
# Air Installation Compatible Use Zone Study Update

## Dover Air Force Base
## Delaware

AUGUST 2010

# AIR INSTALLATION COMPATIBLE USE ZONE STUDY UPDATE

# DOVER AIR FORCE BASE, DELAWARE

**PREPARED BY**

PARSONS

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| 436 AW | 436th Airlift Wing |
| AEOZ | Airport Environs Overlay Zone |
| AFB | Air Force Base |
| AFI | Air Force Instruction |
| AGL | above ground level |
| AICUZ | Air Installation Compatible Use Zone |
| APZ | Accident Potential Zone |
| AS | Airlift Squadron |
| CZ | Clear Zone |
| dB | decibel |
| DNL | Day-Night Average A-Weighted Sound Level |
| DoD | Department of Defense |
| EIR | Economic Impact Region |
| FAA | Federal Aviation Administration |
| FAR | Federal Aviation Regulation |
| INM | Integrated Noise Model |
| NLR | Noise Level Reduction |
| SR | State Route |
| the Base | Dover Air Force Base |
| UFC | Unified Facilities Criteria |
| USEPA | U.S. Environmental Protection Agency |

# SECTION 1
# PURPOSE AND NEED

## 1.1 INTRODUCTION

This study is an update of the 1999 Dover Air Force Base (AFB), Delaware Air Installation Compatible Use Zone (AICUZ) Study. The update presents and documents changes to the AICUZ study resulting from completion of the basing of C-17 aircraft at Dover AFB (the Base), which resulted in increasing C-17 operations and decreasing the number of C-5 aircraft, as well as other aircraft operations changes at the Base. This AICUZ Study reaffirms Air Force policy of assisting local, regional, state, and federal officials in the areas surrounding Dover AFB by promoting compatible development within the AICUZ area of influence, and protecting Air Force operational capability from the effects of land use that is incompatible with aircraft operations. Specifically, the study documents changes in aircraft operations since the last study and provides noise contours and compatible use guidelines for land areas surrounding Dover AFB-. This information is provided to assist local communities and to serve as a tool for future planning and zoning activities. Changes that have occurred since the 1999 Dover AFB AICUZ Study or are projected to occur are to:

- Base and operate 12 C-17 aircraft at Dover AFB;
- Reduce the number of C-5 aircraft based at Dover AFB from 32 to 18.
- Add, eliminate, and modify aircraft flight tracks to correspond to flying operations changes; and
- Make technical improvements to the NOISEMAP computer modeling program.

## 1.2 PURPOSE AND NEED

The purpose of the long-standing AICUZ program is to promote compatible land development in areas subject to aircraft noise and accident potential. As the City of Dover and Kent County prepare and modify land use development plans, recommendations from this updated AICUZ Study should be included in the planning process to prevent incompatible land use that could compromise the ability of Dover AFB to fulfill its mission. Accident potential and aircraft noise should be major considerations in the planning process.

Air Force AICUZ guidelines reflect land use recommendations for the Clear Zones (CZ), Accident Potential Zones (APZ) I and II, and four noise zones exposed to noise levels at or above 65 decibels (dB) Day-Night Average A-Weighted Sound Level (DNL). These guidelines were established based on studies prepared and sponsored by several federal agencies, including the United States Department of Housing and Urban Development, United States Environmental Protection Agency (USEPA), United States Air Force, and state agencies. The guidelines recommend land uses that are compatible with airfield operations while allowing maximum beneficial use of adjacent properties. The Air Force has no desire to recommend land use regulations that render property economically useless. It does, however, have an obligation to the inhabitants of the Dover AFB area of influence and the citizens of the United States to point out ways to protect the public investment in the installation and the people living in areas adjacent to the Base. The AICUZ area of influence

includes the area within the DNL of 65 dBA and greater noise exposure area as well as the area within the CZs and APZs.

## 1.3 PROCESS, PROCEDURE, AND NOISE METRICS

Preparation and presentation of this update to Dover AFB's AICUZ Study is part of the continuing Air Force participation in the local planning process. Guidance for the Air Force AICUZ program is contained in Air Force Instruction (AFI) 32-7063, *Air Installation Compatible Use Zone Program*, which implements Department of Defense (DoD) Instruction 4165.57, *Air Installations Compatible Use Zones*.

As local communities prepare land use plans and zoning ordinances, the Air Force recognizes it has the responsibility to provide input on its activities relating to the community. This study is presented in the spirit of cooperation and assistance by Dover AFB to aid in the land use planning process around the Base. Noise contours depicted on the AICUZ maps in this study are based on the September of 2008 to September of 2009 levels of flying activity.

Aircraft operational data used in this study were collected at Dover AFB in September 2008 and validated as well as updated in October 2009. The noise contours created for this AICUZ Study were based on the most current operations data at the time this study was conducted.

The AICUZ program uses the latest technology to define noise levels in areas near Air Force installations with a flying mission. An analysis of Dover AFB's flying operations was performed, including types of aircraft, flight patterns utilized, variations in altitude, power settings, number of operations, and hours of operations. After verification for accuracy, the data were input into the NOISEMAP Version 7.352 computer modeling program and the DNL metric was used to define the noise zones for Dover AFB. The noise contours for Dover AFB were plotted on an area map and overlaid with the CZ and APZ areas for the airfield.

## 1.4 COMPUTERIZED NOISE EXPOSURE MODELS

The Air Force developed the NOISEMAP computer program to describe noise impacts created by aircraft operations. NOISEMAP is one of two United States Environmental Protection Agency (USEPA)-approved computer programs; the other is the Integrated Noise Model (INM) used by the Federal Aviation Administration (FAA) for noise analysis at civil airports. The NOISEMAP and INM programs are similar; however, INM does not contain noise data for all military aircraft.

NOISEMAP is a suite of computer programs and components developed by the Air Force to predict noise exposure in the vicinity of an airfield due to aircraft flight, maintenance, and ground run-up operations. The components of NOISEMAP are:

- BASEOPS - the input module for NOISEMAP and is used to enter detailed aircraft flight track and profile as well as ground maintenance operational data.
- NOISEFILE - a comprehensive database of measured military and civil aircraft noise data. Aircraft operational information is matched with the noise measurements in the NOISEFILE after the detailed aircraft flight and ground maintenance operational data has been entered into BASEOPS.

- NMAP - the computational module in NOISEMAP. NMAP takes BASEOPS input and uses the NOISEFILE database to calculate the noise levels generated by aircraft events at specified grid points in the airbase vicinity. The output of NMAP is a series of georeferenced data points, specific grid point locations, and corresponding noise levels.
- NMPLOT - the program for viewing and editing the sets of georeferenced data points. NMPLOT plots the NMAP output in a noise contour grid that can be exported as files to be used in mapping programs for analyzing the noise impacts.

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# SECTION 2
# INSTALLATION DESCRIPTION

## 2.1 DESCRIPTION OF DOVER AIR FORCE BASE

Dover AFB is located in Kent County in central Delaware, southeast of the City of Dover, the capital of Delaware. The Base is situated on approximately 3,900 acres of land. Figure 2.1 shows Dover AFB location map. Access to the Base from the north is via U.S. 13, U.S. 113, and by the State Route (SR)-1 Bypass. U.S. 113 and SR-1 provide access from the south and SR-9 flanks the east side of the Base. From the west, SR-10 provides direct access to the Base via a north gate. Dover AFB has two active runways, 01/19 and 14/32.

## 2.2 MISSION

The 436th Airlift Wing (436 AW) is the host unit at Dover AFB and reports to the Air Mobility Command, headquartered at Scott AFB, Illinois. The vision of the wing is to "Continue to be America's preeminent expeditionary airlift team." During wartime, 436 AW is responsible for deployment and resupply of the major combat units of the United States. The Wing also provides administrative, logistical, and medical support to 436 AW units, tenant agencies, as well as retirees and their families who live in the Dover community. The organizational structure of 436 AW consists primarily of a Wing Headquarters, Maintenance Group, Medical Group, Operations Group, and Mission Support Group.

Major tenant units at the Base include the 512th Airlift Wing (Air Force Reserve Command), Air Force Office of Special Investigations, the Army and Air Force Exchange Service, Defense Commissary Agency, Air Force Mortuary Affairs Operations Center, and Detachment 3 of the 373rd Training Squadron. The 436th Operations Group is home to the wing's primary flying units, the 3rd and 9th Airlift Squadrons (AS). Flying squadrons in the 512th AW include the 326 AS and 709 AS.

## 2.3 ECONOMIC IMPACT

The Economic Impact Region (EIR) for Dover AFB is the geographic area subject to significant base-generated economic impacts, and is defined as the area within a 50-mile radius of the Base. This area includes the Delaware counties of Kent, Sussex, and New Castle, the City of Dover, and the Towns of Frederica, Little Creek, and Magnolia. The area most immediately impacted is Kent County and the City of Dover.

### 2.3.1 Local Economic Characteristics

As shown in Table 2.1, Kent County had a population of over 126,000 in 2000. The City of Dover, with a 2008 population of 35,811, an increase of nearly 12 percent from the 2000 population, constitutes approximately 25 percent of Kent County's total population.

