clear Zones and secondary priority to APZs

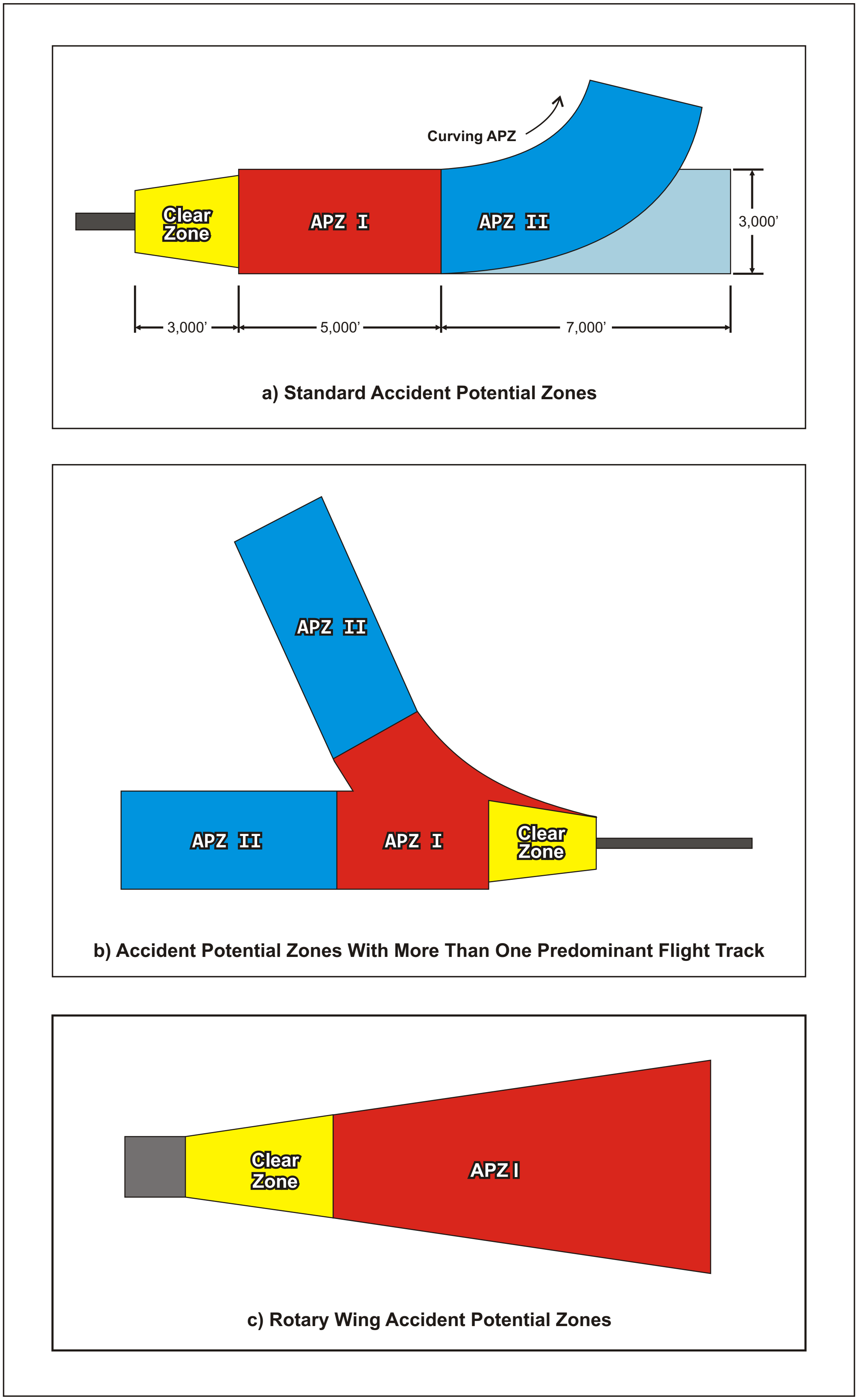
In addition to the Clear Zone, there is a lateral Clear Zone, also called the primary surface that extends outwards from each side and for the length of the runway. The width of the primary surface area for Class B Runways is 1,500 feet (see Section 5.2.1 – Imaginary Surfaces for more details).

5.1.3 Rotary-wing APZ Configurations and Areas

APZs for helicopters are much smaller than those for fixed-wing aircraft and are outlined below:

- **Clear Zone.** The Takeoff Safety Zone for visual flight rules (VFR) rotary-wing facilities shall be used as the Clear Zone. The Takeoff Safety Zone is that area under the VFR approach/departure surface until that surface is 50 feet above the established landing area elevation.

02:002215\B2595-NU08_03-NAS Pax River - Fig 5-1 APZs.cdr



a) Standard Accident Potential Zones

b) Accident Potential Zones With More Than One Predominant Flight Track

c) Rotary Wing Accident Potential Zones

Figure 5-1 Accident Potential Zones for Class B Runway and Helicopter Pads

- **APZ I.** An area beyond the Clear Zone for the remainder of the approach/departure zone, which is defined as the area under the VFR approach/departure surface until that surface is 150 feet above the established landing area elevation.
- **APZ II.** Normally not applied to helicopter flight paths unless the local accident history indicates the need for additional protection (No APZ II areas are present for NS Norfolk Chambers Field).

The Clear Zones for helicopters are provided for all Visual Flight Rules (VFR) landing pads/runways. The use of APZ I is provided for all VFR landing pads/runways located at air installations that support daily training and operations missions. Normally, helipads provided to support administrative functions and hospitals, which generate a low volume of helicopter operations, do not require APZ I or APZ II.

5.1.4 Comparison of 1999 (2005 JLUS) and 2009 AICUZ APZs

Figure 5-2 illustrates the modeled APZs for both fixed-wing and rotary-wing aircraft generated as part of this AICUZ and Figure 5-3 compares the 1999 APZs and the 2009 AICUZ APZs at NS Norfolk Chambers Field. Table 5-1 provides a comparison of the acreages (not including over water or on-station acreage) consumed by the Clear Zone and each APZ. Because the rotary-wing aircraft APZs do not extend off-station, none of the acreage totals listed in Table 5-1 are associated with rotary-wing APZs.

Table 5-1
Fixed-Wing and Rotary-Wing AICUZ APZs
(1999 and 2009)
NS Norfolk Chambers Field

APZ	Total Land Area[1]		
	1999 AICUZ APZs (acres)	2009 AICUZ APZs (acres)	Change in Area of APZs (acres)
Clear Zone	111	111	0
APZ I	723	606	-117
APZ II	569	656	87
Total Area	**1,403**	**1,373**	**-30**

Note:
[1] Does not include on-station acreage or any area over water.

As both the table and figure illustrate, there is little change (slight reduction) between the 1999 APZs and the 2009 AICUZ APZs. The fixed-wing APZs remain essentially the same as the general arrival and departure flight tracks that warrant APZs have not changed. There has been a slight shift to the south that relates to adjustments made to Flight Track 10D1 utilizing Runway 10/28. This change in the location and size of the APZs associated with this flight track brings the APZs into compliance with correct APZ size specifications outlined in OPNAVINST 11010.36C.

The helicopter APZs have changed slightly; however, all APZs associated with helicopter operations are contained within the NS Norfolk Chambers Field property. Thus, there are no off-station areas affected or major concerns with the changes depicted.

The change in the number of acres contained within the APZs decreased by 30 acres. There was a shift in the proportion of acres contained with in APZ I and APZ II (with the number in APZ II increasing in 2009). This was due to the shift in the APZs associated with Flight Track 10D1 noted above.

5.2 Flight Safety

Flight safety refers to important safety steps taken and/or measures implemented to ensure both pilot safety during aircraft operations and the safety of those on the ground including those that live and work in the vicinity of an air station. This section discusses flight safety issues such as imaginary planes and transition surfaces, Bird/Animal Strike Hazard (BASH) issues, and measures to avoid other potential pilot interferences, such as EMI, smoke, dust, steam, and lighting.

5.2.1 Imaginary Surfaces

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, such as buildings, towers, poles, and other vertical obstructions to airspace navigation. Brief descriptions of the imaginary surfaces for Class B runways are provided in Table 5-2. These areas are also labeled on Figure 5-4. Figure 5-5 shows the composite imaginary and transitional surfaces at NS Norfolk Chambers Field. Certain uses (i.e., wind turbine farms) would constitute vertical obstructions within the installation's airspace.

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

Planes and Surfaces	Geographical Dimensions
Class B	
Primary Surface	Aligned (longitudinally) with each runway and extending 200 feet from each runway end. The width is 1,500 feet.
Clear Zone	Located immediately adjacent to the end of the runway and extends 3,000 feet beyond the end of the runway and is 1,500 feet wide and flares out to 2,284 feet wide. The Clear Zone is subdivided into Types I, II, and III to define the degree of restrictive use. Type I: This zone is immediately adjacent to the end of the runway. It should be cleared, graded, and free of above ground objects (except for airfield lighting) and is to receive special ground treatment or pavement in the area designated as the runway overrun. This type of clear zone is required at both ends of all runways. Type II: This zone is used only for Class B runways, and is an extension of the Type I clear zone except that the width is reduced. The Type II clear zone shall be graded and cleared of all above ground objects (except for airfield lighting). Type III: This zone is laterally adjacent to the Type II clear zone for Class B runways. Objects in this zone shall not penetrate the approach departure clearance surface. Trees, shrubs, bushes or any other natural growth shall be topped 10 feet below the approach-departure clearance surface or to a lesser height if necessary to insure visibility of airfield lighting. Buildings for human habitation shall not be sited in the Type III clear zone even if they would not penetrate the approach-departure clearance surface.

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

Planes and Surfaces	Geographical Dimensions
Approach-Departure Clearance Surfaces	An inclined or combination inclined and horizontal plane, symmetrical about the runway centerline. The slope of the surface is 50:1 until an elevation of 500 feet and continues horizontally 50,000 feet from the beginning. The outer width is 16,000 feet.
Inner Horizontal Surface	An oval shaped plane 150 feet above the established airfield elevation. Constructed by scribing an arc with a radius of 7,500 feet around the centerline of the runway.
Outer Horizontal Surface	A horizontal plane located 500 feet above the established airfield elevation, extending outward from the conical surface for 30,000 feet.
Conical Surface	An inclined plane that extends from the inner horizontal surface outward and upward at a 20:1 slope and extends for 7,000 feet and to a height of 500 feet above the established airfield elevation.
Transitional Surface	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 and the runway centerline, extended at a slope of 7:1 from the sides of the primary surface and from the sides of the approach surfaces.

Source: U.S. Department of Transportation – Federal Aviation Administration 2006, Navy 1982.

5.2.2 Bird/Animal Strike Hazard

Wildlife represents a significant hazard to flight operations. Birds, in particular, are drawn to the open, grassy areas and warm pavement of airfields. Although most bird and animal strikes do not result in crashes, they 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:

- Waste disposal operations;
- Wastewater treatment facilities;
- Landfills;
- Golf courses;
- Wetlands;
- Dredge disposal sites;
- Seafood processing plants; and

- Stormwater ponds.

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

NS Norfolk Chambers Field has an active BASH program. The airfield safety officer is the acting BASH coordinator, and they have a cooperative working relationship with the NAS Oceana safety officer and their wildlife experts to aid in managing the program at NS Norfolk Chambers Field.

5.2.3 Electromagnetic Interference (EMI)

New generations of military aircraft are highly dependent on complex electronic systems for navigation and critical flight and mission-related functions. A portion of these operations at the installation include armed aircraft and advanced weapons systems. Consequently, care should be taken in siting any activities that create EMI. Consequently, care should be taken in siting any activities that create EMI. EMI is defined by the ANSI as any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics/electrical equipment. It can be induced intentionally, as in forms of electronic warfare, or unintentionally, as a result of accidental emissions and responses, such as high tension line leakage. Additionally, EMI may be caused by atmospheric phenomena, such as lightning and precipitation static, and by non-telecommunication equipment, such as vehicles and 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 could obstruct the pilot's vision during takeoff, landing, or other periods of low-altitude flight.

2009 AICUZ APZs

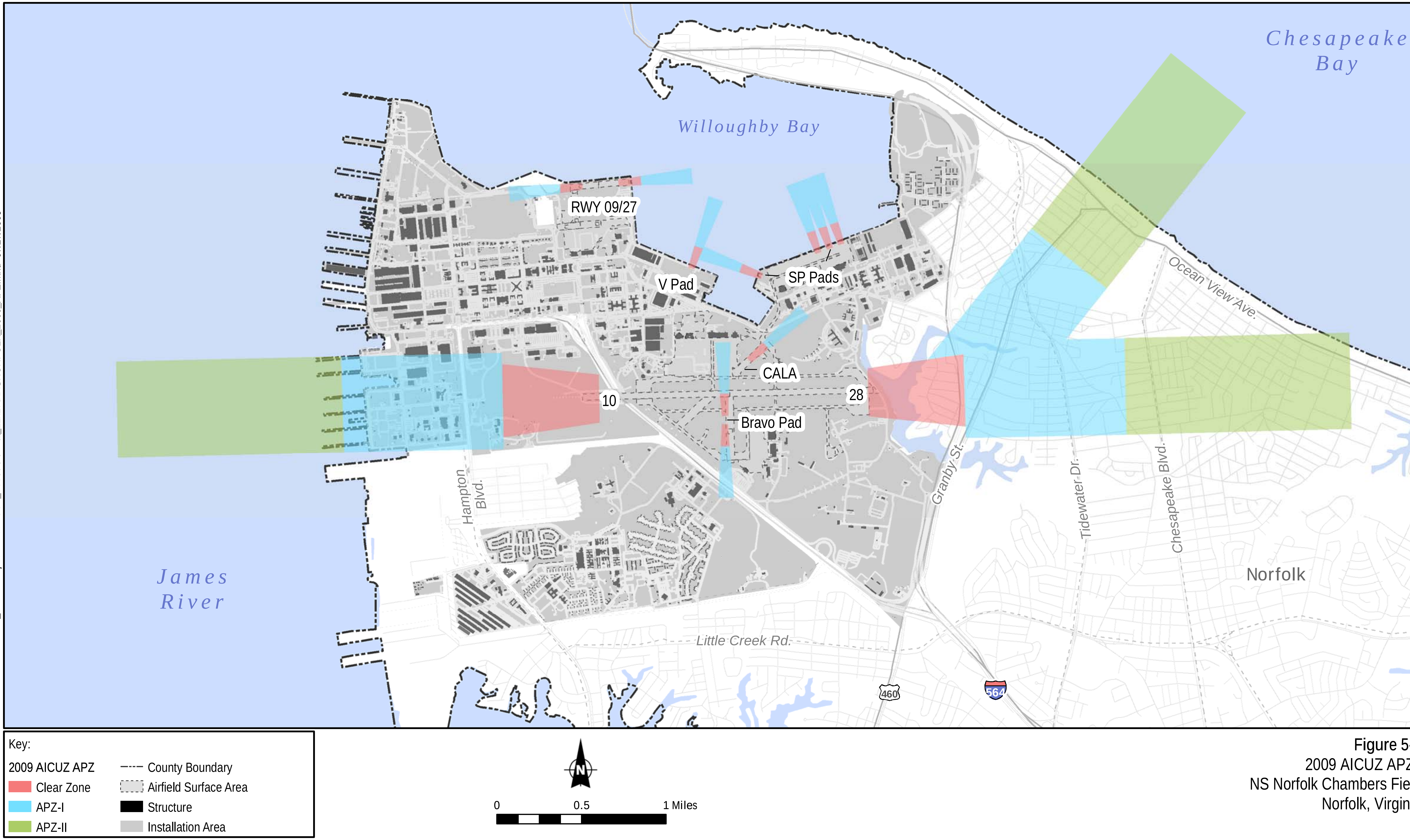


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Figure 5-2
2009 AICUZ APZs
NS Norfolk Chambers Field
Norfolk, Virginia

Comparison of 1999 and 2009 AICUZ APZs

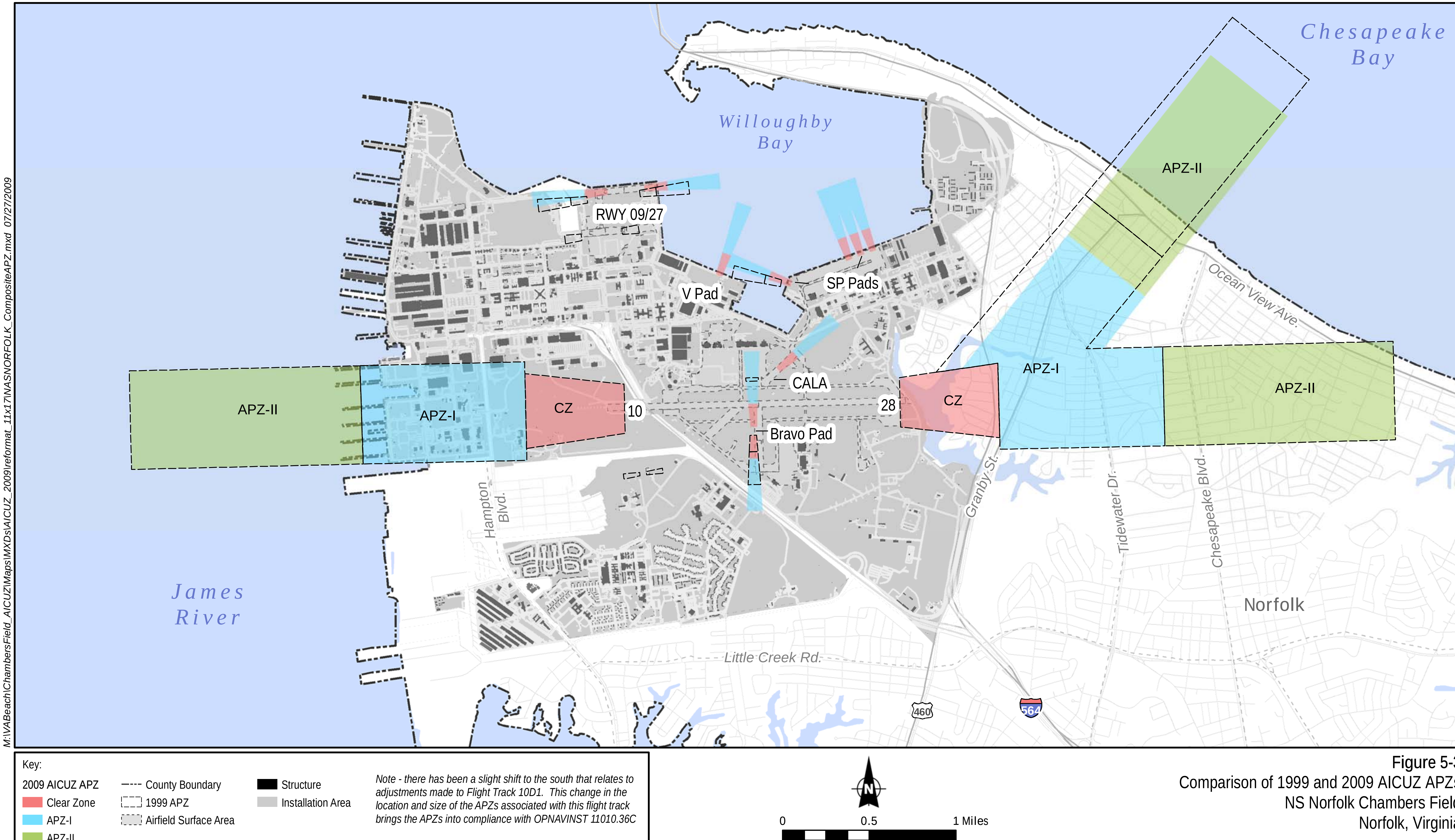
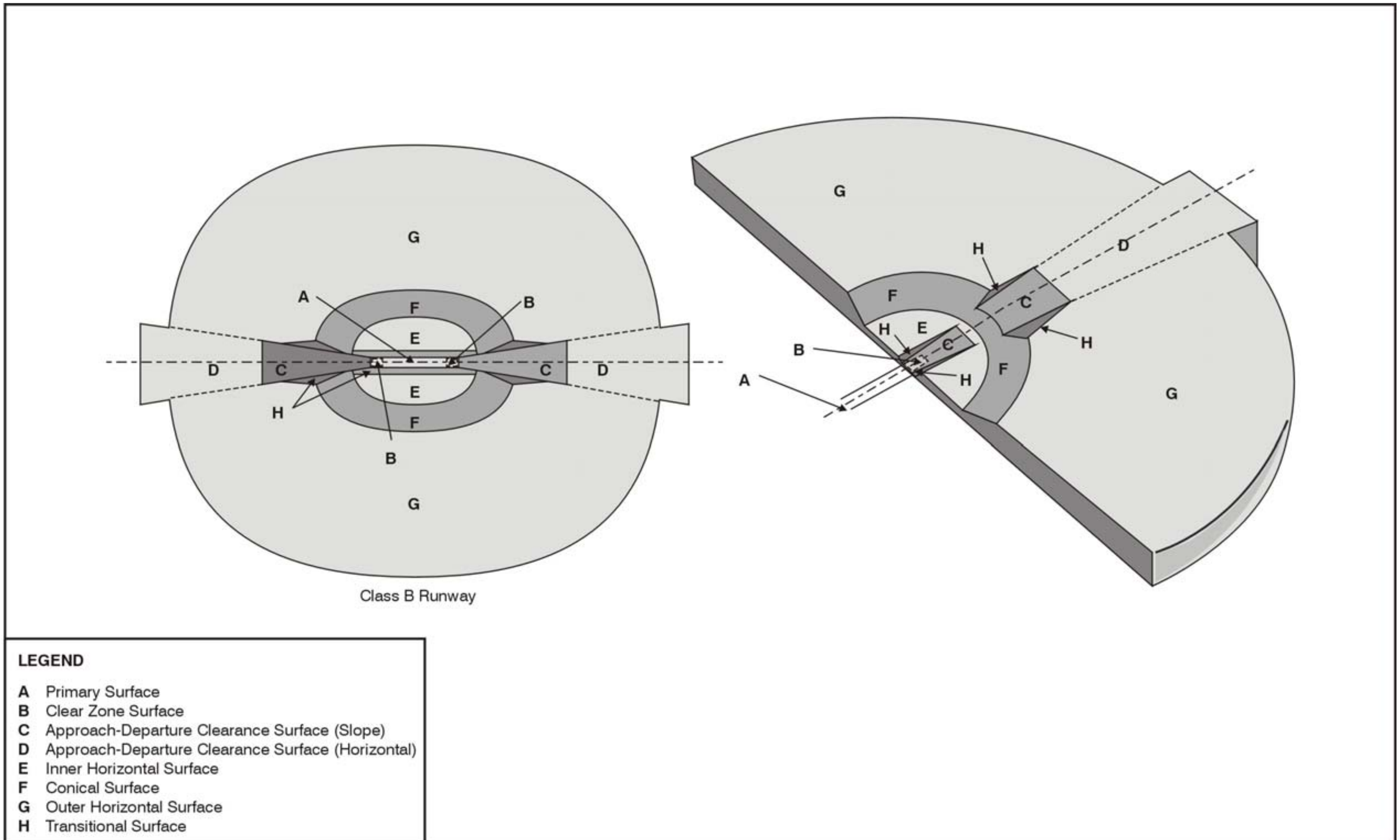


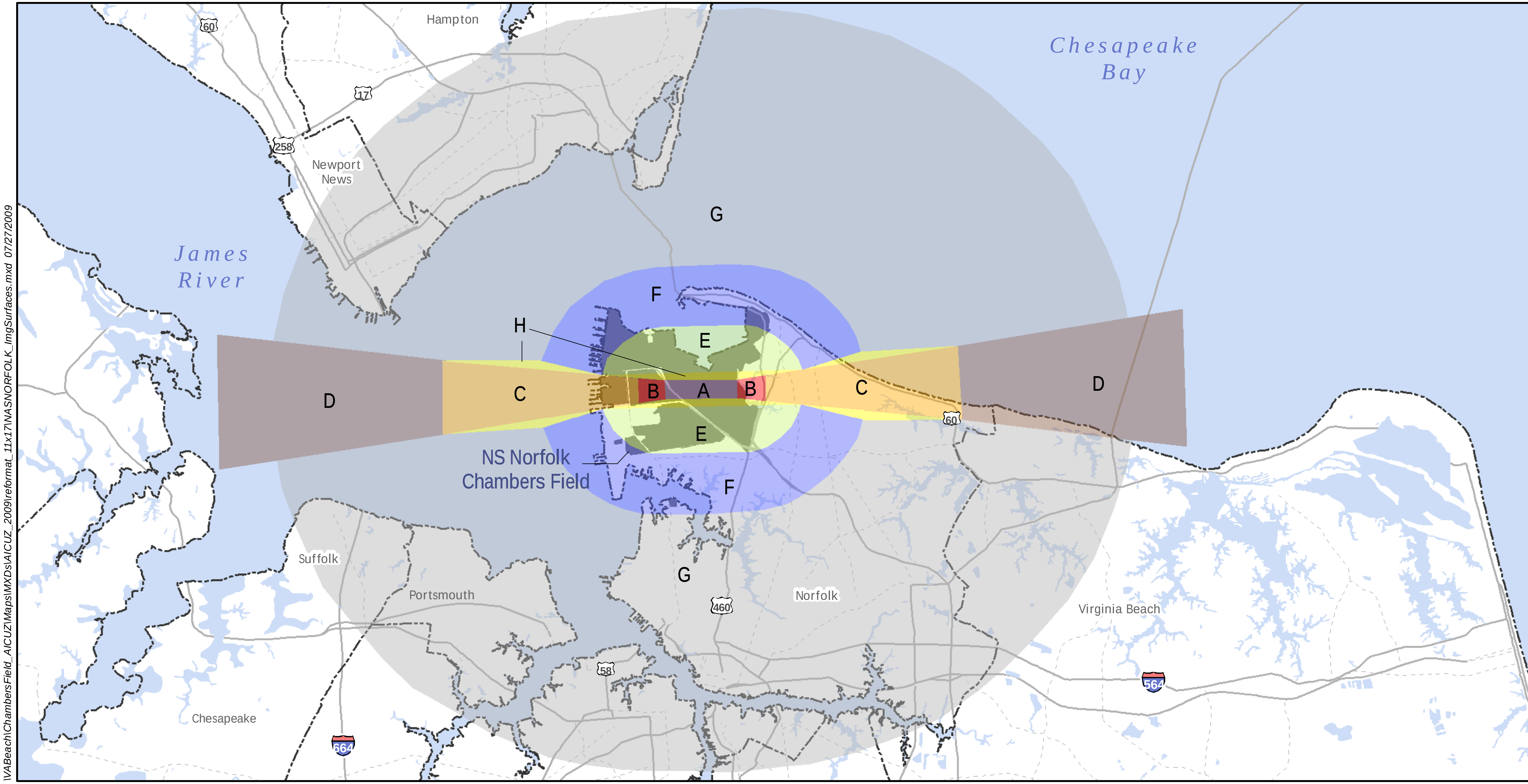
Figure 5-3
Comparison of 1999 and 2009 AICUZ APZs
NS Norfolk Chambers Field
Norfolk, Virginia



SOURCE: US Department of the Navy 1999.

Figure 5-4
Imaginary Surfaces and Transition Planes for Class B Fixed-Wing Runways

Imaginary Surfaces and Transition Planes



Key:

Installation Area	
A: Primary Surface	
B: Clear Zone Surface	
C: Approach-Departure Clearance Surface (Sloped)	
D: Approach-Departure Clearance Surface (Horizontal)	
E: Inner Horizontal Surface	
F: Conical Surface	
G: Outer Horizontal Surface	
H: Transitional Surface	

Figure 5-5
Imaginary Surfaces and Transition Planes
at NS Norfolk Chambers Field
Norfolk, Virginia

6 Land Use Compatibility Analysis

Chapter 6

The APZs and noise contours make up the AICUZ zones for an air installation. The AICUZ zones define the minimum recommended acceptable area within which land use controls are needed to protect the health, safety, and welfare of those living or working near a military airfield and to preserve the defense flying mission. The AICUZ zones combined with the AICUZ guidance and recommendations set forth in this AICUZ Study are the fundamental tools necessary for the AICUZ planning process. It is recommended that the AICUZ noise zones and APZs be adopted into the City of Norfolk's planning process to best guide compatible development around the installation.

This section addresses land use compatibility within aircraft noise zones and APZs by examining zoning and existing and planned land uses near NS Norfolk Chambers Field. This section begins with a description of the local planning authority - the City of Norfolk, then provides a discussion of the generalized land use compatibility criteria used to evaluate land use compatibility in an AICUZ and is followed by a land use compatibility assessment.

6.1 Planning Authority

The development and control of lands outside of the military installation is beyond the control of the base commander at NS Norfolk. Development of these lands is dictated by local comprehensive land use planning along with regulations.

The local planning authority in the City of Norfolk is the Department of Planning and Community Development. The Department houses the divisions of Planning, Building Safety, and Housing. The two primary roles of the Department are to provide comprehensive planning services and oversight of construction and building safety.

The City of Norfolk Planning Commission is located in the Department of Planning and Community Development. It is the seven-member body appointed by the City Council that is responsible for the review of land use and zoning matters for the City of Norfolk. The City Planning Commission also develops "The General Plan" for the City, a plan for land use and development in the City. Staffed by members of the Department of Planning and Community Development, the Commission only makes recommendations for land use and zoning, the City Council makes all final decisions and is responsible for final approvals of changes or plans related to land use and zoning.

In addition, the City of Norfolk is a member municipality of the Hampton Roads Planning District Commission (HRPDC), which is one of 21 "planning district commissions" in the Commonwealth of Virginia, whose purpose is "…to encourage and facilitate local government cooperation and state-local cooperation in addressing on a regional basis problems of greater than local significance." The HRPDC provides additional resources to aid municipalities, such as the City of Norfolk, to work with other local municipalities in a coordinated fashion – an example of which is the development of the Hampton Roads JLUS that was discussed previously in Section 1.4.