The Delaware Population Consortium projects that Kent County's population will increase to over 159,000 by 2010, 169,433 by 2015, and 178,257 by 2020. This increase represents a faster rate than the State of Delaware as a whole, remaining at about 3 percent per decade

**Table 2.1 Historic and Projected Population**

| Area | 1990 | 2000 | 2010 projection | 2020 projection |
|---|---|---|---|---|
| Dover | 27,529 | 32,043 | 37,479 | 38,635 |
| Kent County | 110,993 | 126,697 | 159,722 | 178,257 |

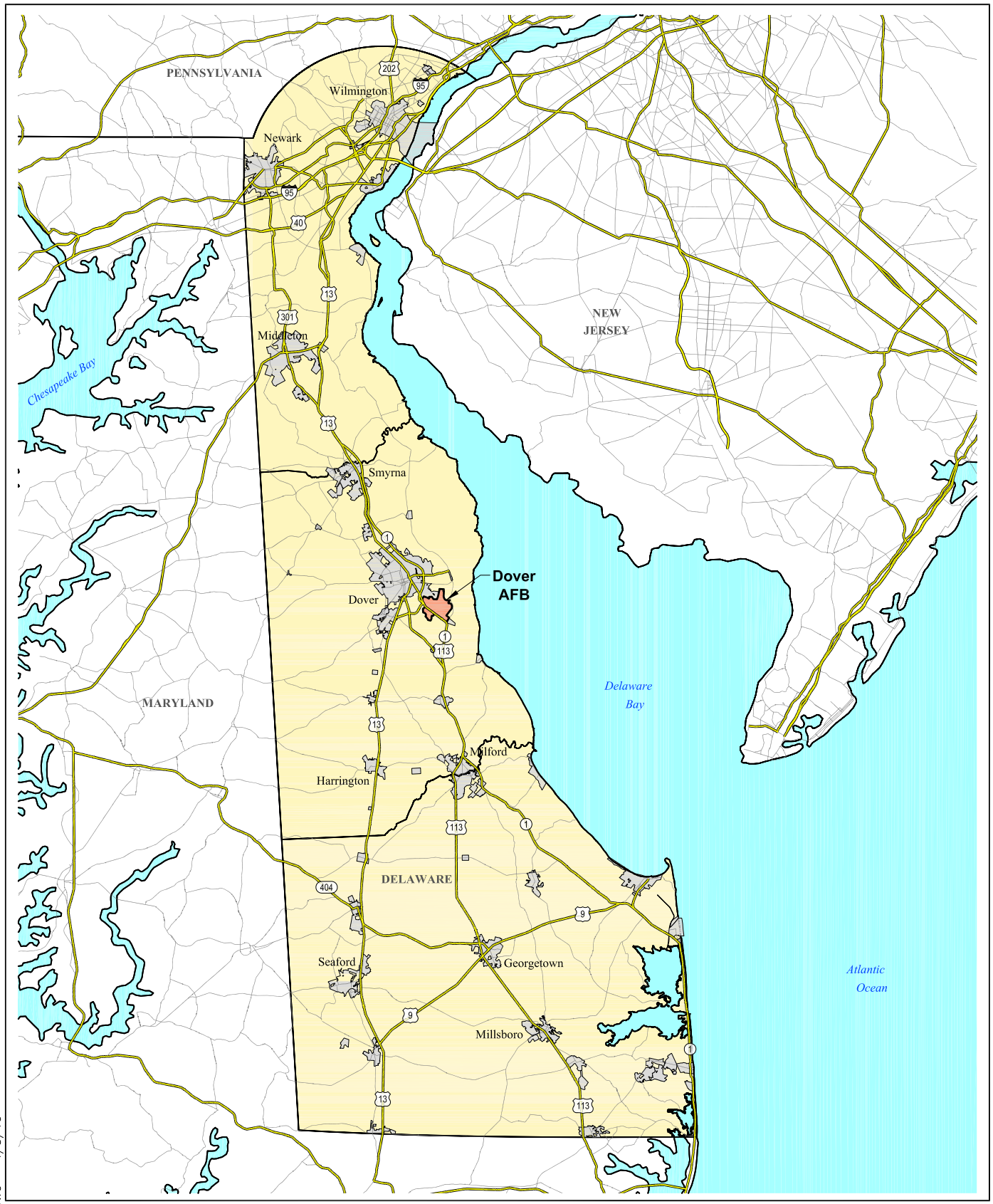
*Source: US Census Bureau, 2000; City of Dover Comprehensive Plan, 2008; the Delaware Population Consortium, 2009*

In 2009, employment in Kent County was estimated to be nearly 63,000 persons. The county's unemployment rate typically ranges between four and five percent. Professional, Educational, Health, Leisure, and Hospitality Services employ the largest percentage of workers, with nearly 22,000 employees (35% of total). Table 2.2 presents the Kent County non-farm employment, by employment sector.

**Table 2.2 Kent County Non-farm Employment Estimates, Dec-09**

| Sector | Employees |
|---|---|
| Construction, Mining, Natural Resources | 2,500 |
| Manufacturing | 3,300 |
| Trade, Transportation & Utilities | 13,100 |
| Information | 700 |
| Finance Insurance and Real Estate | 2,100 |
| Services | 21,700 |
| Government | 19,300 |
| **Total** | **62,700** |

*Source: Delaware Department of Labor & U.S. Department of Labor, Bureau of Labor Statistics*

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## Dover AFB Location Map

Figure 2.1

### 2.3.2 Base Impact

The geographic area subject to significant Base-generated economic impacts is defined as the area within a 50-mile radius of Dover AFB. As of the fiscal year 2010, Dover AFB employed 7,175 military personnel and civilians (Table 2.3). The annual payroll of the installation is $340.5 million (Table 2.4).

As a result of payroll expenditures, annual expenses, and the estimated value of indirect jobs in the local area, Dover AFB has an estimated total economic impact on the region of more than $528.8 million. The majority of this economic impact is due to the payroll and contracts provided by the Base.

**Table 2.3 Personnel by Classification**

| Classification | Total |
|---|---|
| **Active Duty Military** | **5,483** |
| Military Dependents | 3,652 |
| Appropriated Fund Civilian | 1,105 |
| Non-Appropriated Fund Civilian | 587 |
| **Total Dependents and Civilian Personnel** | **5,344** |
| **Total** | **10,827** |

*Source: Dover AFB FY09 Economic Impact Statement*

**Table 2.4 Annual Payroll and Expenditures ($M)**

| Category | ($M) |
|---|---|
| Total Annual Military Payroll | 249.6 |
| Total Annual APF and NAF Civilian Payroll | 90.9 |
| **Subtotal Payroll** | **340.5** |
| Annual Expenses for Construction Services and Procurement | 96.0 |
| **Total** | **436.5** |

*Source: Dover AFB FY09 Economic Impact Statement*

# SECTION 3
# AIRCRAFT OPERATIONS

## 3.1 INTRODUCTION

It is necessary to fully evaluate the exact nature of flying activities to describe the relationship between aircraft operations and land use at and around the Base airfield. The October 2009 inventories of Base aircraft operations included where aircraft fly, how high they fly, how many times they fly over a given area, and the time of day they fly.

Section 3.2 discusses aircraft operations at Dover AFB; Section 3.3 discusses runway and flight track utilization for all operations by aircraft type; Section 3.4 describes aircraft maintenance activity; Section 3.5 discusses aircraft flight profiles; and Section 3.6 presents climatological data.

## 3.2 AIRCRAFT OPERATIONS

It is estimated that about 35,500 annual aircraft operations occur at Dover AFB. An aircraft operation is defined as one takeoff/departure, one approach/landing, or half a closed pattern. A closed pattern consists of two portions, a takeoff/departure and an approach/landing, *i.e.,* two operations. A sortie is a single military aircraft flight from the initial takeoff through the termination landing. The minimum number of aircraft operations for one sortie is two operations, one takeoff (departure), and one landing (approach).

Table 3.1 summarizes the average annual day aircraft operations for Dover AFB based on information provided by Base staff, flying organization, and air traffic control personnel. Aircraft types operating at the Base consist primarily of military aircraft. In addition to the Dover AFB based C-5 and C-17 aircraft, numerous types of transient military and civil air carrier aircraft conduct operations at the Base. Operations of the transient military and civilian aircraft types were combined based on similar characteristics (*e.g.*, number and type of engines, size of aircraft, airspeed, *etc*.). The table reflects a total of approximately 121 average annual day aircraft operations at Dover AFB. Approximately 26 percent of the total daily aircraft flight operations occur at night (10:00 p.m.-7:00 a.m.).

Although the number of military and civil aircraft operations at an installation usually varies from day to day, NOISEMAP requires input of the specific numbers of daily flight and aircraft maintenance engine runup operations. The Air Force does not follow the FAA's use of the "average annual day" in which annual operations are averaged over an entire 365-day year. Neither does the Air Force use the "worst-case day" since it typically does not represent the typical noise exposure. Instead, the Air Force uses the "average busy day" concept in which annual operations for an aircraft type are averaged over the number of flying days per year by that aircraft type.

**Table 3.1 Average Busy Day Aircraft Operations at Dover AFB**

| Category/ Aircraft Type | Daily Arrival/ Departure Operations | Daily Closed Pattern Operations | Total Daily Operations |
|---|---|---|---|
| **Dover AFB Based Aircraft** | | | |
| C-17 | 4.10 | 32.50 | 36.60 |
| C-5 | 3.70 | 44.97 | 48.66 |
| Aero Club | 0.86 | 13.28 | 14.14 |
| *Subtotal* | *8.66* | *90.74* | *99.40* |
| **Transient Military Aicraft** | | | |
| C-17 | 1.93 | 0.00 | 1.93 |
| C-5 | 3.11 | 0.00 | 3.11 |
| F-18 | 0.06 | 0.00 | 0.06 |
| A-10 | 0.09 | 0.00 | 0.09 |
| T-1 | 0.03 | 0.00 | 0.03 |
| T-38 | 0.23 | 0.00 | 0.23 |
| F-16 | 0.13 | 0.00 | 0.13 |
| KC-135 | 0.53 | 0.00 | 0.53 |
| C-21 | 0.53 | 0.00 | 0.53 |
| P-3 | 0.03 | 0.00 | 0.03 |
| UH-60 | 1.02 | 0.00 | 1.02 |
| UH-1 | 0.43 | 0.00 | 0.43 |
| *Subtotal* | *8.12* | *0.00* | *8.12* |
| **Civilian Aircraft** | | | |
| B-747 | 7.33 | 0.00 | 7.33 |
| DC-10 | 0.36 | 0.00 | 0.36 |
| Cessna | 1.51 | 0.00 | 1.51 |
| Falcon 20 | 3.55 | 0.00 | 3.55 |
| MD-11 | 0.33 | 0.00 | 0.33 |
| B-737 | 0.13 | 0.00 | 0.13 |
| *Subtotal* | *13.21* | *0.00* | *13.21* |
| **Total** | **29.99** | **90.74** | **120.73** |
| | | | |

Note: An operation is one arrival/departure or one takeoff/landing; One closed pattern consists of two operations, one takeoff and one landing.