6.2 Land Use Compatibility Guidelines and Classifications

> The Navy's land use compatibility guidelines recommend that noise-sensitive land uses be placed outside high-noise zones, and people-intensive uses not be placed in APZs.

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

Additionally, Table 6-1 shows existing generalized land use classifications and the associated land-use compatibility with each land use designation for noise zones and APZs. The generalized land use categories highlighted in Table 6-1 do not represent the local community's land use designations. Local land use and zoning are discussed in Section 6.3. Table 6-1 provides generic land use categories for the purpose of illustrating a basic and high level understanding of land use compatibility across some common land use types.

Table 6-1
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		Clear Zone	APZ I	APZ II
	<55	55-64	65-69	70-74	75-79	>80			
Single Family Residential	Compatible	Compatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Compatible (1)
Multi-Family Residential, Transient Lodging	Compatible	Compatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible
Public Assembly	Compatible	Compatible	Compatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible
Schools and Hospitals	Compatible	Compatible	Compatible (2)	Compatible (2)	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible
Manufacturing (ex. Petrol/chem.; textile)	Compatible	Compatible	Compatible	Compatible	Incompatible	Incompatible	Incompatible	Incompatible	Compatible
Parks	Compatible	Compatible	Compatible	Compatible	Incompatible	Incompatible	Incompatible	Compatible (4)	Compatible (4)
Business Services	Compatible	Compatible	Compatible	Compatible (2)	Compatible (2)	Incompatible	Incompatible	Compatible (3)	Compatible (3)
Agriculture, Forestry and Mining	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible

Source: Adapted from OPNAVINST 11010.36C

Notes:
This generalized land-use table provides an overview of recommended land use. To determine specific land-use compatibility, see Appendix B.
(1) = Maximum density of 1-2 dwellings per acre.
(2) = Land use and related structures generally compatible however, measures to achieve recommended noise- level reduction should be incorporated into design and construction of the structures.
(3) = Maximum Floor Area Ratio that limit people density may apply
(4) = Facilities must be low intensity.

Key:
Compatible (green)
Incompatible (red)

6.3 Existing Land Use and Zoning

The City of Norfolk has a total land area of 54 square miles (140 square kilometers), with an additional 43 square miles (110 square kilometers) of water area, for a total of approximately 97 square miles (250 square kilometers). The City of Norfolk is also bordered by the cities of Virginia Beach, Chesapeake, and Portsmouth. The City of Norfolk is a largely developed urban center and zoned with a mix of residential, commercial, and industrial development. Land use patterns and zoning in the immediate vicinity of the installation are discussed below.

6.3.1 Existing Land-Use

Land use surrounding NS Norfolk Chambers Field features a wide range of uses including residential (both single-family and multi-family), hotels, restaurants, professional offices, light industrial and technology parks, and retail establishments. Figure 6-1 illustrates land uses surrounding NS Norfolk Chambers Field. It should be noted that the area to the southwest of NS Norfolk Chambers Field, known as Glenwood Park, is classified in the City's land use data set as "industrial." However, the current use of this area is actually residential and commercial.

The northern and western borders of NS Norfolk Chambers Field border water – James and Elizabeth River (west) and Willoughby Bay (north). To the south of the installation, there is a mix of industrial uses, along with low-, medium-, and high-density residential development. (The City of Norfolk considers areas with 8.7 units or less per net residential acre low-density residential, between 8.8 and 20 units per net residential acre is medium-density residential, and above 20.1 units per net residential acre is considered high-density.) There is also a pocket of commercial and residential uses along Hampton Boulevard bordering NS Norfolk Chambers Field property. This is the Glenwood Park neighborhood, which includes commercial and residential land uses as well as a church.

Immediately to the east of NS Norfolk Chambers Field is a cemetery (Forest Lawn Cemetery), along with low- and medium-density residential development. Moving farther to the east towards Ocean View Avenue, the area transitions to several land uses, including mostly low-density residential, with medium-density and commercial uses increasing closer to the coastline. There are also several parks (i.e., Northside Park) and a golf course (Ocean View Golf Course) in the area to the east of the installation. Several schools and churches were also identified in this area, which will be discussed in more detail in Section 6.4.

Tables 6-2 and 6-3 present existing land uses contained within the 2009 AICUZ noise zones and 2009 AICUZ APZs at NS Norfolk Chambers Field by acreage.

Table 6-2
Existing Land Use Types within 2009 AICUZ Noise Zones
NS Norfolk Chambers Field

Land Use Type	Acres [1]			
	Noise Zone 1 (<64 DNL)	Noise Zone 2 (65-74 DNL)	Noise Zone 3 (75+ DNL)	Total
Commercial	42.3	48.4	0	90.7
Industrial	268.9	243.8	2.5	515.2
Institutional/Public Service/Open Space	521.3	269.4	1.8	792.5
Residential Low Density	**548.4**	**913.9**	**83.4**	**1,545.7**
Residential Medium/High Density	436.3	251.5	34.6	722.4
Total	**1,817.2**	**1,727.0**	**122.3**	**3,666.5**

Note:
[1] Does not include on-station acreage or any area over water.

Composite AICUZ Map with Land Use

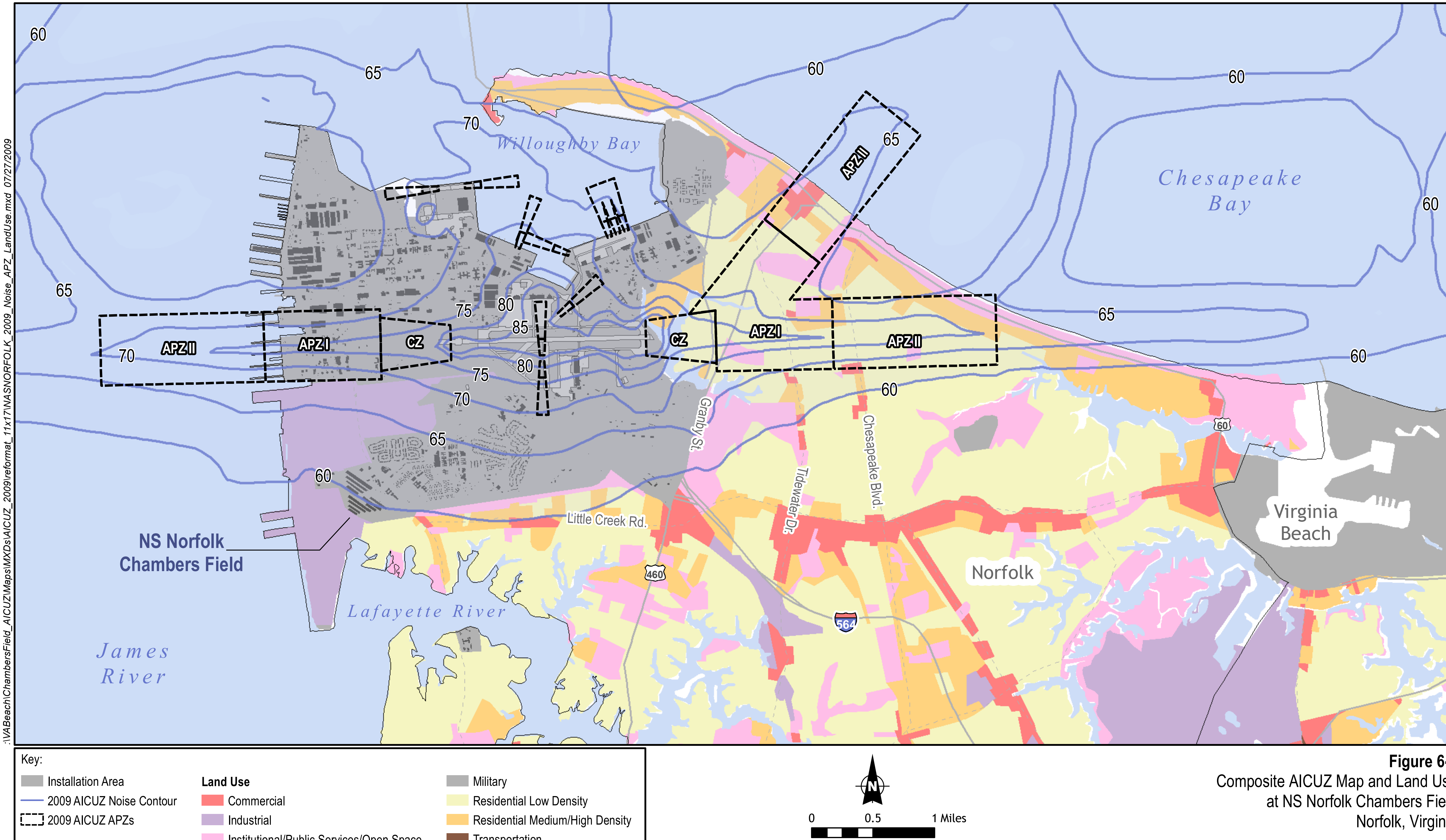


Figure 6-1
Composite AICUZ Map and Land Use at NS Norfolk Chambers Field Norfolk, Virginia

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Table 6-3
Existing Land Use Types within 2009 AICUZ APZs
NS Norfolk Chambers Field

Land Use Type	Acres [1]			
	Clear Zone	APZ I	APZ II	Total
Commercial	0	2.6	42.7	45.3
Industrial	0	0.9	0	0.9
Institutional/Public Service/Open Space	0	101.1	70.7	171.8
Residential Low Density	**75.1**	**446.2**	**423.4**	**944.7**
Residential Medium/High Density	7.8	32.0	113.3	153.1
Total	**82.9**	**582.8**	**650.1**	**1,315.8**

Note:
[1] Does not include on-station acreage or any area over water.

The majority of land covered by the 2009 AICUZ noise contours is "residential low density" with approximately 1,545 acres of land contained with in the noise contours (primarily in Noise Zone 1 and Noise Zone 2). Institutional/Public Service/Open Space and residential medium/high density land uses were second and third, respectively.

The majority of land covered by the 2009 AICUZ APZs is "residential low density." The acres under residential low density are divided relatively evenly between APZ I and APZ II.

6.3.2 Existing Zoning

Figure 6-2 portrays existing zoning in the areas around NS Norfolk Chambers Field. Existing zoning patterns around NS Norfolk Chambers Field include a mix of low, medium, and high-density residentially zoned property, commercial zoning, mixed-use, business zones, recreational and industrial use zoning. In general, the zoning around NS Norfolk Chambers Field reveals a pattern of dense development, as there is very little undeveloped property. High-density and commercial development is concentrated along specific corridors, such as Hampton Boulevard, Little Creek Road, and Ocean View Avenue. Intermixed between these corridors are mostly low-density residential development and some recreational uses.

> The City of Norfolk presents the Navy's AICUZ noise zones and APZs as a layer in their Norfolk Interactive Mapper feature, found on the web at http://gis.norfolk.gov/website/htmlviewer/genmap/viewer.htm.

The City of Norfolk has adopted an Airport Safety Overlay (ASO) District into their City Zoning Ordinance (Article II, Chapter 11-1 "Airport Safety Overlay District ASO"), which addresses obstructions in the vicinity of the airports (Norfolk International Airport and NS Norfolk Chambers Field).

Specifically, the ordinance states that it is "necessary in the interest of public health, safety, and general welfare that the creation or establishment of obstructions that are hazards to air navigation be prevented." The ordinance describes the Airport Safety Zones, where these obstructions should be avoided. The Zones are located beneath the approach surfaces, transitional surfaces, horizontal surfaces, and conical surfaces of the respective airports (these were discussed previously in Section 5.2.1 – Imaginary Surfaces and are depicted in Figures 5-4 and 5-5). Other restrictions that apply in the ordinance follow the flight safety concerns identified in Section 5.2, including electromagnetic interference, lighting/reflection interferences, and BASH. The City of Norfolk's Airport Safety Overlay District ordinance is attached to this study as Appendix C.

The City of Norfolk displays the Navy's noise contours and APZs (from the 2005 Hampton Roads JLUS) via their "Norfolk Interactive Mapper" feature on their website (http://gis.norfolk.gov/website/html viewer/genmap/viewer.htm). This tool allows all those interested in the AICUZ zones for NS Norfolk Chambers Field (e.g. local planners, the public, and private developers) to view where the AICUZ noise contours and APZs fall relative to the neighborhoods of the City of Norfolk. This mapping feature would need to be updated with the 2009 AICUZ noise contours and APZs so the public has the most up-to-date information available (see Section 7.2.2).

6.4 Compatibility Concerns at NS Norfolk Chambers Field

Several incompatible land uses and major existing compatibility concerns exist around NS Norfolk Chambers Field (see Figure 6-3).

Composite AICUZ Map with Zoning

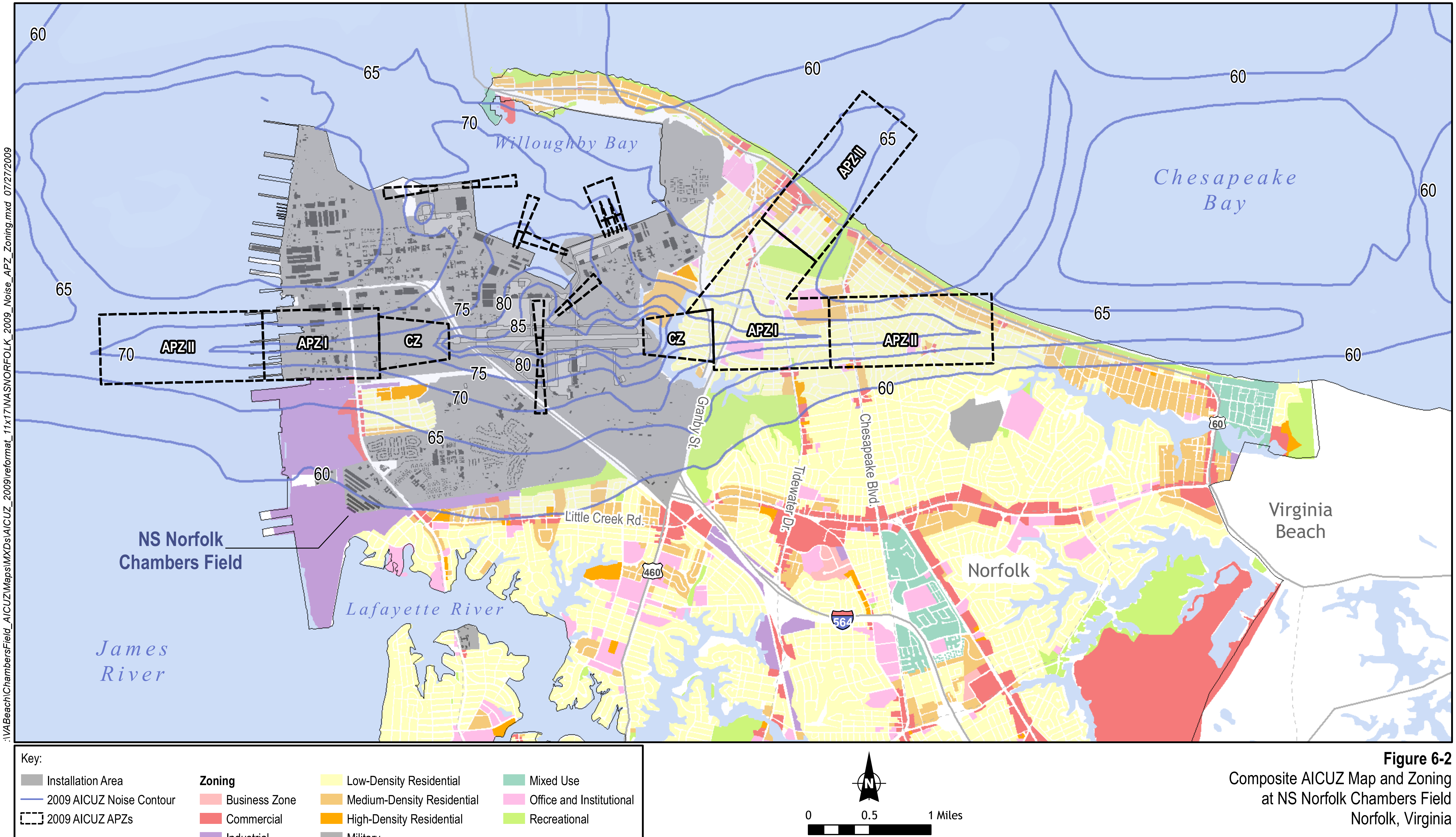
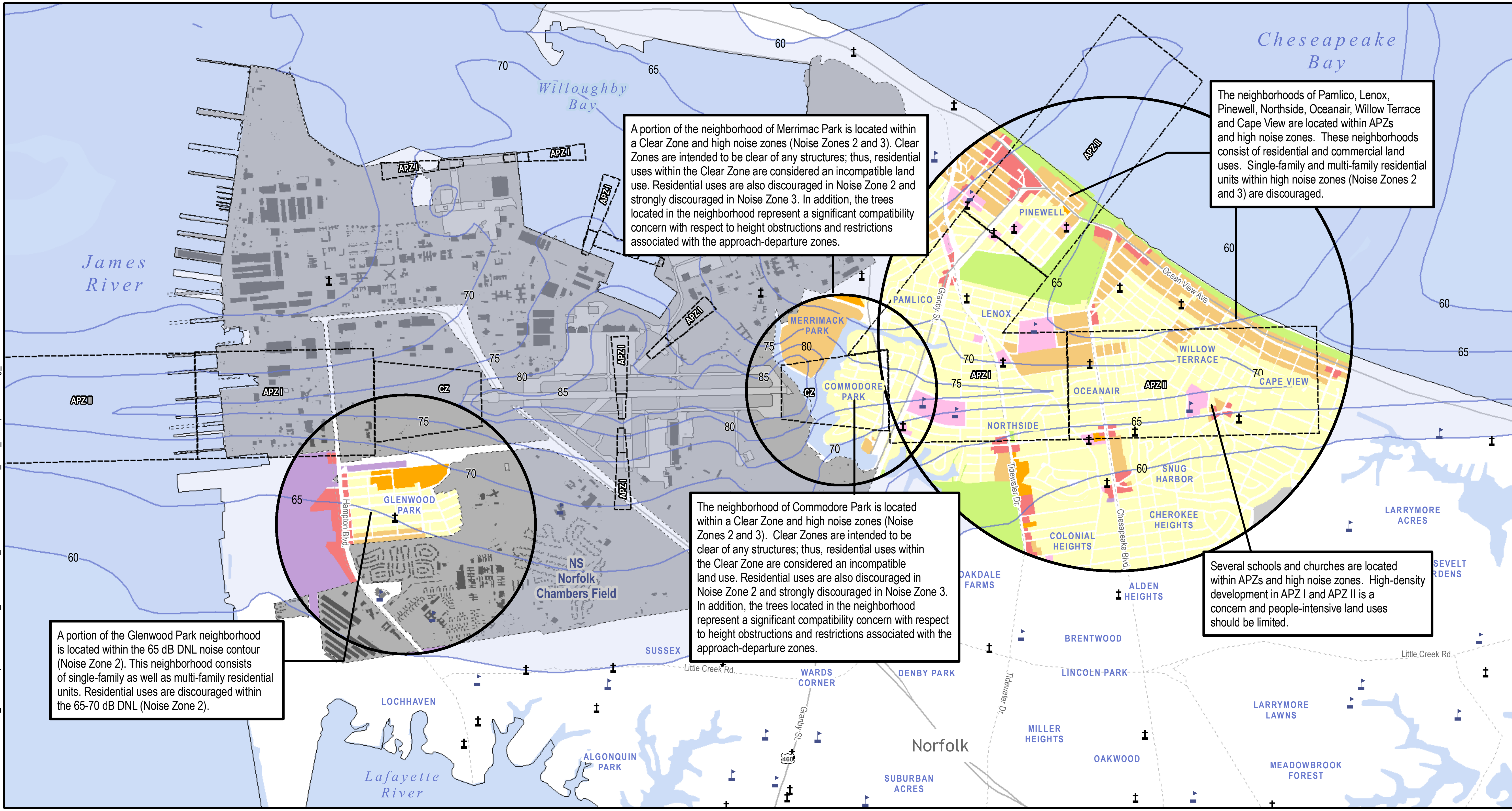


Figure 6-2
Composite AICUZ Map and Zoning
at NS Norfolk Chambers Field
Norfolk, Virginia

Compatibility Concerns and 2009 AICUZ



Key:

School	**Zoning**	Low-Density Residential	Mixed Use
Church	Business Zone	Medium-Density Residential	Office and Institutional
Installation Area	Commercial	High-Density Residential	Recreational
2009 AICUZ APZs	Industrial	Military	

0 0.5 1 Miles

Figure 6-3
Compatibility Concerns and 2009 AICUZ
at NS Norfolk Chambers Field
Norfolk, Virginia

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Several incompatible land uses and major existing compatibility concerns around NS Norfolk Chambers Field include the following:

- Residential areas located to the southwest of the base in the **Glenwood Park** area (currently in Noise Zone 2) are a compatibility concern (see Figure 6-4). The AICUZ instruction discourages residential land uses within Noise Zone 2.

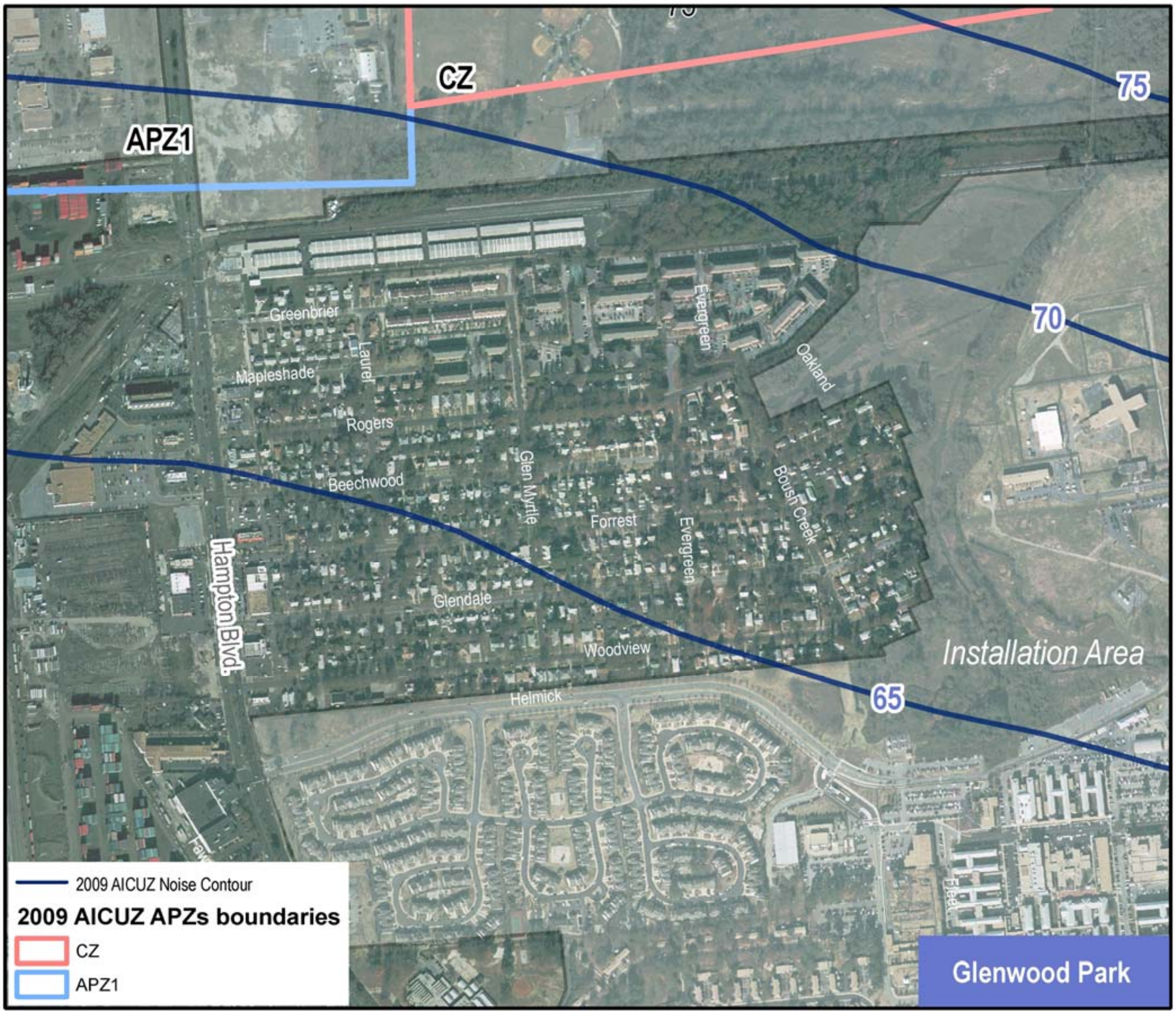

Figure 6-4
Areas of Compatibility Concern at Glenwood Park
NS Norfolk Chambers Field, Norfolk, Virginia

- Residential areas immediately east of the airfield in the **Commodore Park** area (currently in Clear Zone) are a compatibility concern (see Figure 6-5). The AICUZ instruction views any structures in a Clear Zone as an incompatible use. This area also has significant vegetation growth (i.e., trees) that is a compatibility concern with respect to height restrictions as outlined in the Airport Safety Overlay District (Section 11-1.4), discussed in Section 6.3.2 and presented in Appendix C. Although the Navy has full ownership of the trees and structures on-station, the trees on residential properties are outside the control of the Navy and are considered incompatible with aircraft operations.

  In addition, this neighborhood is within the 70 dB DNL noise contour (Noise Zone 2) and a portion is within the 75 dB DNL noise contour (Noise Zone 3). Residential land uses are strongly discouraged in these high noise zones.

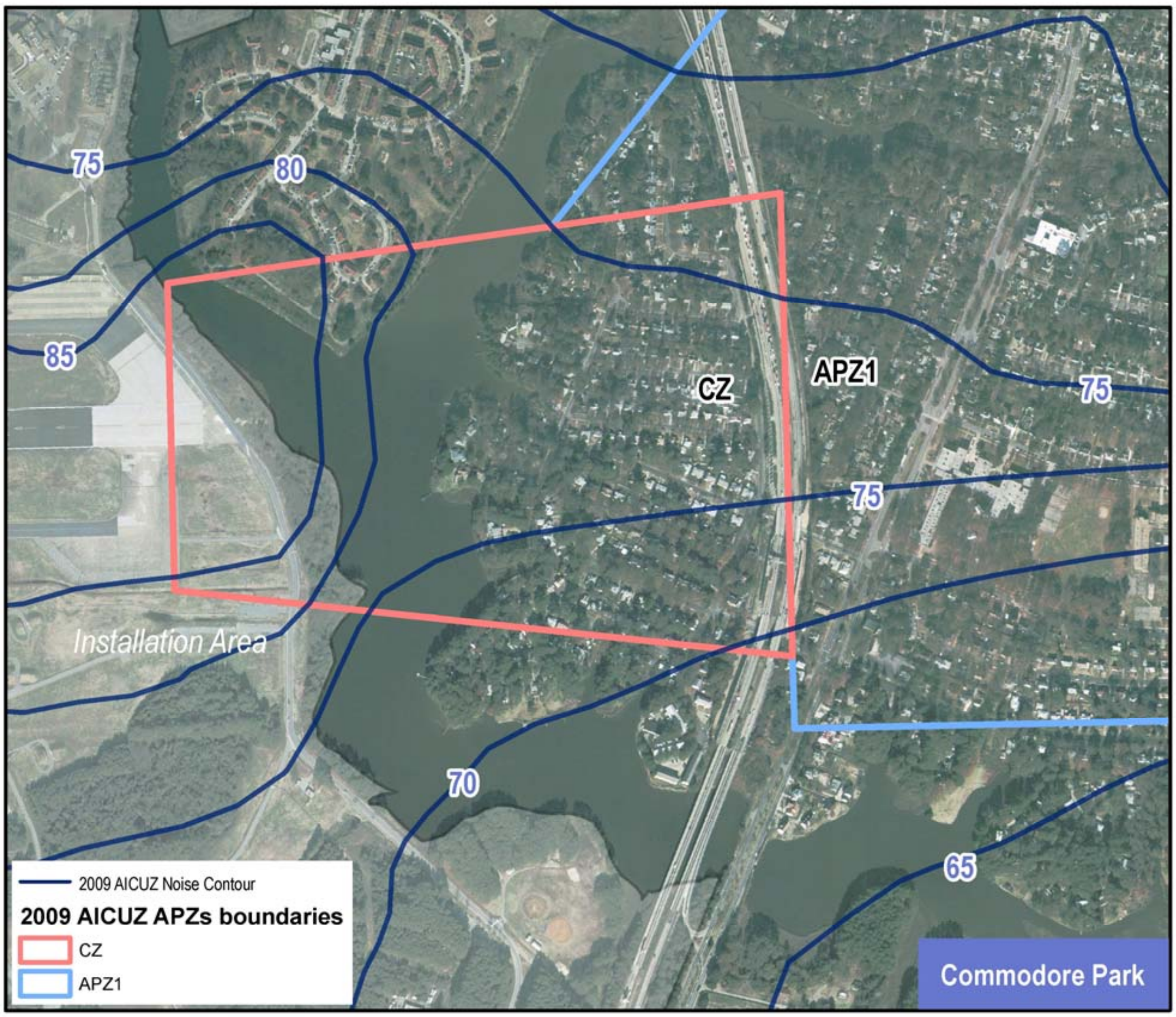

Figure 6-5
Areas of Compatibility Concern at Commodore Park
NS Norfolk Chambers Field, Norfolk, Virginia

- Residential areas east of the base in the **Merrimac Park** area (currently in Clear Zone, Noise Zone 2, and Noise Zone 3) are a compatibility concern (see Figure 6-6). The AICUZ instruction strongly discourages residential land uses within Noise Zone 2 and 3. In addition, a portion of Merrimac Park is within the Clear Zone, where residential development is considered incompatible.