## 3.3 RUNWAY AND FLIGHT TRACK UTILIZATION

The Base has two runways. Runway 01/19 is oriented 010°–190°, is 9,600 feet long and 200 feet wide, and has 1,000-foot long overruns at each end. Runway 14/32 is oriented 140°–320°, is 12,900 feet long and is 150 feet wide, and has a 150-foot long overrun at the northwest end and a 1,000-foot long overrun at the southeast end. The airfield elevation is 28 feet above mean sea level. Overhead traffic patterns accomplished by fighter and trainer type aircraft are flown at an altitude of approximately 2,500 feet above ground level (AGL). Rectangular patterns for large, heavy aircraft are accomplished about 1,800 feet AGL. Light aircraft such as Aero Club aircraft fly patterns at approximately 700 feet AGL. Radar patterns are flown about 3,000 feet AGL.

A hangar off the northwest end of Runway 14/32 affects the operations on the runway; the location of the hangar reduces the length of runway available for landing on Runway 14 and takeoff on Runway 32. The runway threshold on the northwest end of Runway 14/32 is displaced 4,248 feet to the southeast to assure proper clearance between landing aircraft and the hangar. With this adjustment, approximately 8,652 feet of runway are available for landing on Runway 14. Landings on Runway 14 are restricted to helicopters and Dover AFB Aero Club aircraft. However, Runway 14 may be used by other aircraft during closure of Runway 01/19 and when crosswind and runway conditions prevent aircraft from landing on Runway 01/19.

For Runway 32 departures, the threshold is displaced 2,830 feet from the northwest end, leaving 10,070 feet for takeoff. Aircraft departing on Runway 32 turn to a heading of 360 degrees after takeoff to avoid the hangar.

Aircraft arrival and departure flight tracks at Dover AFB are influenced by other airports within the area. The Chandele Estates Airport is 5 miles north; Johnson's Airport is 4 miles south; the Henderson Aviation Airport is 8 miles southwest; the Jenkins Airport is 5 miles west; the Delaware Airpark is 8 miles northwest; and the Smyrna Airport is 11 miles northwest. The location and proximity of these airports relative to Dover AFB require that arriving and departing aircraft be routed to avoid conflict. Likewise, regional aircraft routings are developed, to the maximum extent practicable, to establish common tracks that serve the arrival and departure "flow" for all the airports within the area.

To reduce aircraft noise in the areas surrounding Dover AFB, the Base has established noise abatement procedures advising pilots to avoid overflying beach towns. Additionally, pilots should not overfly the Town of Little Creek nor housing units to the maximum extent possible. To reduce noise to the northwest of the airfield, aircraft taking off on Runway 32 will turn to the north (360º) when reaching 400 feet AGL, use radar vectors for departure, and delay flap retraction until 2,000 feet AGL or reaching pattern altitude. Missed approaches for Runway 32 are executed prior to the approach end of the runway by turning to a heading of 360º. Landing on Runway 14 is restricted to helicopters and Dover AFB Aero Club aircraft; however, the runway may be used for aircraft emergency landings or during excessive wind conditions.

Aircraft operating at Dover AFB use the following flight patterns:

- Departures on Runways 01 and 19 proceed straight-out, Runway 14 departures turn slightly right after the end of the runway, and departures from Runway 32 turn to a heading of 360º (except for the spiral up departure, which climbs to altitude before proceeding to the northwest);
- Straight-in approaches;
- Overhead landing patterns;
- Radar closed patterns;
- Tactical C-17 arrivals, departures, and closed patterns in which the aircraft spirals up and down above the airfield; and
- Overhead and rectangular closed patterns.

Flight patterns specific to Dover AFB result from several considerations, including:

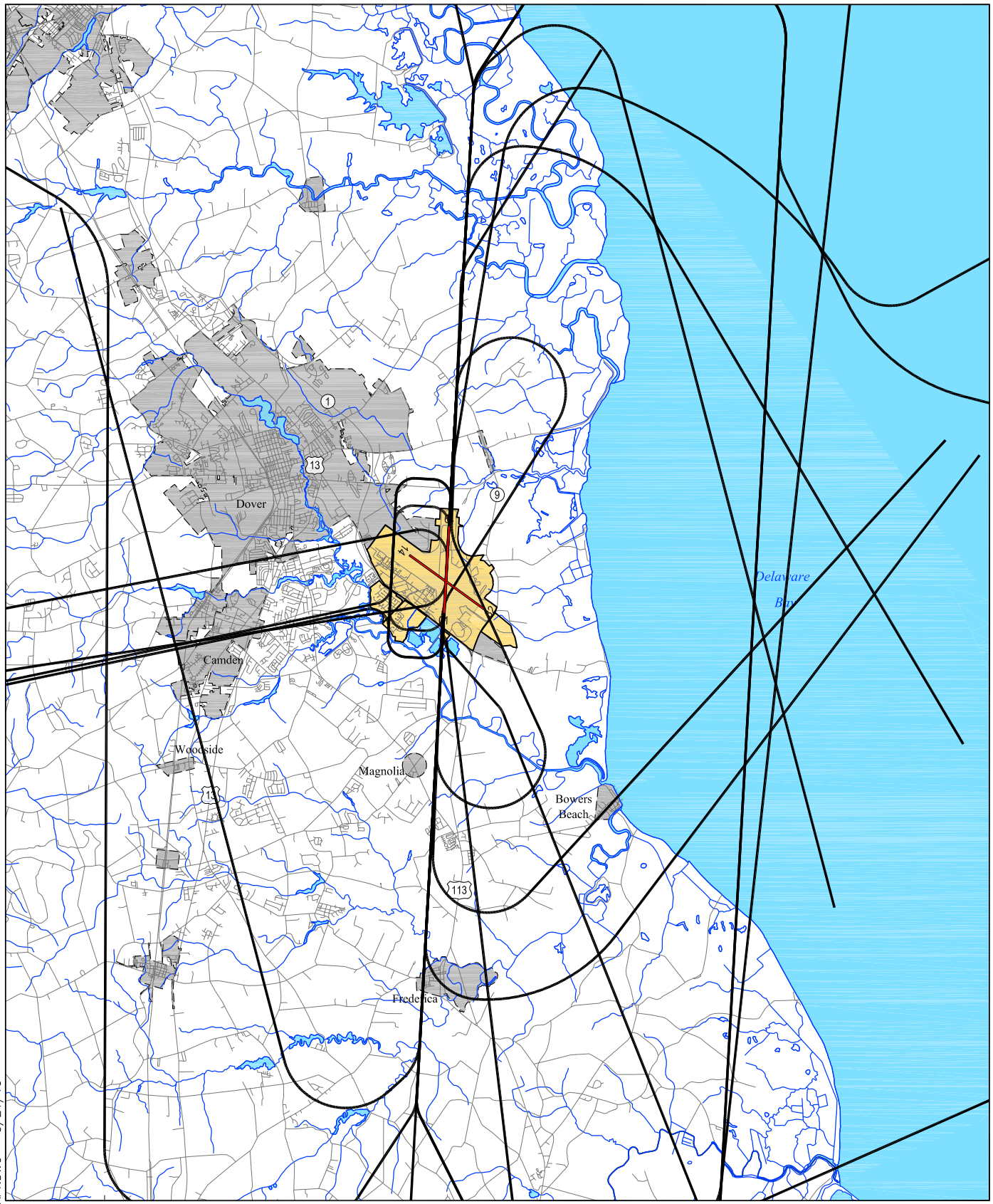
- Takeoff patterns routed to avoid noise-sensitive areas, such as the City of Dover, as much as possible;
- Criteria governing the speed, rate of climb, and turning radius for each type of aircraft;
- Efforts to control and schedule missions to keep noise levels low, especially at night; and
- Coordination with the FAA to minimize conflict with civil aircraft operations.

Planning for the areas surrounding an airfield considers three primary aircraft operational/land-use determinants: (1) aircraft accident potential to land users; (2) aircraft noise; and (3) hazards to operations from land uses (*e.g.*, height of structures). Each of these concerns is addressed in conjunction with mission requirements and safe aircraft operations to determine the optimum flight track for each aircraft type. The flight tracks depicted in Figures 3.1 through 3.6 are the result of such planning and depict the representative flight tracks used for noise modeling. Following are the percents of use for the four runways: Runway 01, 53 percent; Runway 19, 30 percent; Runway 14, 5 percent; and Runway 32, 12 percent.

## 3.4 AIRCRAFT MAINTENANCE RUNUP OPERATIONS

To the maximum extent possible, aircraft maintenance engine runup locations have been established in areas to minimize noise for people on Base, as well as for those in the surrounding communities. Aircraft maintenance engine runup operations are accomplished by based flying units and their associated maintenance functions.

Average annual day aircraft maintenance runup operations were calculated similarly to flight operations described in Section 3.1. Weekly, monthly, or annual estimates of runups provided by Dover AFB aircraft maintenance personnel were divided by the typical number of days runups were performed over the respective period.