Figure 6-6
Areas of Compatibility Concern at Merrimac Park
NS Norfolk Chambers Field, Norfolk, Virginia

- There are three schools (Mary Calcott Elementary School, Northside Junior High [Middle] School, and Oceanair Elementary School) and three churches (First Church of God, Saint John Lutheran Church and Ocean View Presbyterian Church) located east of the airfield (in APZ I) that are a compatibility concern, which are considered people-intensive uses and are strongly discouraged in APZ I. An area of the APZ I where two of the churches and two of the schools are located is depicted in Figure 6-7. For a map showing all schools and churches located in APZs, refer to Figure 6-3.

Figure 6-7
Areas of Compatibility Concern at Schools in APZ 1
NS Norfolk Chambers Field, Norfolk, Virginia

- Several additional schools and churches located in areas farther east of the airfield (in APZ II) are a compatibility concern. They are considered people intensive uses and are discouraged in APZ II.

- Low- and medium-density residential areas located east of the airfield (in APZs I and II) are a compatibility concern. According to AICUZ guidance, the maximum density for residential structures in APZ II is 1-2 dwellings per acre. The majority of the residential properties in the City of Norfolk, although considered "low-density" do not meet the AICUZ criteria and thus, are strongly discouraged in both APZ I and APZ II.

  Many of these same low- and medium-density residential areas are also located within the 65 dB DNL noise contour (Noise Zone 2) where residential land uses are discouraged.

- Several transportation-related projects are in-process in the City of Norfolk and surrounding municipalities. These projects temporarily add traffic, congestion, and potentially long-term development, which has the potential to create land use compatibility concerns in the vicinity of NS Norfolk Chambers Field.

  One such transportation project includes the I-564 Intermodal Connector, which begins at I-564 in Norfolk with a flyover bridge heading west. It crosses over Hampton Boulevard and ties into NS Norfolk and Norfolk International Terminals at Virginia Avenue. It is a four lane facility designed to interstate standards with enough right-of-way and median dimensions to add multimodal lands (i.e., HOV, busway, or passenger rail) in the future (FHA and VDOT 2001). The Hampton Roads Transportation Planning Organization (HRTPO) in a letter dated March 25, 2009, requested that the VDOT submit the I-564 Connector project for consideration under the $1.5 billion Nationwide Discretionary Grant Program administered by the USDOT Office of the Secretary of Transportation (HRTPO 2009).

The neighborhoods and land uses identified in this section are and continue to be compatibility concerns in the area around NS Norfolk Chambers Field. The Navy and the city of Norfolk should continue to place high priority on these as encroachment concerns in the future.

7 Land Use Tools and Recommendations

Chapter 7

The goals of the AICUZ Program – to protect the health, safety, and welfare of those living and working near military airfields while preserving the defense flying mission – can most effectively be accomplished by active participation of all interested parties, including the United States Department of the Navy (Navy), local governments, private citizens, developers, real estate professionals, and others.

At the installation level, the Base Commander is responsible for ensuring a successful AICUZ Program. Pursuant to OPNAVINST 11010.36C (AICUZ Program), the Base Commander at NS Norfolk Cambers Field is committed to and shall:

- Implement an AICUZ Program for the Air Installation;
- Work with state and local planning officials to implement the objectives of the AICUZ Study;
- If appropriate, designate a community liaison officer to assist in the execution of the AICUZ Study by the Installation and to act as spokesperson for the Command in AICUZ matters;
- Provide assistance in developing AICUZ information, including operational data needed to update the AICUZ Study; and
- Work with local decision makers in the city of Norfolk and Hampton Roads region to evaluate and justify the retention of land or interest of land required for operational performance. It should be noted that a Community Plans and Liaison Officer (CPLO) has been hired at NS Norfolk to serve in this capacity.

This section presents and describes land use planning tools and recommendations for implementing and achieving a successful AICUZ Program.

7.1 Tools for Implementing AICUZ

7.1.1 Federal Tools

Environmental Review

Federal agencies are required to consider environmental impacts of any federal project which could significantly impact the environment by means of an environmental review. For example, the National Environmental Policy Act (NEPA) mandates full disclosure of the environmental effects resulting from proposed federal actions, approvals, or funding. Impacts of the action are generally documented in an Environmental Impact Statement (EIS) or an Environmental Assessment, which is more limited in scope than an EIS. The environmental review process represents a procedure for incorporating the elements of the AICUZ in 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 United States Office of Management and Budget (OMB) requires all Federal Aid Development Projects to be coordinated with and reinforce state, regional, and local planning. Executive Order 12372 allows state governments to set up review periods and processes for federal projects and provides an early entry point into the process to introduce AICUZ concepts and to discuss AICUZ issues.

Housing and Urban Development (HUD) Circular 1390.2

Approvals of mortgage loans from the Federal Housing Administration are subject to requirements of this Housing and Urban Development (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 inside the 65-decibel (dB) 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.

DoD Encroachment Partnering Program

Title 10, United States Code (U.S.C.) § 2684a authorizes the Secretary of Defense or the Secretary of a military department to enter into agreements with an eligible entity or entities to address the use or development of real property in the vicinity of, or ecologically related to, a military installation or military airspace, to limit 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. The DoD can share the real estate acquisition costs for projects that support the purchase of fee or a conservation or other restrictive easement for such property. The eligible entity negotiates and acquires the real estate interest for encroachment partnering projects with a voluntary seller. The eligible entity must transfer the agreed upon restrictive easement interest to the United States of America upon the request of the Secretary.

7.1.2 Commonwealth/Regional Tools

Building Code

The Virginia Uniform Statewide Building Code, which sets types of building materials, construction methods, plan submission requirements and inspection practices, is unchanged based on location of buildings inside noise zones or APZs. However, local governments, such as the City of Norfolk, may enforce building regulations relating to the installation or remodeling of noise reduction measures (Code of Virginia Section 15.2-2295). Further explanation on the local government’s role is in Section 7.1.3.

The Commonwealth of Virginia follows the Dillon Rule, whereby the local municipalities (cities and counties) have only those powers expressly granted to them by the state or commonwealth. The development of a local building code is not one of the powers granted the local municipalities; thus, as it applies to AICUZ and the City of Norfolk, building code issues (i.e., which would potentially specify requirements for implementation of sound attenuation into new construction) in the city of Norfolk would be governed by the building codes dictated by the Commonwealth of Virginia. Therefore, the City should work with the Virginia Board of Housing and Community Development to ensure building code requirements developed at the Commonwealth-level are workable at the City-level with respect to AICUZ compatible development.

Real Estate Disclosure

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 aviation noise and safety zones for air stations such as NS Norfolk Chambers Field, 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 concern by those who were not adequately informed prior to purchase of properties within impact areas.

The Commonwealth of Virginia has adopted the Virginia Residential Disclosure Act (Code of Virginia Sections 55-517 et seq.) that requires that any person marketing property for sale, rental, or lease within the area of a military air installation, to provide written disclosure to all prospective purchasers, renters, or lessees that such property is located within a noise zone or APZ. The disclosure will state the specific noise zone, APZ or both as designated on the official zoning map by the local planning department where the property is located. More information on actions taken by realtors and realtor associations is provided in Section 7.1.4

7.1.3 Local Government Tools

Local Government Comprehensive Plans and Zoning and Planning

The development and control of lands outside of military installations is beyond the control of the base commander. Development of these lands is managed and regulated by local comprehensive land use planning and regulations. The local planning authority in Norfolk is the City of Norfolk's Department of Planning and Community Development. They have developed "The General Plan of Norfolk" that serves to guide the growth and vision of the City's development (City of Norfolk 1992).

In addition, the City of Norfolk has Zoning Ordinances, last updated and adopted in April 2009, which govern development, construction, and land uses throughout the City of Norfolk. As identified in Section 6.3.2 – Existing Zoning and Section 6.4 – Compatibility Concerns at NS Norfolk Chambers Field, there are areas surrounding the base where zoning is considered incompatible according to AICUZ guidance.

Capital Improvements Programs

Capital improvements projects, such as potable water lines, sewage transmission lines, road paving and/or improvements, new right-of-way acquisition, and schools can be used to direct growth and types of growth toward areas compatible with the AICUZ Program. Local government agencies and organizations can develop capital improvement programs that avoid extending capital improvements into or near high-noise zones or APZs. This would, for example, apply to projects in the City of Norfolk such as I-564 corridor project and air terminal interchange.

Purchase of Development Rights

The local government may consider the purchase of development rights.

Transfer of Development Rights (TDR)

The concept of TDR involves purchasing property development rights from one property (i.e. an area proposed for incompatible residential development near an air station) and transferring those rights to another piece of property (i.e. to an area well outside of noise contours and APZs that is more conducive to residential development). Thus, development of the original property with incompatible residential homes is prevented near the air station. Another element of the TDR program is the potential for developers to receive approvals for increased densities in the receiving areas as an inducement to the developer for agreeing to a TDR. TDRs also require local governments to adopt a TDR ordinance identifying sending and receiving areas in the jurisdiction.

Public Land Acquisition Programs

Public land acquisition programs can be used (as the conditions of the programs permit) for acquisition of land to support the AICUZ Program. These programs take different forms in different jurisdictions and are administrated by a range of public agencies. There is no known active public land acquisition program in the City of Norfolk, however, a program of this type in Norfolk could include an active land acquisition program for the purpose of purchasing land as it becomes available around the air station to protect key land assets by limiting impacts from the redevelopment of that land that is considered incompatible with air station activities.

Health Code Programs

These programs protect people from adverse elements that may endanger them, including poor sanitary facilities, diseases, and inadequate or unsafe water supplies. The programs also can be used to protect people from noise impacts.

Special Planning Districts

Local governments have the power to create special planning districts, such as “military influence areas” or “airport overlay zones/districts” where local governments can either enact restrictions on land development or require notification for proposed development within the special planning area. The City of Norfolk has adopted one such special planning district. This is an Airport Safety Overlay (ASO) District, whose purpose is to prevent the establishment of obstructions or hazards in the airspace around Norfolk International Airport and NS Norfolk Chambers Field. A copy of the Airport Overlay District is included in Appendix C.

7.1.4 Private Citizens/Real Estate Professionals/Businesses

Business Development and Construction Loans to Private Contractors

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. Local banking and financial 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.

Private Citizens

Private citizens should be provided all the information available to make informed decisions when purchasing or altering any property in proximity to an air station.

Real Estate Professionals

Real estate professionals should ensure that prospective buyers or lessees are fully aware of what it means to be within a high-noise zone and/or APZ. Truth-in-sales and rental ordinances can be enacted to ensure adequacy in providing public disclosure of the impact in high noise and accident potential zones. Real estate professionals also have the ability to show prospective buyers and lessees properties at a time when noise exposure is expected to be at its worst in order to provide full disclosure. Real estate professional in the City of Norfolk should continue to use the NS Norfolk Chambers Field AICUZ brochure as a tool to assist themselves and prospective homebuyers in understanding the location of homes in the City relative to the AICUZ Zones for the air station.

In Virginia, real estate professionals are required through the Virginia Residential Disclosure Act to ensure that prospective buyers or lessees are fully aware of what it means to be within a high-noise zone and/or APZ. In addition, the Hampton Roads Realtors Association (HRRA) also encourages its members to provide written disclosure in all real estate transactions and advise their clients to verify whether property is located within a noise zone or APZ, especially in property transactions with non-members of the HRRA.

7.2 Recommendations

7.2.1 NS Norfolk Chambers Field Recommendations

Although ultimate control over land use and development in the vicinity of NS Norfolk Chambers Field is the responsibility of the City of Norfolk, the Navy has the ability and responsibility to conduct actions and implement programs in support of local efforts. To do so, NS Norfolk Chambers Field should continue and/or consider the following:

Air Operations Procedures

Aircrew discipline in pattern operations should be enforced along with field noise abatement procedures, as set forth in Section 4.4. The Navy should continue to examine ways to improve noise abatement procedures.

Noise Complaint Hotline

The hotline ensures a standard procedure is followed for noise complaints called into NS Norfolk Chambers Field from operations at the airfield and surrounding airspace. This procedure is outlined in Section 4.3 of the AICUZ Study. Complaints should be collected in a standard format for plotting locations in a spatial database for future planning use. Recording these complaints help:

- Document whether newly developing sites that may be noise-sensitive in the future;
- Provide land use planning information for the local government;
- Determine which operational flight tracks are responsible for the noise complaint and at what time most complaints occur; and
- Provide valuable information for real estate transactions.

Community Outreach Activities

Continue successful community outreach efforts that have begun at NS Norfolk Chambers Field. Several successful initiatives have started and future initiatives aimed at further protecting Navy assets should continue or expand. NS Norfolk Chambers Field representatives have participated in a compatible land use meeting with the local municipalities to identify areas where potential incompatible land uses exist in order to prevent encroachment. These meetings can also be used to address current and future aircraft related activity at the NS Norfolk Chambers Field, noise complaints (both the process for making them and how they are resolved), and other relevant topics related to the interaction between NS Norfolk Chambers Field and its neighbors. These and similar initiatives where Navy representatives are working with the community serves to enhance the lines of communication and all parties ability to address potential concerns that arise.

Presentation of the AICUZ Program

AICUZ can be a complex program and process that requires discussion and elaboration. NS Norfolk Chambers Field personnel have access to and can continue to make presentations on the program to individuals or collectively to community decision makers, including local planning commissions, city councils, county legislatures, government councils, and other interested agencies. Presentation on the Program's elements would provide an opportunity to inform and educate individuals or groups who make land use decisions (e.g., infrastructure siting, schools, zoning changes) and to answer any questions about the Program.

Additionally, the NS Norfolk Chambers Field Web site could be expanded to include AICUZ-specific topics and various materials for this presentation and distribution should be developed or updated to include flight simulations, videos, poster boards, an electronic or slide presentation, and fact sheets. This presentation information could be used as part of the community outreach activities and would inform the general public on AICUZ issues and how the installation contributes to the local economy, and the need for responsible land use planning.

Keep Engaged in the Local Planning Process

The Navy representative for NS Norfolk Chambers Field, including either the Commanding Officer and/or the base or regional Community Planning Liaison Officer (CPLO) should attend public hearings and provide comments on actions that affect AICUZ planning for NS Norfolk Chambers Field, including comprehensive plan issues, updates to the City's General Plan, and land development regulations updates and amendments impacting both the City of Norfolk and the air station. In addition, a Navy representative should continue to attend and participate in the monthly Navy Traffic Task Force meetings with City of Norfolk staff.