**Dover Air Force Base 2010 AICUZ**

LEGEND

- Flight Track
- Runway
- Roadway
- Dover AFB
- Municipal Boundary

N

0 15,000

Feet

# Arrival Flight Tracks Runway 01/19

Figure 3.1

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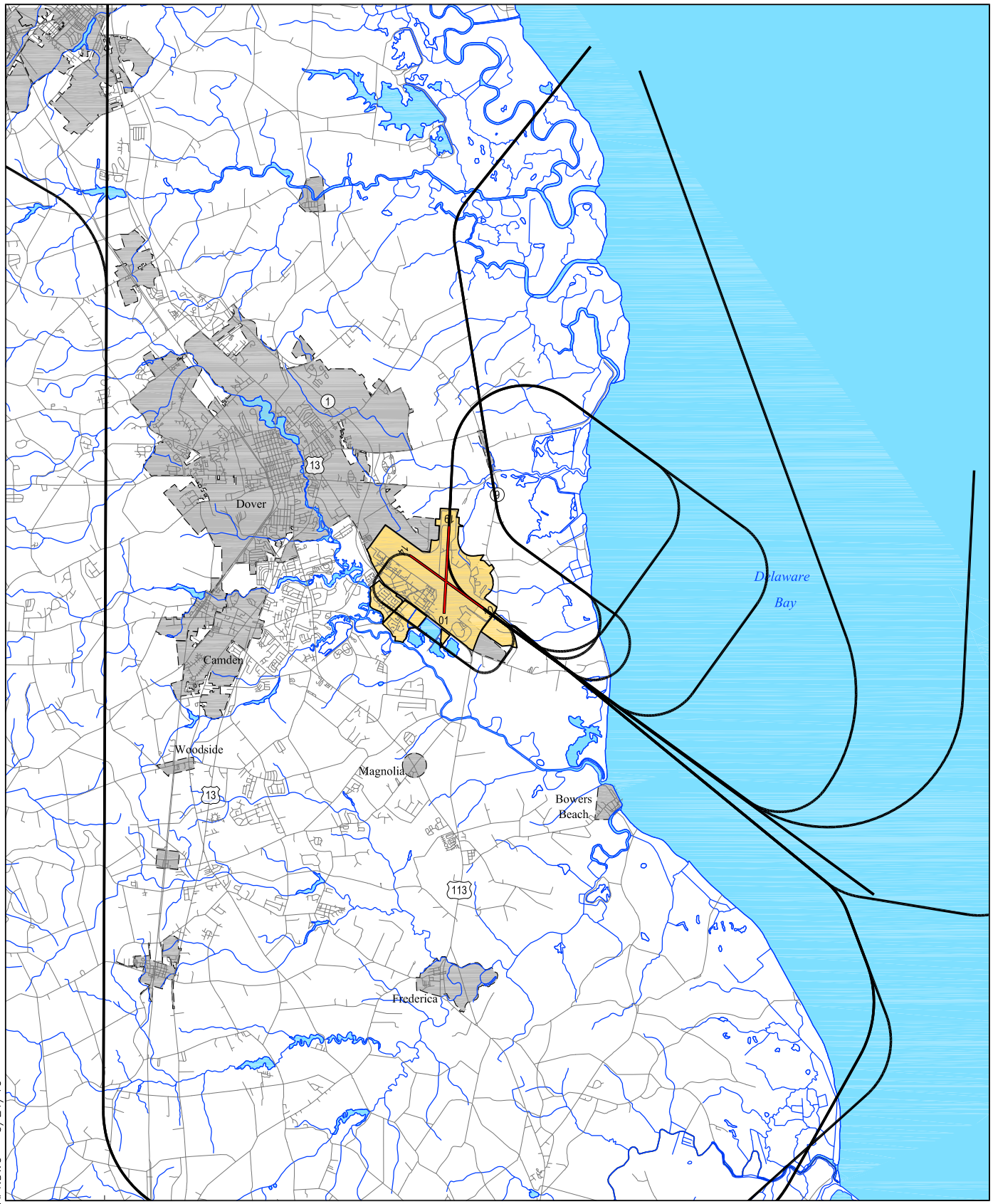



**Dover Air Force Base 2010 AICUZ**

LEGEND

- Flight Track
- Runway
- Roadway
- Dover AFB
- Municipal Boundary

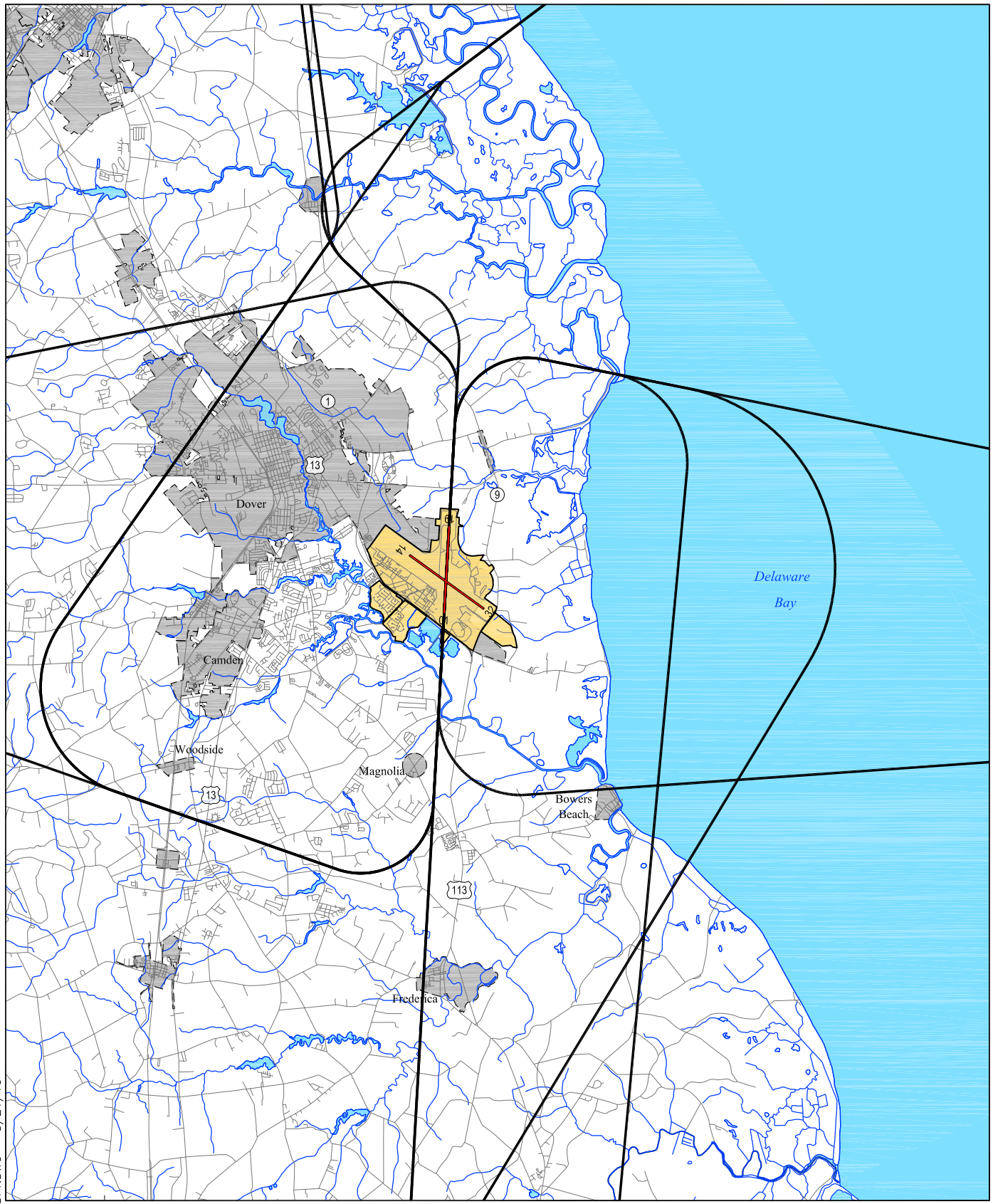
N

0 15,000 Feet

# Arrival Flight Tracks Runway 14/32

Figure 3.2

747076 DOV10-AICUZ-1432AFT.DWG 5/21/10




**Dover Air Force Base 2010 AICUZ**

LEGEND

- Flight Track
- Runway
- Roadway
- Dover AFB
- Municipal Boundary

N

0 15,000

Feet

# Departure Flight Tracks Runway 01/19

Figure 3.3

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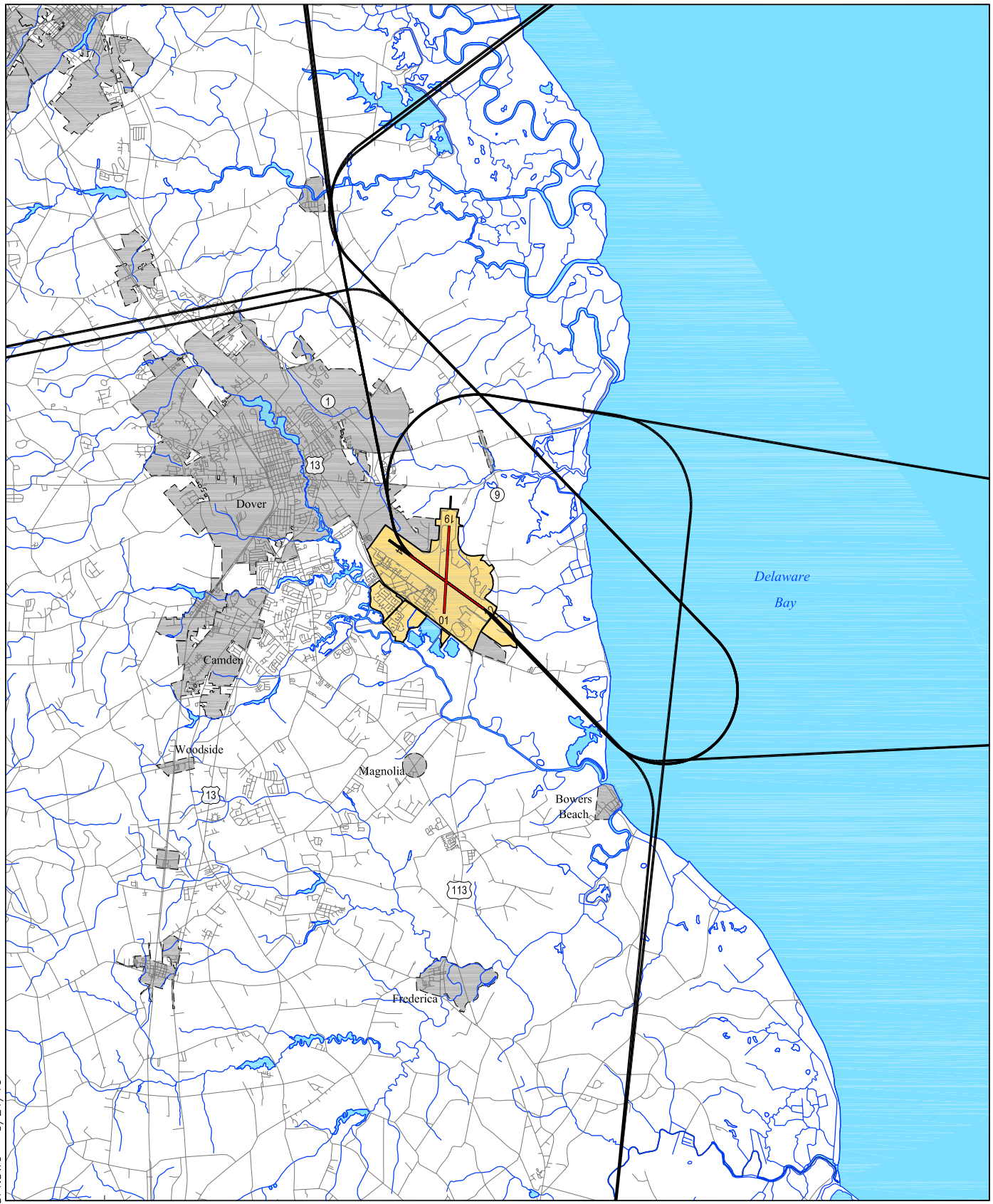