Local Plans, Regulations, and Policies

The Navy representative for NS Norfolk Chambers Field including either the Commanding Officer and/or the base or regional CPLO should continue to be an active participant in local government and regional reviews, recommendations, and decision-making processes for land uses that may affect the operational integrity of the installation, including:

- Capital improvements plans, such as potable water lines, sewage transmission lines, road paving and/or improvements, and new right-of-way acquisition;
- Building code changes;
- Community facilities construction (e.g., amphitheaters, stadiums, and churches);
- Construction of new educational facilities;
- Establishment of local zoning ordinances, comprehensive plans or other ordinances that may affect the installation;
- Development of lighting guidelines and standards for new and existing development; and
- Approvals for subdivisions, site plans, wetland permits, and all other proposed approvals necessary for development.

7.2.2 Local Government and Agency Recommendations

Communication

While it is NS Norfolk Chambers Field'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 NS Norfolk Chambers Field regarding land use decisions that potentially could affect the operational integrity of the installation. Working groups and regular meetings or conferences help to ensure open lines of communication between the local/community decision makers and Navy representatives (i.e., the Commanding Officer and/or CPLO).

To communicate with the public, local government Web sites should continue to provide acknowledgement of the AICUZ Program for NS Norfolk Chambers Field and provide a link to the installation's web site for information on aircraft operations and the NS Norfolk Chambers Field AICUZ Program.

Decisions with Future Impacts

It is recommended that when local governments make land use decisions in proximity to the established AICUZ footprint, local governments recognize:

- Noise contours and APZs comprising the AICUZ footprint are dynamic, and potential exists for changes in the AICUZ footprint as operational needs to satisfy the military mission change;
- Because of the AICUZ Program's dynamics, it is recommended local governments work with NS Norfolk Chambers Field representatives (i.e., the CPLO) to establish a special planning area or district (i.e., similar to the Airport Safety Overlay District) for areas outside the established noise contours and APZs that are most likely to present compatibility problems if changes in operations at NS Norfolk Chambers Field should they occur. As a beginning point, it is recommended local governments use the flight tracks presented in Section 3.4 to preserve the operational integrity of these flight tracks and protect the health and safety of the underlying population; and
- The City of Norfolk currently addresses safety and height restrictions in the vicinity of Norfolk International Airport and NS Norfolk Chambers Field through the use of APZs and language based on FAA height guidance. As part of this land use strategy, the City would establish new development controls regarding compatible land uses in noise zones and APZs around NS Norfolk Chambers Field. The Airport Safety Overlay District would retain the baseline zoning but limit increased residential densities in compliance with OPNAV guidance, where compatible with existing land uses. The Airport Safety Overlay District would also require disclosure for real estate transactions and sound attenuation for new residential construction in noise exposed areas.

Land-Use Plans and Regulations

As discussed in Section 7.1.2, local governments currently within the AICUZ footprint recognize their responsibility in providing land use controls in areas encumbered by the AICUZ footprint to protect the health, safety, and general welfare of the population. It is recommended that the City of Norfolk's Zoning Ordinance be updated to reflect the 2009 AICUZ noise contours, APZs and Clear Zones. In addition, the 2009 AICUZ noise contours and APZs should be uploaded to the City of Norfolk's "Norfolk Interactive Mapper" tool located on the City's website (http://gis.norfolk.gov/website/htmlviewer/genmap/viewer.htm).

Capital Improvement

It is recommended all capital improvement projects in proximity to the installation (i.e., within the 2009 AICUZ noise zones and APZs or within the imaginary surfaces for the airfield) be evaluated by local planners in conjunction with input from NS Norfolk Chambers Field and reviewed for potential direct and indirect impacts that such improvements may have on the operations at NS Norfolk Chambers Field.

In addition, lighting guidelines developed by NS Norfolk should be shared with the community (i.e., the City of Norfolk). The City of Norfolk should be encouraged to review and incorporate pertinent elements of the guidelines for the approval of new development and redevelopment.

Building Codes

As stated in Section 7.1.3, the Commonwealth of Virginia operates under the Dillon Rule by which there are no local building codes. However, local enforcement can ensure consistency with noise attenuation recommendations of the AICUZ Program as specified in OPNAVINST 11010.36C.

Public Land Acquisition Programs

These programs should be reviewed to ascertain whether they can be used in support of the AICUZ Program.

Another course of action, as recommended in the Hampton Roads JLUS, is to encourage the City of Norfolk to establish a Voluntary Property Acquisition Program. Such a program would allow the City to acquire, as available federal or other resources permit, the fee simple purchase from willing sellers of existing properties within the Clear Zone of NS Norfolk Chambers Field (EDAW 2005). Acquisition of these properties would create a buffer around the active runway and would protect both public and pilot safety.

7.2.3 Private Citizens/Real Estate Professionals/Businesses Recommendations

Real Estate Professionals

Real estate professionals should:

- Provide written disclosure to prospective purchasers, renters, or lessees when a property is located within an APZ or a noise zone;
- Provide, on their websites, acknowledgement of the AICUZ Program for NS Norfolk Chambers Field and provide a link to the installation's website for information on aircraft operations and the AICUZ Program;
- Provide an AICUZ brochure to prospective buyers and lessees (the AICUZ brochure is produced by Navy and distributed by the Navy as requested to appropriate government agencies, organizations, businesses and individuals. Brochures are available at the Public Affairs Office at NS Norfolk Chambers Field); and

- To the greatest extent possible, make prospective buyers and lessees aware of the potential magnitude of noise exposures they might experience.

Business Development and Construction Loans to Private Contractors

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 will promote compatible development of the area surrounding NS Norfolk Chambers Field and protect lenders and developers alike. Local banking and financial institutions should be encouraged to incorporate a "Due Diligence Review" of all loan applications, to determine possible noise or APZ impacts on the mortgaged property. The Navy can play a role in this strategy by providing AICUZ seminars to lenders throughout the region.

Citizens

The citizens of the local community are recommended to:

- Before purchasing or altering any property to become informed about the AICUZ Program at NS Norfolk Chambers Field 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.

7.2.4 Summary

The AICUZ Program provides the tools necessary to promote compatible development and activities near military installations. As outlined in this section, responsibilities for disseminating relevant material, sharing knowledge, and developing cooperative relationships is the responsibility of numerous entities and individuals, not only the military and local government, but community members as well. By working together, the military and the community help to preserve the defense mission while improving the quality of life of those living around the installation.

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Appendix A
Discussion of Noise and
Its Effect on the Environment

A.1 Basics of Sound

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

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

The measurement and human perception of sound involves three basic physical characteristics: intensity, frequency, and duration. First, intensity is a measure of the acoustic energy of the sound vibrations and is expressed in terms of sound pressure. The greater the sound pressure, the more energy 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.

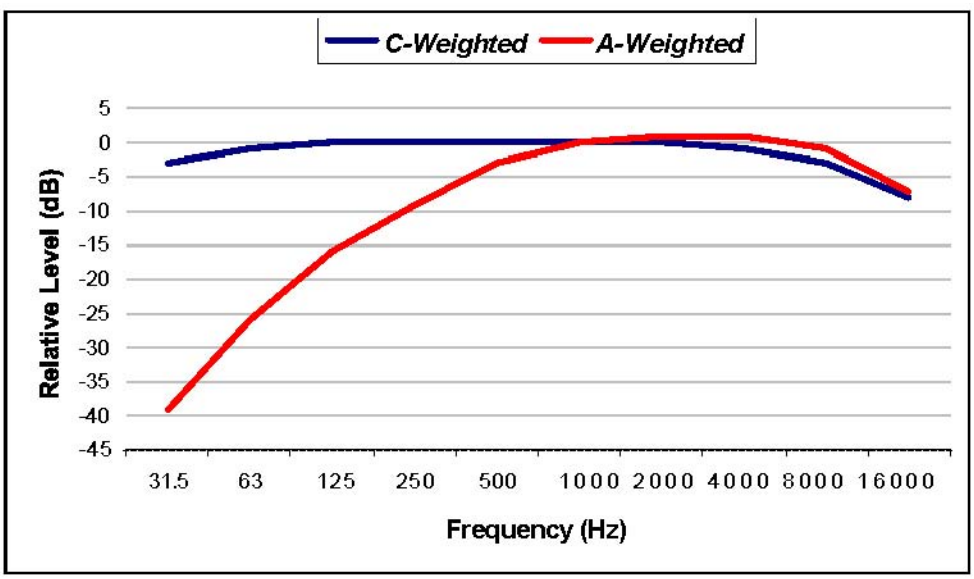
Second, the total sound level produced by two sounds of different levels is usually only slightly more than the higher of the two. For example:

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 A-1 are also the most adequate to quantify environmental noises.



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

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

A.1.2 A-weighted Sound Level

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

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

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

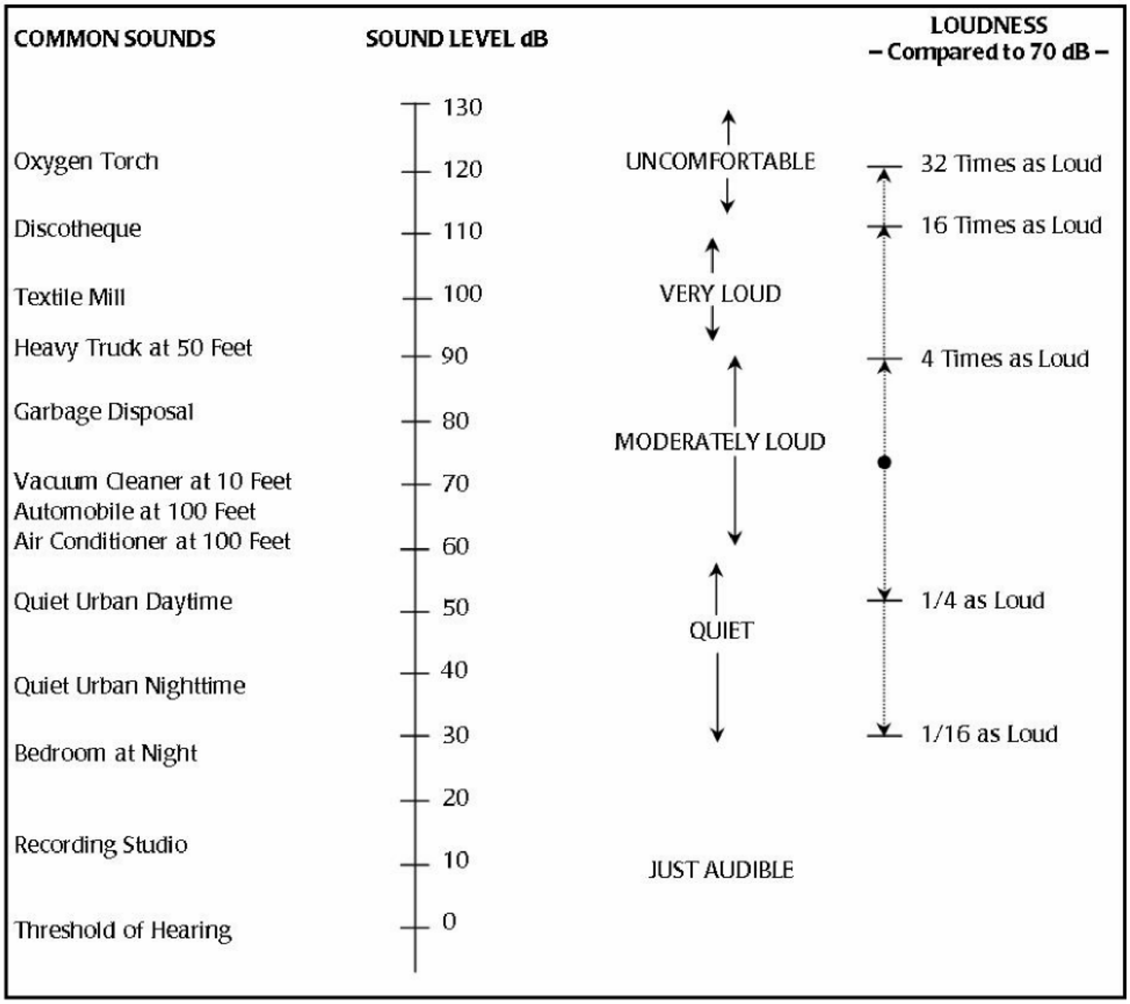
C-weighted Sound Level

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

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

A.2 Noise Metrics

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.

A.2.1 Maximum Sound Level (L_{max})

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

During an aircraft overflight, the noise level starts at the ambient or background noise level, rises to the maximum level as the aircraft flies closest to the observer, and returns to the background level as the aircraft recedes into the distance. The maximum sound level indicates the maximum sound level occurring for a fraction of a second. For aircraft noise, the "fraction of a second" over which the maximum level is defined is generally 1/8 second, and is denoted as "fast" response (American National Standards Institute 1988). Slowly varying or steady sounds are generally measured over a period of one second, denoted "slow" response. The maximum sound level is important in judging the interference caused by a noise event with conversation, TV or radio listening, sleep, or other common activities. Although it provides some measure of the intrusiveness of the event, it does not completely describe the total event, because it does not include the period of time that the sound is heard.

A.2.2 Peak Sound Pressure Level (L_{pk})

The peak sound pressure level, is the highest instantaneous level obtained by a sound level measurement device. The peak sound pressure level is typically measured using a 20 microseconds or faster sampling rate, and is typically based on unweighted or linear response of the meter.

A.2.3 Sound Exposure Level (SEL)

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

SEL is a logarithmic measure of the total acoustic energy transmitted to the listener during the event. Mathematically, it represents the sound level of a constant sound that would, in one second, generate the same acoustic energy as the actual time-varying noise event. For sound from aircraft overflights, which typically lasts more than one second, the SEL is usually greater than the $_{Lmax}$ 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.

A.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 A-3. It represents the results of a large number of social surveys relating community responses to various types of noises, measured in day-night average sound level.