**Dover Air Force Base 2010 AICUZ**

LEGEND

- Flight Track
- Runway
- Roadway
- Dover AFB
- Municipal Boundary

N

0 15,000

Feet

# Departure Flight Tracks Runway 14/32

Figure 3.4

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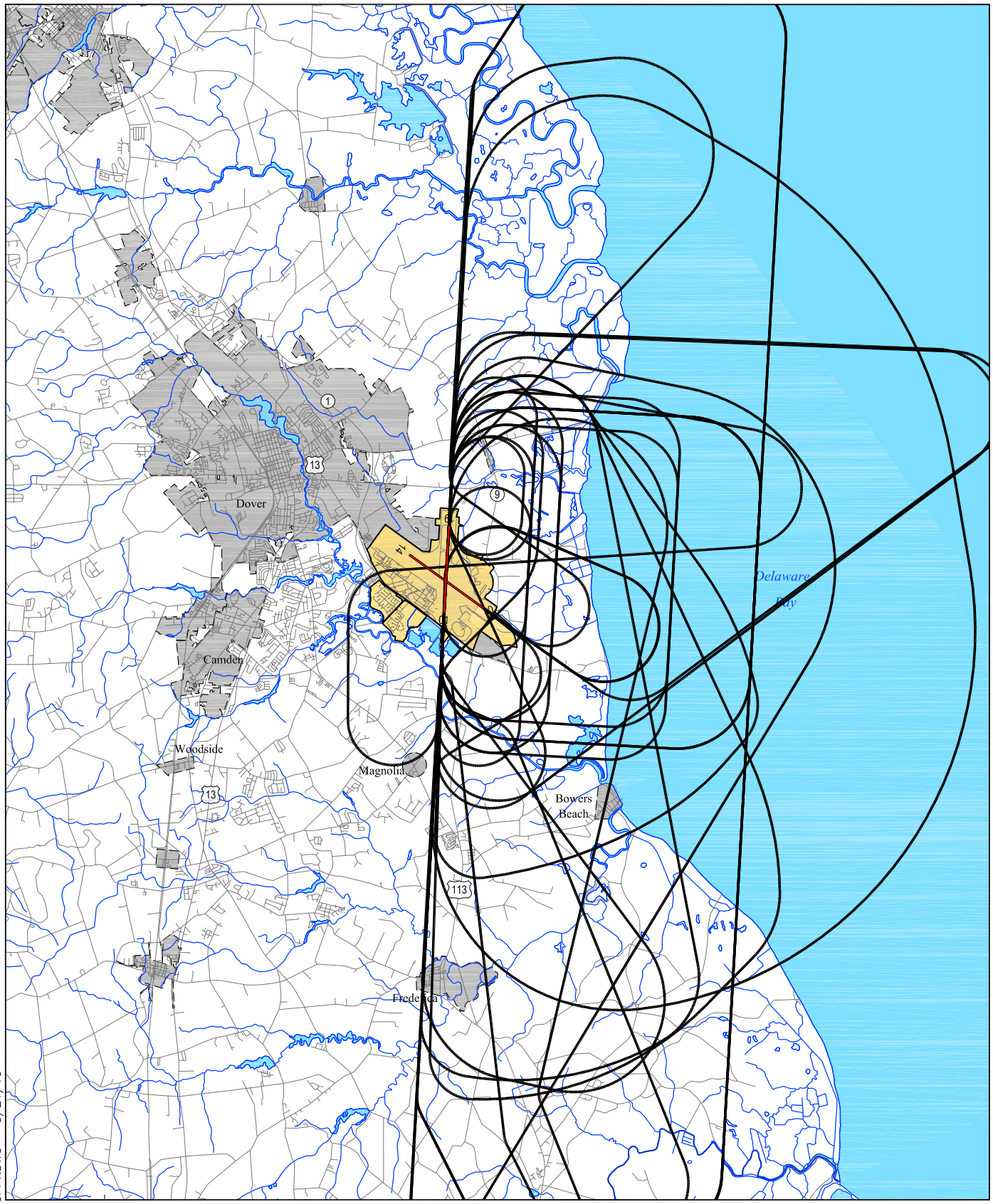



**Dover Air Force Base 2010 AICUZ**

LEGEND

- Flight Track
- Runway
- Roadway
- Dover AFB
- Municipal Boundary

N

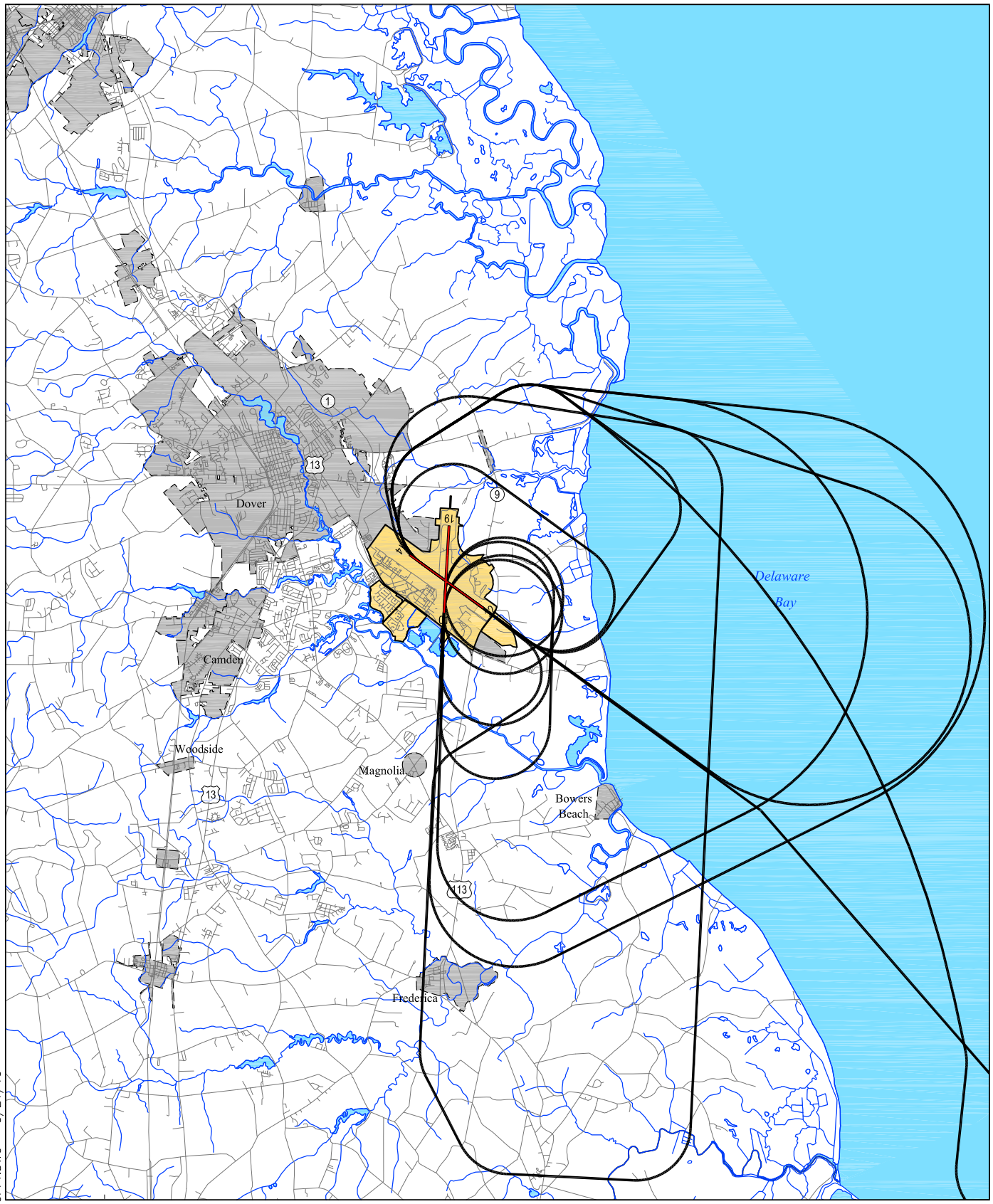
0 15,000

Feet

# Closed Pattern Flight Tracks - Runway 01/19

Figure 3.5

747076 DOV10-AICUZ-0119CPFT.DWG 5/21/10




**Dover Air Force Base 2010 AICUZ**

LEGEND

- Flight Track
- Runway
- Roadway
- Dover AFB
- Municipal Boundary

N

0 15,000

Feet

# Closed Pattern Flight Tracks - Runway 14/32

Figure 3.6

747076 DOV10-AICUZ-1432CPFT.DWG 5/21/10

## 3.5 AIRCRAFT FLIGHT PROFILES

For purposes of this AICUZ Study, aircraft "flight profiles" denote the aircraft power settings, altitudes above runway level, and airspeeds along each flight track. Aircraft flight profiles for C-5 and C-17 aircraft were obtained from Dover AFB personnel. Generic flight profiles from the BASEOPS database were used to model operations for the other military aircraft types. Noise data from the NOISEFILE database were used to model operations for all aircraft types.

## 3.6 CLIMATOLOGICAL DATA

Weather conditions, measured by temperature and relative humidity, are an important factor in the propagation of noise. Temperature and relative humidity affect sound absorption. The average temperature and humidity for each month of the year are input into BASEOPS, which then calculates the sound absorption coefficient for each month. Ranking the twelve monthly sound absorption coefficients from smallest to largest, BASEOPS chooses the sixth smallest sound absorption coefficient to represent the typical weather conditions at the installation. The month with the sixth smallest sound absorption coefficient for Dover AFB is the month with the average monthly temperature of 36 degrees Fahrenheit and 66 percent relative humidity.

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# SECTION 4
# EFFECTS OF AIRCRAFT OPERATIONS

## 4.1 INTRODUCTION

This section has two purposes. The first is to describe the imaginary surfaces associated with obstructions to air navigation, noise exposure, CZs, and APZs. The second is to present applicable land-use compatibility guidelines and the Air Force's participation in the land-use planning process.

## 4.2 RUNWAY AIRSPACE IMAGINARY SURFACES

Obstructions to air navigation are considered to be:

- Natural objects or man-made structures that protrude above the planes or imaginary surfaces, and/or;
- Man-made objects that extend more than 500 feet AGL at the site of the structure.

### 4.2.1 Explanation of Terms

The following elevation, runway length, and dimensional criteria apply:

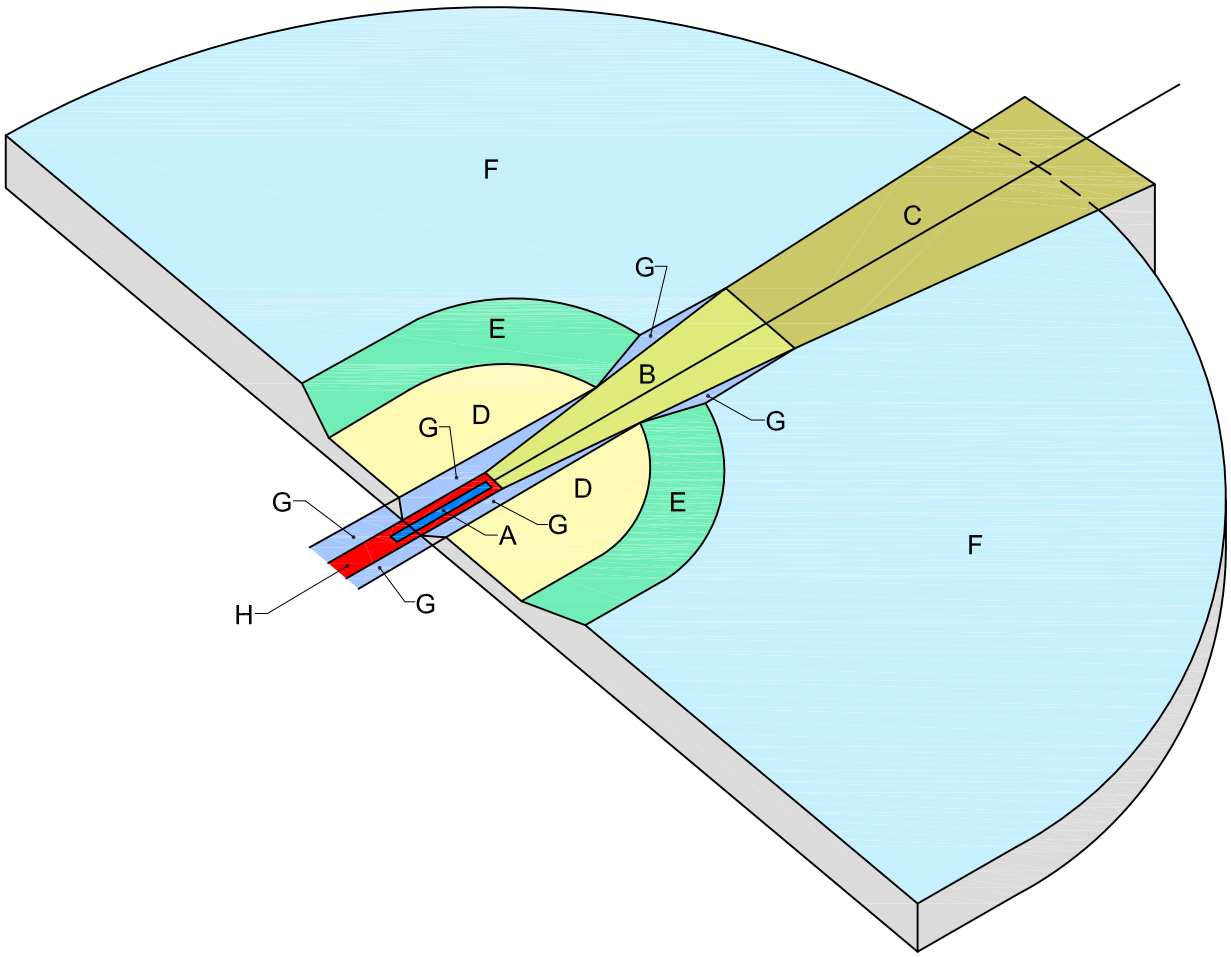
- Controlling Elevation—whenever surfaces or planes within the obstruction criteria overlap, the controlling (or governing) elevation becomes that of the lowest surface or plane.
- Runway Length—Dover AFB has two runways. Runway 01/19 is 9,600 feet long and Runway 14/32 is 12,900 feet long. Both runways are Class B runways designed and built for sustained aircraft landings and take-offs.
- Established Airfield Elevation—The established elevation for the Dover AFB airfield is 28 feet above mean sea level.
- Dimensions—All dimensions are measured horizontally unless otherwise noted.

### 4.2.2 Runway Airspace Imaginary Surfaces

Runway airspace imaginary surfaces, in graphical form, are the result of the application of obstruction height criteria to Dover AFB. Imaginary surfaces are surfaces in space around airfields in relation to runways. The surfaces are designed to define the obstacle-free airspace at and around the airfield. Refer to Unified Facilities Criteria (UFC) 3-260-01, *Airfield and Heliport Planning and Design* (2008), for a more complete description of runway airspace imaginary surfaces for Class B runways. Figure 4.1 depicts the runway airspace imaginary surfaces for the Dover AFB Class B runways. Air Force obstruction criteria in UFC 3-260-01 are based on those contained in Federal Aviation Regulation (FAR) Part 77, *Objects Affecting Navigable Airspace*, Subpart C. The following paragraphs contain definitions of the runway airspace imaginary surfaces for Air Force Class B runways:

- Primary Surface—An imaginary surface symmetrically centered on the runway, extending 200 feet beyond each runway end, which defines the limits of the obstruction clearance requirements in the vicinity of the landing area. The width of the primary surface is 2,000 feet, or 1,000 feet on each side of the runway centerline.

- Clear Zone Surface—An obstruction-free surface (except for features essential for aircraft operations) on the ground symmetrically centered on the extended runway centerline beginning at the end of the runway and extending outward 3,000 feet. The CZ width is 3,000 feet (1,500 feet to either side of runway centerline).
- Accident Potential Zone Surfaces—APZ I begins at the outer end of the CZ and is 5,000 feet long and 3,000 feet wide. APZ II begins at the outer end of APZ I and is 7,000 feet long and 3,000 feet wide.
- Approach-Departure Clearance Surface—This imaginary surface is symmetrically centered on the extended runway centerline, beginning as an inclined plane (glide angle) 200 feet beyond each end of the primary surface, and extending for 50,000 feet. The slope of the approach-departure clearance surface is 50:1 until it reaches an elevation of 500 feet above the established airfield elevation. It then continues horizontally at this elevation to a point 50,000 feet from the starting point. The width of this surface at the runway end is 2,000 feet, flaring uniformly to a width of 16,000 feet at the end point.
- Inner Horizontal Surface—This imaginary surface is an oval plane at a height of 150 feet above the established airfield elevation. The inner boundary intersects with the approach-departure clearance surface and the transitional surface. The outer boundary is formed by scribing arcs with a radius 7,500 feet from the centerline of each runway end and interconnecting these arcs with tangents.
- Conical Surface—This is an inclined imaginary surface extending outward and upward from the outer periphery of the inner horizontal surface for a horizontal distance of 7,000 feet to a height of 500 feet above the established airfield elevation. The slope of the conical surface is 20:1. The conical surface connects the inner and outer horizontal surfaces.
- Outer Horizontal Surface—This imaginary surface is located 500 feet above the established airfield elevation and extends outward from the outer periphery of the conical surface for a horizontal distance of 30,000 feet.
- Transitional Surface—This imaginary surface extends outward and upward at right angles to the runway centerline and extended runway centerline at a slope of 7:1. The transitional surface connects the primary and the approach-departure clearance surfaces to the inner horizontal, the conical, and the outer horizontal surfaces.




Note:
The outer edge of the outer horizontal surfaces (F) extends to 44,500 feet from the runway centerline.