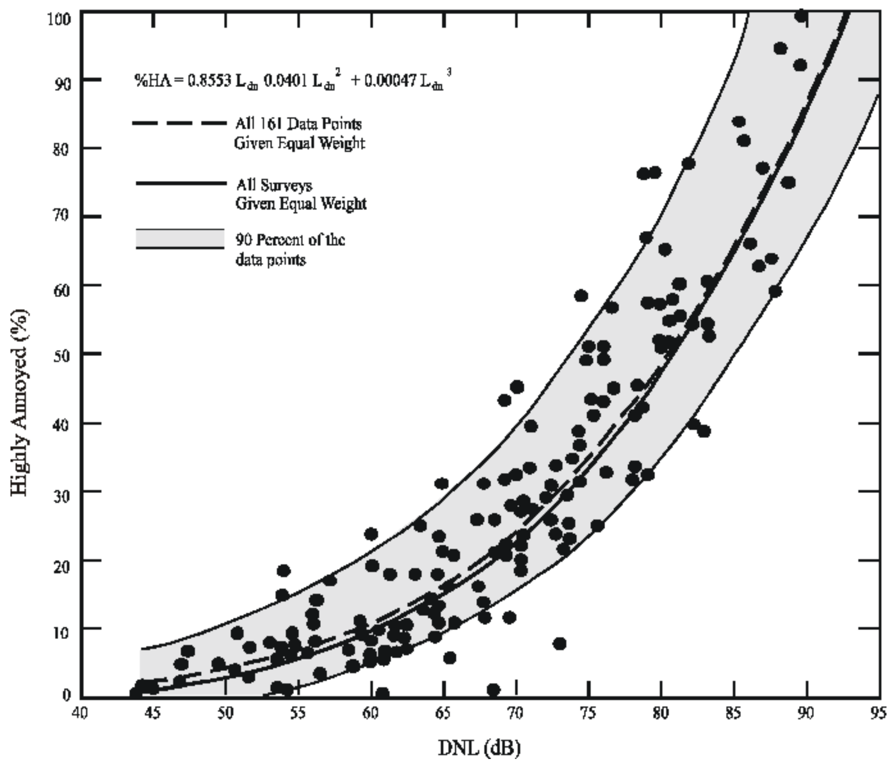


Figure A-3. Community Surveys of Noise Annoyance

A more recent study has reaffirmed this relationship (Fidell, et al. 1991). Figure A-4 (Federal Interagency Committee On Noise 1992) shows an updated form of the curve fit (Finegold, et al. 1994) in comparison with the original. The updated fit, which does not differ substantially from the original, is the current preferred form. In general, correlation coefficients of 0.85 to 0.95 are found between the percentages of groups of people highly annoyed and the level of average noise exposure. The correlation coefficients for the annoyance of individuals are relatively low, however, on the order of 0.5 or less. This is not surprising, considering the varying personal factors that influence the manner in which individuals react to noise. However, for the evaluation of community noise impacts, the scientific community has endorsed the use of DNL (American National Standards Institute 1980; American National Standards Institute 1988; U.S. Environmental Protection Agency 1974; Federal Interagency Committee On Urban Noise 1980 and Federal Interagency Committee On Noise 1992).

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

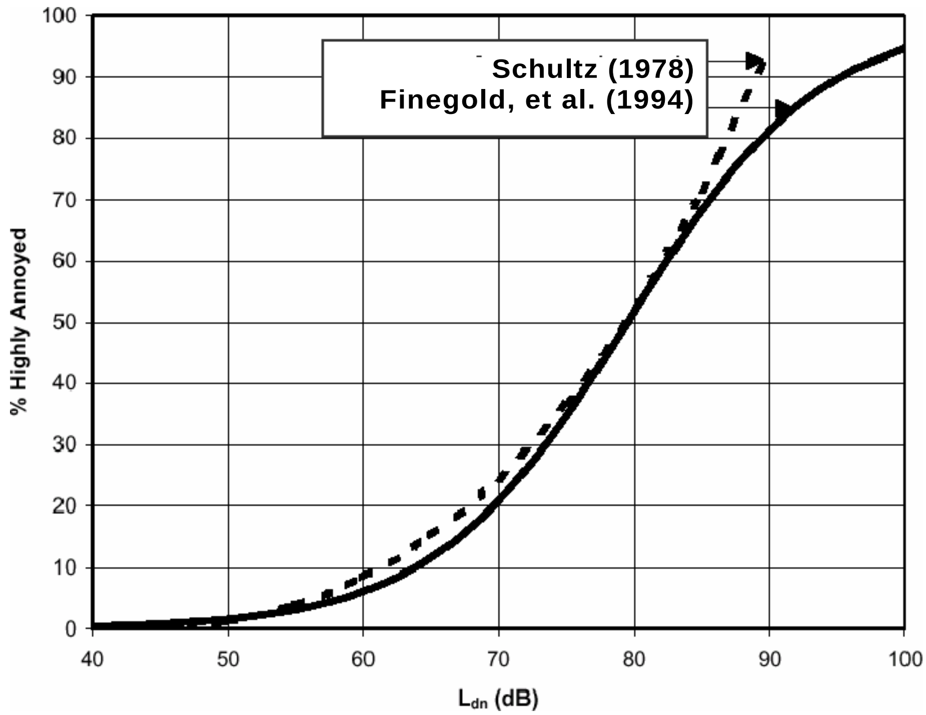


Figure A-4. Response of Communities to Noise; Comparison of Original (Schultz, 1978) and Current (Finegold, et al. 1994) Curve Fits

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

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

A.2.5 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.

A.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 $CNEL_{mr}$.

A.3 Noise Effects

A.3.1 Annoyance

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

A.3.2 Speech Interference

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

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.

A.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 A-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 A-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 A-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

A.3.4 Hearing Loss

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

The EPA has established 75 dB for an 8-hour exposure and 70 dB for a 24-hour exposure as the average noise level standard requisite to protect 96% of the population from greater than a 5 dB PTS (U.S. Environmental Protection Agency 1978). Similarly, the National Academy of Sciences Committee on Hearing, Bioacoustics, and Biomechanics (CHABA) identified 75 dB as the minimum level at which hearing loss may occur (Committee on Hearing, Bioacoustics, and Biomechanics 1977). However, it is important to note that continuous, long-term (40 years) exposure is assumed by both EPA and CHABA before hearing loss may occur.

Federal workplace standards for protection from hearing loss allow a time-average level of 90 dB over an 8-hour work period or 85 dB over a 16-hour period. Even the most protective criterion (no measurable hearing loss for the most sensitive portion of the population at the ear's most sensitive frequency, 4,000 Hz, after a 40-year exposure) is a time-average sound level of 70 dB over a 24-hour period.

Studies on community hearing loss from exposure to aircraft flyovers near airports showed that there is no danger, under normal circumstances, of hearing loss due to aircraft noise (Newman and Beattie 1985).

A laboratory study measured changes in human hearing from noise representative of low-flying aircraft on MTRs. (Nixon, et al. 1993). In this study, participants were first subjected to four overflight noise exposures at A-weighted levels of 115 dB to 130 dB. One-half of the subjects showed no change in hearing levels, one-fourth had a temporary 5-dB increase in sensitivity (the people could hear a 5-dB wider range of sound than before exposure), and one-fourth had a temporary 5-dB decrease in sensitivity (the people could hear a 5-dB narrower range of sound than before exposure). In the next phase, participants were subjected to a single overflight at a maximum level of 130 dB for eight successive exposures, separated by 90 seconds or until a temporary shift in hearing was observed. The temporary hearing threshold shifts resulted in the participants hearing a wider range of sound, but within 10 dB of their original range.

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

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

A.3.5 Nonauditory Health Effects

Studies have been conducted to determine whether correlations exist between noise exposure and cardiovascular problems, birth weight, and mortality rates. The nonauditory effect of noise on humans is not as easily substantiated as the effect on hearing. The results of studies conducted in the United States, primarily concentrating on cardiovascular response to noise, have been contradictory (Cantrell 1974). Cantrell (1974) concluded that the results of human and animal experiments show that average or intrusive noise can act as a stress-provoking stimulus. Prolonged stress is known to be a contributor to a number of health disorders. Kryter and Poza (1980) state, "It is more

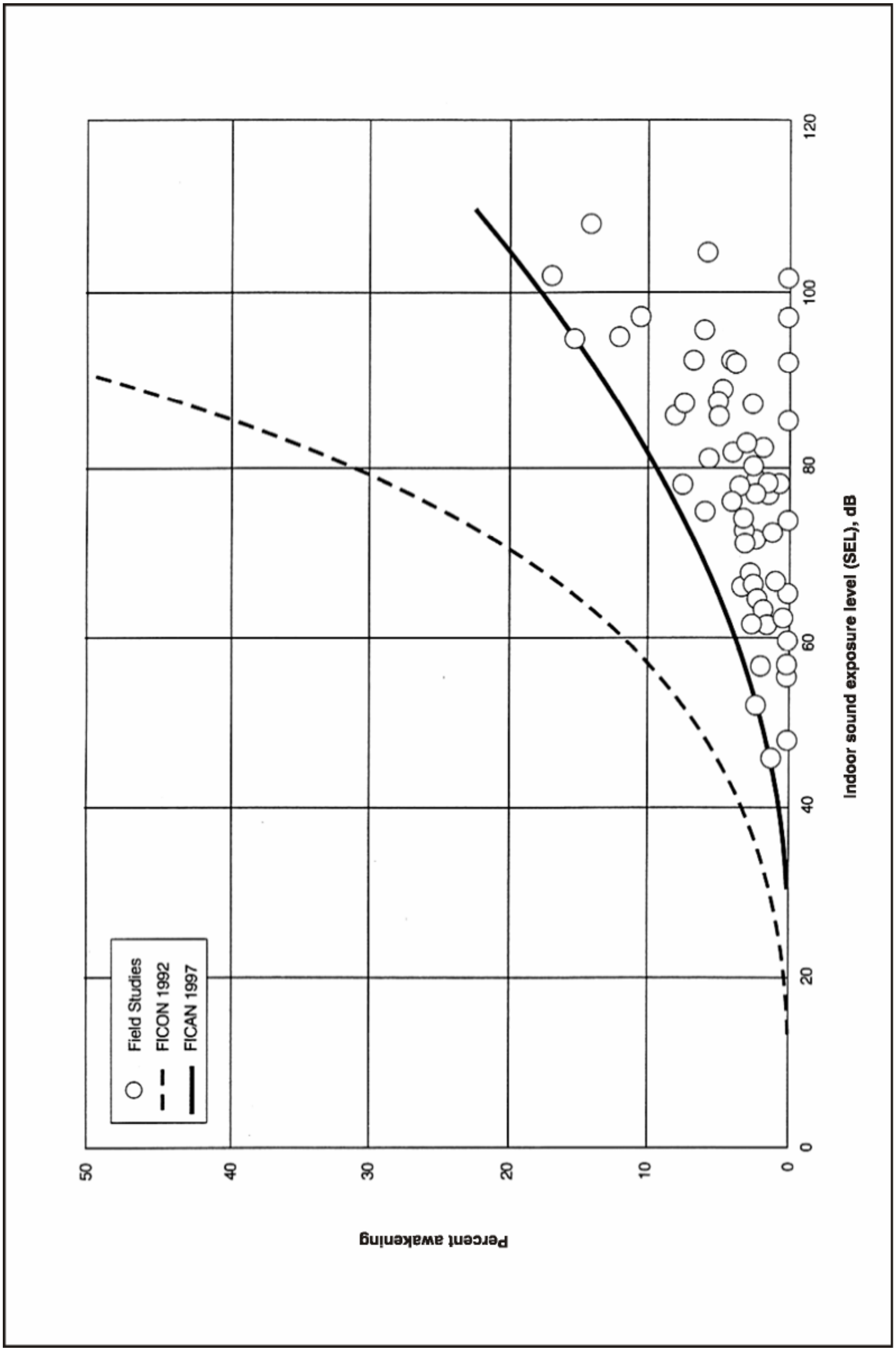


Figure A-5. Recommended Sleep Disturbance Dose-Response Relationship

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).

A.3.6 Performance Effects

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

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

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

A.3.7 Noise Effects on Children

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

A review of the scientific literature indicates that 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.

A.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).

A.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).

A.3.8 Effects on Domestic Animals and Wildlife

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

The relationships between potential auditory/physiological effects and species interactions with their environments are not well understood. Manci, et al. (1988), assert that the consequences that physiological effects may have on behavioral patterns 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.

A.3.8.1 Domestic Animals

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

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

Cattle

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

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

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

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

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

Horses

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

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

Swine

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

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

Domestic Fowl

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

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

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

Turkeys

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

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

A.3.8.2 Wildlife

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

A.3.8.2.1 MAMMALS

Terrestrial Mammals

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

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

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

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

Marine Mammals

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

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

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

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

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

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

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

A.3.8.2.2 BIRDS

Auditory research conducted on birds indicates that they fall between the reptiles and the mammals relative to hearing sensitivity. According to Dooling (1978), within the range of 1 to 5 kHz, birds show a level of hearing sensitivity similar to that of the more sensitive mammals. In contrast to mammals, bird sensitivity falls off at a greater rate to increasing and decreasing frequencies. Passive observations and studies examining aircraft bird strikes indicate that birds nest and forage near airports. Aircraft noise in the vicinity of commercial airports apparently does not inhibit bird presence and use.

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

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

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

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

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

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

A.3.8.2.2.1 RAPTORS

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

Ellis, et al. (1991), performed a study to estimate the effects of low-level military jet aircraft and mid- to high-altitude sonic booms (both actual and simulated) on nesting peregrine falcons and seven other raptors (common black-hawk, Harris' hawk, zone-tailed hawk, red-tailed hawk, golden eagle, prairie falcon, bald eagle). They observed responses to test stimuli, determined nest success for the year of the testing, and evaluated site occupancy the following year. Both long- and short-term effects were noted in the study. The results reported the successful fledging of young in 34 of 38 nest sites (all eight species) subjected to low-level flight and/or simulated sonic booms. Twenty-two of the test sites were revisited in the following year, and observations of pairs or lone birds were made at all but one nest. Nesting attempts were underway at 19 of 20 sites that were observed long enough to be certain of breeding activity. Reoccupancy and productivity rates were within or above expected values for self-sustaining populations.

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

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

Bald Eagle

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

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

Osprey

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

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

Red-tailed Hawk

Anderson, et al. (1989), conducted a study that investigated the effects of low-level helicopter overflights on 35 red-tailed hawk nests. Some of the nests had not been flown over prior to the study.

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

A.3.8.2.2.2 MIGRATORY WATERFOWL

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

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

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

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

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

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

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

A.3.8.2.2.3 WADING AND SHORE BIRDS

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

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

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

Subsequent laboratory tests of exposure of eggs to sonic booms and other impulsive noises (Bowles et al 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.

A.3.8.3 Fish, Reptiles, and Amphibians

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

A.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.

A.3.9 Property Values

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

Newman and Beattie (1985) reviewed the literature to assess the effect of aircraft noise on property values. One paper by Nelson (1978), reviewed by Newman and Beattie, suggested a 1.8 to 2.3 percent decrease in property value per decibel at three separate airports, while at another period of time, they found only a 0.8 percent devaluation per decibel change in DNL. However, Nelson also noted a decline in noise depreciation over time which he theorized could be due to either noise sensitive people being replaced by less sensitive people or the increase in 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.