LEGEND

- A Primary Surface
- B Approach-Departure Clearance Surface (50:1 Slope Ratio)
- C Approach-Departure Clearance Surface (Horizontal)
- D Inner Horizontal Surface (45.72m [150'] Elevation)
- E Conical Surface (20:1 Slope Ratio)
- F Outer Horizontal Surface (152.40m [500'] Elevation)
- G Transitional Surface (7:1 Slope Ratio)
- H Runway

# Class B Air Force Runway Airspace Imaginary Surfaces

Figure 4.1

747076 DOV10-AICUZ-IMSURF.DWG 6/8/10

## 4.3 RESTRICTED AND/OR PROHIBITED LAND USES

The land areas outlined by these criteria should be regulated to prevent uses that might otherwise be hazardous to aircraft operations. The following uses should be restricted and/or prohibited for runways:

- Releases into the air of any substance that would impair visibility or otherwise interfere with the operation of aircraft (e.g., steam, dust, or smoke);
- Light emissions, either direct or indirect (reflective), that would interfere with pilot vision;
- Electrical emissions that would interfere with aircraft communications systems or navigational equipment;
- Uses that would attract birds or waterfowl, including but not limited to, operation of sanitary landfills, waste transfer facilities, maintenance of feeding stations, sand and gravel dredging operations, storm water retention ponds, created wetland areas, or the growing of certain vegetation; and
- Structures within 10 feet of aircraft approach-departure and/or transitional surfaces.

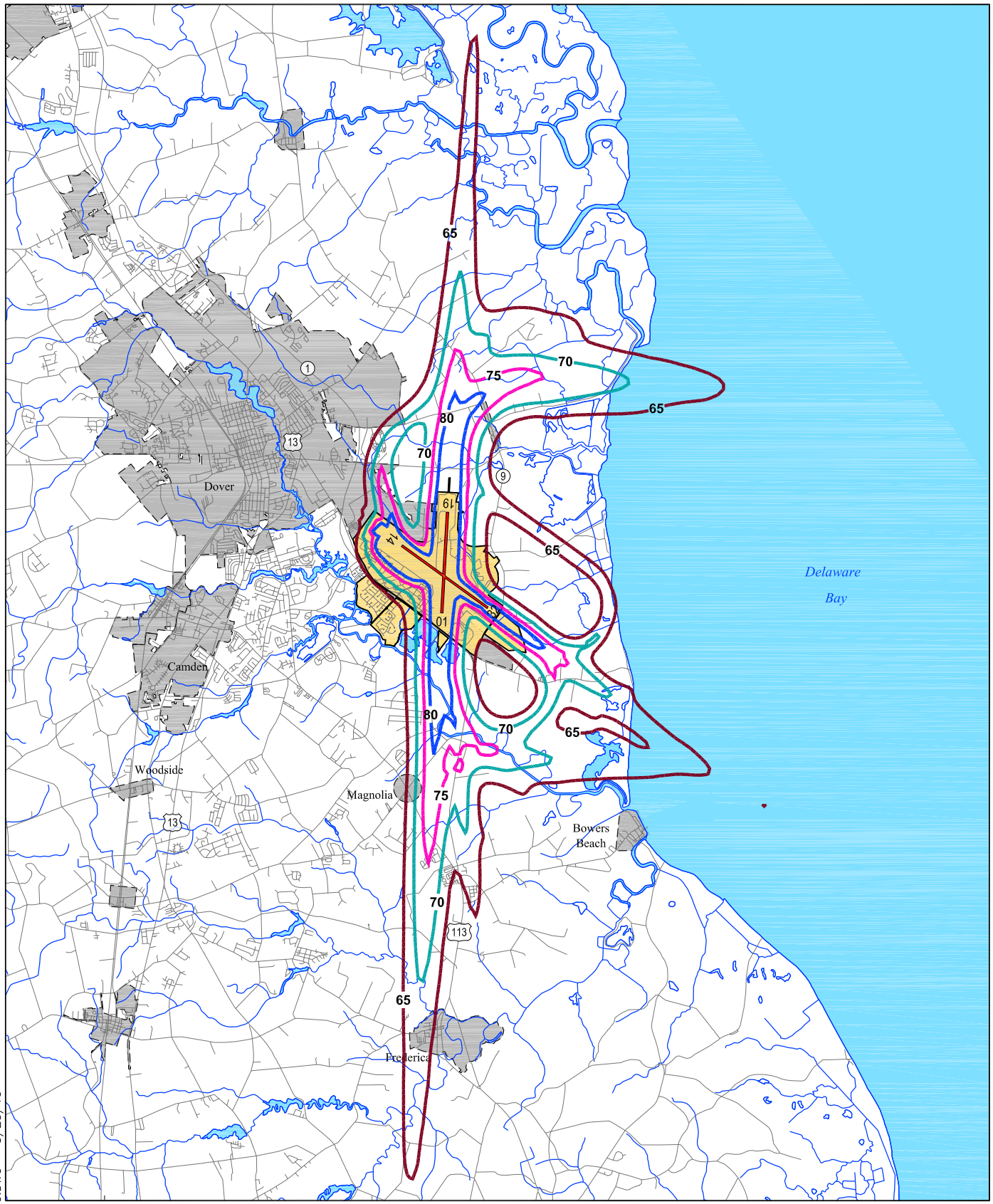
## 4.4 NOISE EXPOSURE

NOISEMAP Version 7.352 was used to calculate and plot the DNL noise contours based on the average busy day aircraft operations data collected and updated in 2008 and 2009 and described in Sections 3.1 through 3.6. Figure 4.2 shows the DNL noise contours plotted in 5 dB increments, ranging from DNL of 65 dBA to above 80 dBA.

Different sounds have different frequency content. When describing sound and its effect on a human population, A-weighted (dB) sound levels are typically used to account for the response of the human ear. The term "A-weighted" refers to a filtering of the sound signal to emphasize frequencies in the middle of the audible spectrum and to de-emphasize low and high frequencies in a manner corresponding to the way the human ear perceives sound. This filtering network has been established by the American National Standards Institute. The A-weighted noise level has been found to correlate well with people's judgments of noisiness of different sounds and has been in use for many years as a measure of community noise.

Table 4.1 shows the off-Base noise exposure within the DNL 65 dBA and greater noise exposure area for aircraft operations at Dover AFB in terms of acreage and estimated affected population. DNL is the measure of the total noise environment. DNL averages the sum of all aircraft noise producing events over a 24-hour period, with a 10 dB upward adjustment added to the nighttime events (between 10:00 p.m. and 7:00 a.m.).

The population data used in preparing this estimate was obtained from the United States Census Bureau 2000 census. To estimate affected population, it was assumed that population was equally distributed within a census tract area. Using this assumption, the total acreage and population in each census tract surrounding Dover AFB were collected and assessed. Using the noise contour information, the number of acres of land in each noise zone (i.e., DNL of 65-69 dBA, 70-74 dBA, 75-79 dBA, and 80 dBA and greater) was divided by the number of acres of land in each census tract to determine what portion of the census tract was contained within each noise zone.




**Dover Air Force Base 2010 AICUZ**

LEGEND

- 65 dBA Contour
- 70 dBA Contour
- 75 dBA Contour
- 80 dBA Contour
- Runway
- Roadway
- Dover AFB
- Municipal Boundary

N

0 13,000

Feet

# 2010 DNL Noise Contours

Figure 4.2

747076 DOV10-AICUZ-ABDNC.DWG 3/25/10

To determine population, the population total in each block-group was then multiplied by this ratio to estimate affected population. Because of the limited land area within the 80 dBA zone, a visual count of structures was conducted. The general population density per household was then applied to determine the estimated population within the 80 dBA zone.

**Table 4.1 Area and Population Within DNL 65 dBA and Greater Noise Exposure Area (Off-Base Only)**

| DNL Noise Zone | 2010 Study | 1999 Study |
|---|---|---|
| 65–69 dBA | 11,252 | 1,952 |
| 70–74 dBA | 5,032 | 610 |
| 75–79 dBA | 2,076 | 171 |
| 80+ dBA | 961 | 51 |
| **Total** | **19,321** | 2,784 |

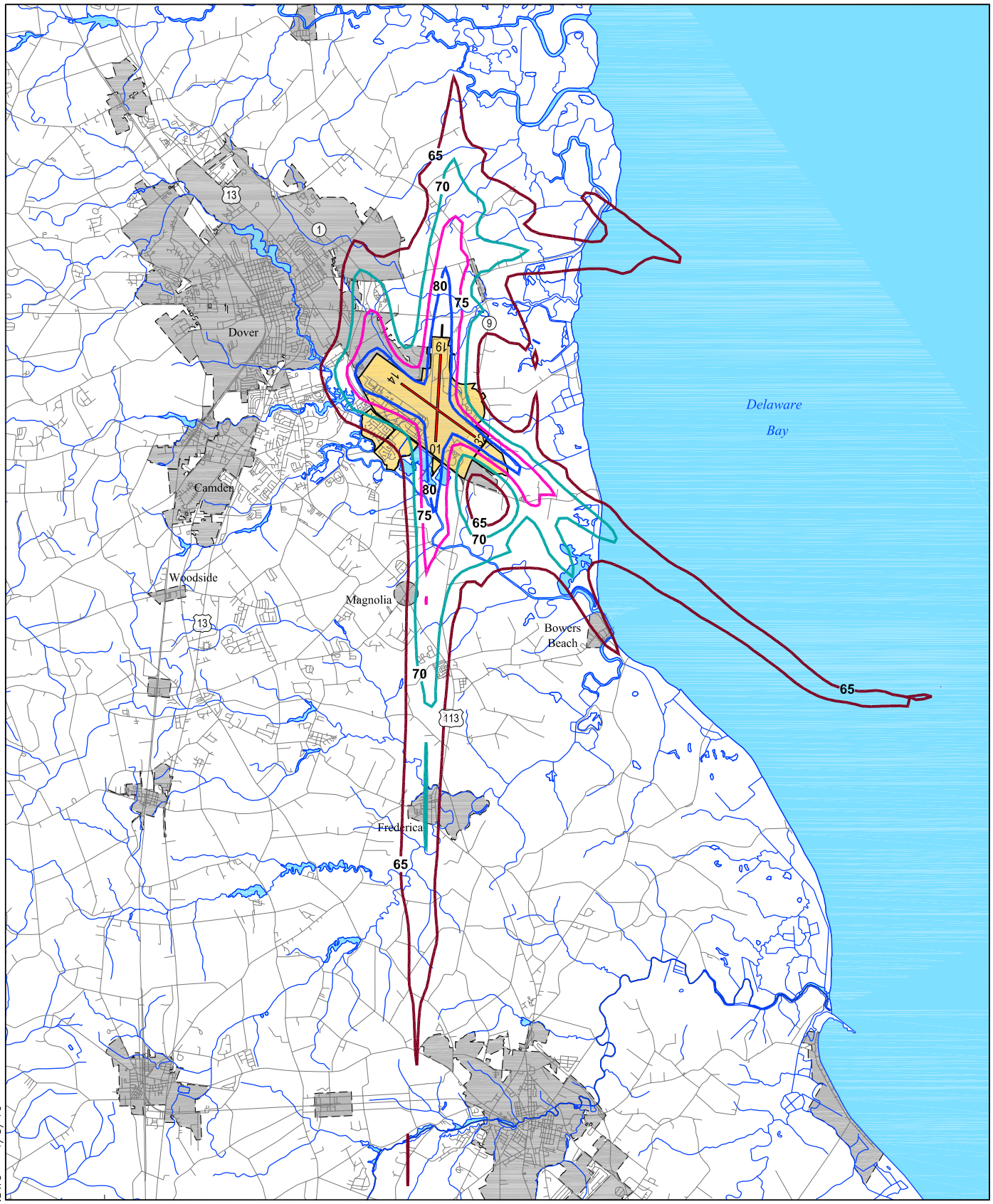
From Table 4.1, a total of 19,321 acres and 2,784 persons are expected to be in the off-Base area within the DNL 65 dBA and greater noise exposure area. The largest affected population is anticipated to be within the DNL 65–69 dBA noise zone. This area is estimated to contain 11,252 acres in off-Base land area (approximately 58% of the total) and an estimated population of 1,952 persons (70% of the total) based on the calculated population densities for the area.