A.3.10 Noise Effects on Structures

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

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

A.3.11 Noise Effects on Terrain

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

A.3.12 Noise Effects on Historical and Archaeological Sites

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

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

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

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Appendix B
Land-Use Compatibility Recommendations

Table B-1
Land-Use Compatibility Recommendations

Land Use		Suggested Land Use Compatibility						
		Noise Zone 1 (DNL or CNEL)		Noise Zone 2 (DNL or CNEL)		Noise Zone 3 (DNL or CNEL)		
SLUCM No.	Land Use Name	<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: semidetached	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**							
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; 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
30	**Manufacturing (continued)**							
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

Table B-1
Land-Use Compatibility Recommendations

Land Use		Suggested Land Use Compatibility						
		Noise Zone 1 (DNL or CNEL)		Noise Zone 2 (DNL or CNEL)		Noise Zone 3 (DNL or CNEL)		
SLUCM No.	Land Use Name	<55	55-64	65-69	70-74	75-79	80-84	85+
40	**Transportation, communication and utilities**							
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
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
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	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 fac.	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	Y	Y	Y	25	30	N	N
70	**Cultural, entertainment and recreational**							
71	Cultural activities (& 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

Table B-1
Land-Use Compatibility Recommendations

Land Use		Suggested Land Use Compatibility						
		Noise Zone 1 (DNL or CNEL)		Noise Zone 2 (DNL or CNEL)		Noise Zone 3 (DNL or CNEL)		
SLUCM No.	Land Use Name	<55	55-64	65-69	70-74	75-79	80-84	85+
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 rec.)	Y	Y[1]	Y[1]	25	30	N	N
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 recreation	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 or extraction	Y	Y	Y	Y	Y	Y	Y

Table B-2
Air Installations Compatible Use Zones
Suggested Land Use Compatibility in Accident Potential Zones[1]

SLUCM No.	Land Use Name	Recommendations			
		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: semidetached	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 0.56 in APZ II
22	Textile mill products; manufacturing	N	N	Y	same as above
23	Apparel and other finished products; 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 & 0.56 in APZ II
25	Furniture and fixtures; manufacturing	N	Y	Y	same as above
26	Paper and allied products; manufacturing	N	Y	Y	same as above
27	Printing, publishing, and allied industries	N	Y	Y	same as above
28	Chemicals and allied products; manufacturing	N	N	N	
29	Petroleum refining and related industries	N	N	N	
30	**Manufacturing[3] (continued)**				
31	Rubber and misc. plastic products; manufacturing	N	N	N	
32	Stone, clay, and glass products; manufacturing	N	N	Y	Max FAR 0.56 in APZ II
33	Primary metal products; manufacturing	N	N	Y	same as above
34	Fabricated metal products; manufacturing	N	N	Y	same as above
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 & 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	same as above
42	Motor vehicle transportation	N	Y[5]	Y	same as above
43	Aircraft transportation	N	Y[5]	Y	same as above
44	Marine craft transportation	N	Y[5]	Y	same as above
45	Highway and street right-of-way	N	Y[5]	Y	same as above
46	Auto parking	N	Y[5]	Y	same as above
47	Communication	N	Y[5]	Y	same as above
48	Utilities	N	Y[5]	Y	same as above
48.5	Solid Waste disposal (Landfills, incineration, etc.)	N	N	N	
49	Other transportation, comm., and utilities	N	Y[5]	Y	See Note 5

Table B-2
Air Installations Compatible Use Zones
Suggested Land Use Compatibility in Accident Potential Zones[1]

SLUCM No.	Land Use Name	Recommendations			
		CLEAR ZONE	APZ-I	APZ-II	Density
50	***Trade***				
51	Wholesale trade	N	Y	Y	Max FAR of 0.28 in APZ I & 0.56 in APZ II
52	Retail trade – building materials, hardware, and farm equipment	N	Y	Y	See Note 6
53	Retail trade[7] – shopping centers, Home Improvement Store, Discount Club, Electronics Superstore	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 & 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	same as above
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[8]**				
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 (credit reporting; mail, stenographic reproduction; advertising)	N	N	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; 2.0 in APZ II
64	Repair Services	N	Y	Y	Max FAR of 0.11 in APZ I; 0.22 in APZ II
65	Professional services	N	N	Y	Max FAR of 0.22 in APZ II
65.1	Hospitals, nursing homes	N	N	N	
65.1	Other medical facilities	N	N	N	
66	Contract construction services	N	Y	Y	Max FAR of 0.11 in APZ I; 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	N	N	Y	Max FAR of 0.22 in APZ II
70	**Cultural, entertainment and recreational**				
71	Cultural activities	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	
74	Recreational activities (including golf courses, riding stables, water recreation)	N	Y[10]	Y[10]	Max FAR of 0.11 in APZ I; 0.22 in APZ II
75	Resorts and group camps	N	N	N	
76	Parks	N	Y[10]	Y[10]	same as 74
79	Other cultural, entertainment and recreation	N	Y[9]	Y[9]	same as 74
80	**Resource production and extraction**				
81	Agriculture (except livestock)	Y[4]	Y[11]	Y[11]	
81.5, 81.7	Livestock farming and breeding	N	Y[11,12]	Y[11,12]	

Table B-2
Air Installations Compatible Use Zones
Suggested Land Use Compatibility in Accident Potential Zones[1]

SLUCM No.	Land Use Name	Recommendations			
		CLEAR ZONE	APZ-I	APZ-II	Density
82	Agricultural related activities	N	Y[11]	Y[11]	Max FAR of 0.28 in APZ I; 0.56 in APZ II no activity which produces smoke, glare, or involves explosives
83	Forestry activities[13]	N	Y	Y	same as above
84	Fishing activities[14]	N[14]	Y	Y	same as above
85	Mining activities	N	Y	Y	same as above
89	Other resource production or extraction	N	Y	Y	same as above
90	**Other**				
91	Undeveloped Land	Y	Y	Y	
93	Water Areas	N[15]	N[15]	N[15]	

Source: Adapted from OPNAVINST 11010.36C

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

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 densities in some categories. In general, land-use restrictions which limit commercial, services, or industrial buildings or structure occupants to 25 per acre in APZ I and 50 per acre in APZ II are the range of occupancy levels, including employees, considered to be low density. Outside events should normally be limited to assemblies of not more than 25 people per acre in APZ I, and Maximum (MAX) assemblies of 50 people per acre in APZ II.
2 The suggested maximum 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 the 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 aboveground transmission lines in APZ I.
6 Within SLUCM Code 52, Max FARs for lumber yards (SLUCM Code 521) are 0.20 in APZ-1 and 0.40 in APZ-II. For hardware/paint and farm equipment stores, SLUCM Code 525, the Max FARs are 0.12 in APZ-1 and 0.24 in APZ-II.
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 and electronics superstores. The Max recommended FAR for SLUCM 53 should be applied to the gross leasable area of the shopping center rather then attempting to use other recommended FARs listed in Table 2 under "Retail" or "Trade."
8 Low intensity office uses only. Accessory use such as meeting places, auditoriums, etc., are not recommended.
9 No chapels are allowed within APZ I or APZ II.
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 C
City of Norfolk
Airport Safety Overlay (ASO) District

11-1 Airport Safety Overlay District ASO

11-1.1 *Purpose statement.* The Airport Safety Overlay District is adopted pursuant to the authority conferred by section 15.1-491.02 of the Code of Virginia, and is based upon the findings that an obstruction has the potential for endangering the lives and property of users of the airports in the city and property or occupants of land in its vicinity; that an obstruction may affect existing and future instrument approach minimums of the airports in the City of Norfolk; and that an obstruction may reduce the size of areas available for the landing, takeoff, and maneuvering of aircraft, thus tending to destroy or impair the utility of the airports and the public investment therein. For these reasons, it is declared:

(a) That it is necessary in the interest of the public health, safety, and general welfare that the creation or establishment of obstructions that are hazards to air navigation be prevented;

(b) That the creation or establishment of an obstruction has the potential for being a public nuisance and may injure the area served by the airport;

(c) That the commonwealth derives accelerated economic development and enhanced interstate commerce from a system of airways and airports held strictly to the highest possible safety standards; and

(d) That the prevention of these obstructions should be accomplished, to the extent legally possible, by the exercise of the police power without compensation.

11-1.2 *Definitions.* As used in this chapter, the following terms shall have the following meanings, unless the context clearly requires otherwise:

Airport. The Norfolk International Airport and the Naval Air Station (NAS), Norfolk.

Airport elevation. The highest point on any usable landing surface expressed in feet above mean sea level.

Approach surface. A surface longitudinally centered on the extended runway centerline, extending outward and upward from the end of the primary surface and at the same slope as the approach zone height limitation slope set forth in section 11-1.4. In plan the perimeter of the approach surface coincides with the perimeter of the approach zone.

Approach, transitional, horizontal, and conical zones. The zones as set forth in section 11-1.3.

Conical surface. A surface extending horizontally 20 feet for every one foot vertically from the periphery of the horizontal surface.

Hazard to air navigation. An obstruction determined by the Virginia Department of Aviation or the Federal Aviation Administration to have a substantial adverse effect on the safe and efficient utilization of navigable airspace in the commonwealth.

Height. For the purposes set forth in this Airport Safety Overlay District, the datum shall be mean sea level elevation unless otherwise specified.

Horizontal surface. A horizontal plane 150 feet above the established airport elevation, the perimeter of which in plan coincides with the perimeter of the horizontal zone.

Nonconforming use. Any preexisting structure or object of natural growth which is inconsistent with the provisions of this ordinance or any amendment to this ordinance.

Obstruction. Any structure, growth, or other object, including a mobile object, which exceeds a limiting height set forth in section 11-1.4.

Primary surface. A surface, with a specified width as provided in section 11-1.3, longitudinally centered on a runway. When the runway has specifically prepared hard surface, the primary surface extends 200 feet beyond each end of that runway. The elevation of any point on the primary surface is the same as the elevation of the nearest point on the runway centerline.

Runway. A specified area on an airport prepared for landing and takeoff of aircraft.

Structure. Any object, including a mobile object, constructed or installed by any person, including but not limited to buildings, towers, cranes, smokestacks, earth formations, overhead transmission lines, flag poles, and ship masts.

Transitional surfaces. Surfaces which extend outward perpendicular to the runway centerline extended at a slope of seven feet horizontally for each foot vertically from the sides of the primary and approach surfaces to where they intersect the horizontal and conical surfaces.

Vegetation. Any object of natural growth.

Zone. Any area defined in section 11-1.3, generally described in three dimensions by reference to ground elevation, horizontal distance from the runway centerline and the primary and horizontal surfaces, and capped at specific vertical limits by the surfaces of the zones provided for in section 11-1.4.

11-1.3 *Airport safety zones.* In order to carry out the provisions of this Airport Safety Overlay District, there are hereby established certain zones which include all of the area of the city lying beneath the approach surfaces, transitional surfaces, horizontal surfaces, and conical surfaces as they apply to the Norfolk International Airport and the NAS, Norfolk. An area located in more than one of the following zones is considered to be only in the zone with the most restrictive height limitation. These zones are as follows:

(a) *Airport zone:* A zone that extends away from the runway and primary surface, and is capped by the horizontal surface.

(b) *Approach zone:* A zone that extends away from the runway, ends along the extended runway centerline, and is capped by the approach surfaces.

(c) *Transitional zone:* A zone that fans away perpendicular to the runway centerline and approach surfaces, and is capped by the transitional surfaces.

(d) *Conical zone:* A zone that circles around the periphery of and outward from the horizontal surface, and is capped by the conical surface.

Specific geometric standards for these zones are to be found in Article 77.25, 77.28 and 77.29, Subchapter E (Airspace), of Title 14 of the Code of Federal Regulations, or in successor federal regulations.

11-1.4 *Airport safety zone height limitations.* No structure shall be erected, altered, or maintained, except as expressly provided in this section, and no vegetation shall be allowed to grow to a height so as to penetrate any referenced surface of any zone provided for in section 11-1.3 at any point.

The height restrictions for the individual zones shall be those planes delineated as surface in Article 77.25, 77.28 and 77.29, Subchapter E (Airspace), of Title 14 of the Code of Federal Regulations, or in successor federal regulations.

11-1.5 *Use restrictions.* Notwithstanding any other provision of this section 11-1, within any zones established by this ordinance no use may be commenced on land or water in such a manner as to:

(a) Create electrical interference with navigational signals or radio communication between the airport and aircraft;

(b) Diminish the ability of pilots to distinguish between airport lights and other lights;

(c) Result in glare in the eyes of pilots using the airport;

(d) Impair visibility in the vicinity of the airport;

(e) Create the potential for bird strike hazards; or

(f) Otherwise in any way endanger or interfere with the landing, takeoff, or maneuvering of aircraft intending to use the airport.

11-1.6 *Nonconforming uses.* This Overlay District shall not require the removal, lowering, or other change or alteration of any structure or vegetation not conforming to the regulations as of the effective date of this ordinance, or otherwise interfere with the continuance of a nonconforming use. Nothing contained in this ordinance shall require any change in the construction, alteration, or intended use of any structure, the construction or alteration of which was begun prior to the effective date of this ordinance, and is diligently prosecuted.

11-1.7 *Permits.*

(a) Except as provided in subsections (a), (b) and (c) of this section, no structure shall be erected or otherwise established in any zone created by this Overlay District unless a permit therefore shall have been applied for and granted. Each application for a permit shall indicate the purpose for which desired with and sufficient geometric specificity to determine whether the resulting structure would conform to the regulations prescribed in this section 11-1. No permit for a structure inconsistent with the provisions of this section 11-1.7 shall be granted unless a variance has been approved as provided in section 11-1.7(d).

(b) No permit shall be granted that would allow the establishment or creation of an obstruction or permit a nonconforming use or structure to become a greater hazard to air navigation than it was on the effective date of this zoning ordinance or any amendments thereto other than with the relief as provided in section 11-1.7(d).

(c) Whenever the zoning administrator determines that a nonconforming structure has been abandoned or more than 50 percent destroyed, physically deteriorated, or decayed, no permit shall be granted that would enable such structure to be rebuilt, reconditioned, or otherwise refurbished so as to exceed the applicable height limit or otherwise deviate from the zoning regulations contained in this Overlay District.

(d) Any person desiring to erect or increase the height or size of any structure not in accordance with these regulations shall apply to the board of zoning appeals for a variance. The application for variance shall be accompanied by a determination from the Virginia Department of Aviation as to the effect of the proposal on the operation of air navigation facilities and the safe, efficient use of navigable airspace. Such variances shall be allowed where it is duly found that a literal application or enforcement of the regulations will result in unnecessary hardship and relief granted will not be contrary to the public interest, will not create a hazard to air navigation, will do substantial justice, and will be in accordance with the spirit of this ordinance. Additionally, no application for a variance to the requirements of this Overlay District may be considered by the board of zoning appeals unless a copy of the application has been furnished to the airport owner for advice as to the aeronautical effects of the variance. If the airport owner does not respond to the application within 15 days after receipt, the board of zoning appeals may act on its own to grant or deny the application for a variance.

(e) Any permit or variance granted may, if such action is deemed advisable to effectuate the purpose of this Airport Safety Overlay District and be reasonable in the circumstances, be so conditioned as to require the owner of the structure in question to install, operate, and maintain, at the owner's expense, such markings and lights as may be deemed necessary by the Federal Aviation Administration, the Virginia Department of Aviation, or the zoning administrator. If deemed proper by the board of zoning appeals this condition may be modified to require the owner to permit the airport owner, at his own expense, to install, operate, and maintain the necessary markings and lights.

11-1.8 *Enforcement.* The zoning administrator shall administer and enforce the regulations prescribed in this section 11-1. Applications for permits and variances shall be made to the zoning administrator on a form prepared for that purpose. Applications required by this section 11-1 should be submitted to the zoning administrator and shall be properly considered and granted or denied.

11-1.9 *Conflicting regulations.* Where there exists a conflict between any of the regulations or limitations prescribed in this section 11-1 and any other regulations applicable to the same subject, where the conflict is with respect to the height of structures or trees, and the use of land, or any other matter, the more stringent limitation or requirement shall govern.