## 4.5 COMPARISON WITH 1999 AICUZ STUDY

Noise contours presented in this study differ in both shape and extent from the noise contours in the 1999 AICUZ Study. Figure 4.3 depicts the 1999 AICUZ Study contours, and Figure 4.4 compares the 2010 and 1999 contours. The overall exposure for this AICUZ Study is about 4,456 acres less than the 1999 AICUZ Study. Table 4.2 lists the total noise exposure for the four noise zones in each study. The decrease in noise exposure is attributed to the reduction in airfield operations at the Base by the noisier C-5 aircraft.

**Table 4.2 Total Acres Within the 2010 and 1999 AICUZ Study Noise Zones (Off-Base and On-Base)**

| | Acres | |
|---|---|---|
| **DNL Noise Zone** | **2010 Study** | **1999 Study** |
| 65–69 dBA | 11,779 | 15,462 |
| 70–74 dBA | 5,528 | 6,262 |
| 75–79 dBA | 2,513 | 2,572 |
| 80+ dBA | 2,258 | 2,238 |
| **Total** | **22,078** | **26,534** |




**Dover Air Force Base 2010 AICUZ**

LEGEND

- 65 dBA Contour
- 70 dBA Contour
- 75 dBA Contour
- 80 dBA Contour
- Runway
- Roadway
- Dover AFB
- Municipal Boundary

N

0 15,000 Feet

# 1999 DNL Noise Contours

Figure 4.3

747076 DOV10-AICUZ-99NC.DWG 4/5/10

## 4.6 CLEAR ZONES AND ACCIDENT POTENTIAL ZONES FOR RUNWAYS

The purpose of this section is to describe the basis for CZs and APZs and apply the zones to the Dover AFB runways.

### 4.6.1 Basis for Clear Zones and Accident Potential Zones

Areas around airports are exposed to the possibility of aircraft accidents even with well-maintained aircraft and highly trained aircrews. Despite stringent maintenance requirements and countless hours of training, past history makes it clear that accidents may occur.

The risk of people on the ground being killed or injured by aircraft accidents is small. However, an aircraft accident is a high-consequence event and, when a crash does occur, the result is often catastrophic. Because of this, the Air Force does not attempt to base its safety standards on accident probabilities. Instead it approaches this safety issue from a land-use-planning perspective. Designation of safety zones around the airfield and restriction of incompatible land uses can reduce the public's exposure to safety hazards.

The AICUZ program includes three safety zones: the CZ, APZ I, and APZ II. These zones were developed from analysis of over 800 major Air Force accidents that occurred within 10 miles of an Air Force installation between 1968 and 1995. Figure B-3 in Appendix B summarizes the location of these accidents.

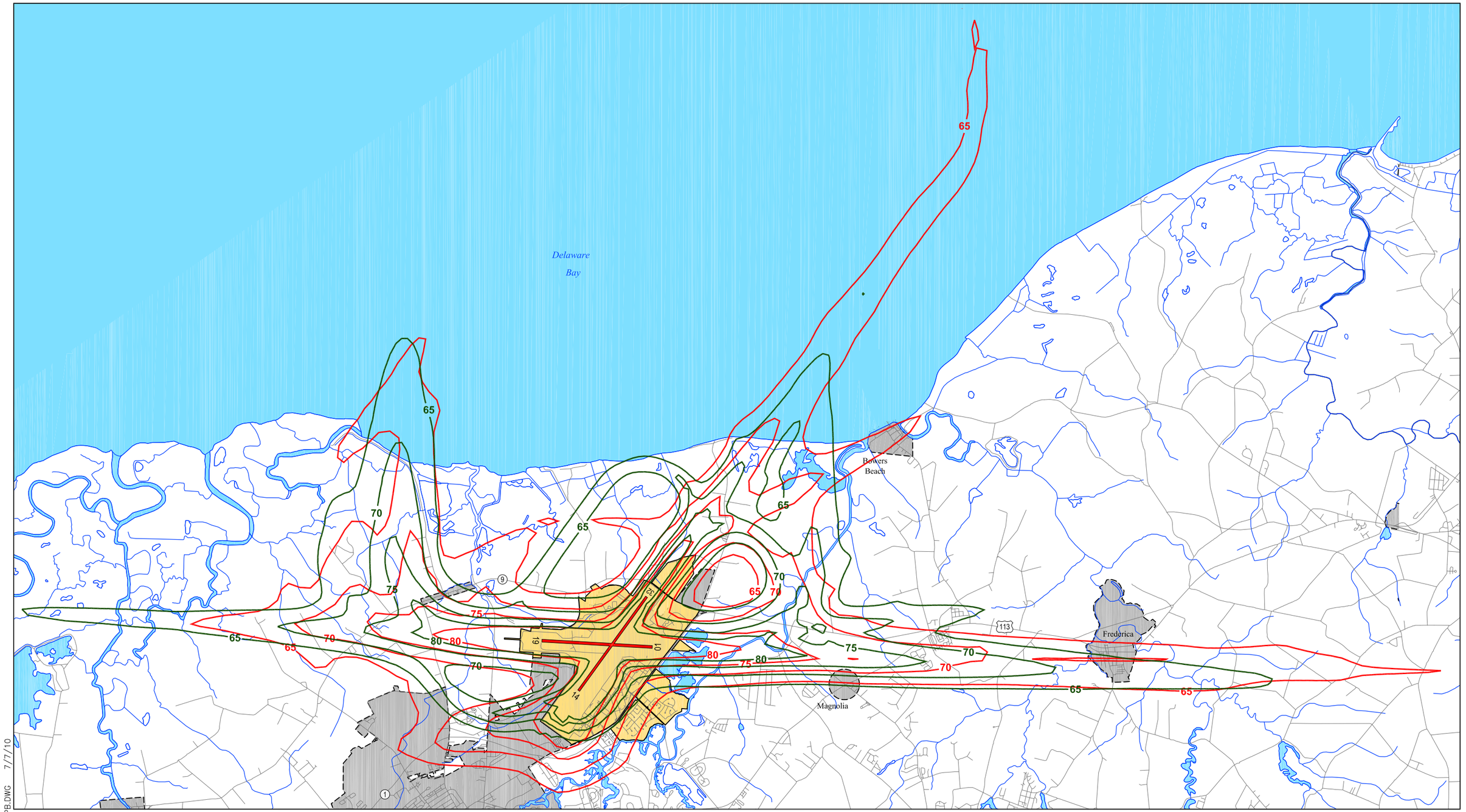
The CZ has the highest accident potential of the three zones, as 27 percent of accidents studied occurred in this area. Due to the relatively high accident potential, the Air Force adopted a policy of acquiring real estate interests in the CZ through purchase or easement when feasible.

APZ I is an area that possesses somewhat less accident potential than the CZ, with 10 percent of the accidents studied occurring in this zone. APZ II has less accident potential than APZ I, with 6 percent of the accidents studied occurring in this zone. While the potential for aircraft accidents in APZs I and II does not warrant land acquisition by the Air Force, land-use planning and controls are strongly encouraged in these areas for the protection of the public.

### 4.6.2 Clear Zones and Accident Potential Zones for Runways 01/19 and 14/32

Figure 4.5 depicts the CZs and APZs for Runways 01/19 and 14/32 at Dover AFB.

Each end of Runway 01/19 and 14/32 at Dover AFB has a 3,000 foot by 3,000 foot CZ and two APZs. Accident potential on or adjacent to the runway or within the CZ is so high that the necessary land use restrictions would prohibit reasonable economic use of land. As stated previously, it is Air Force policy to request that Congress authorize and appropriate funds to purchase the real property interests in this area to prevent incompatible land uses.




**Dover Air Force Base 2010 AICUZ**

LEGEND

- 1999 Noise Contour
- 2010 Noise Contour
- Runway
- Roadway
- Dover AFB
- Municipal Boundary

N

0 8,000 Feet

**Comparison of 2010 and 1999 DNL Noise Contours**

Figure 4.4

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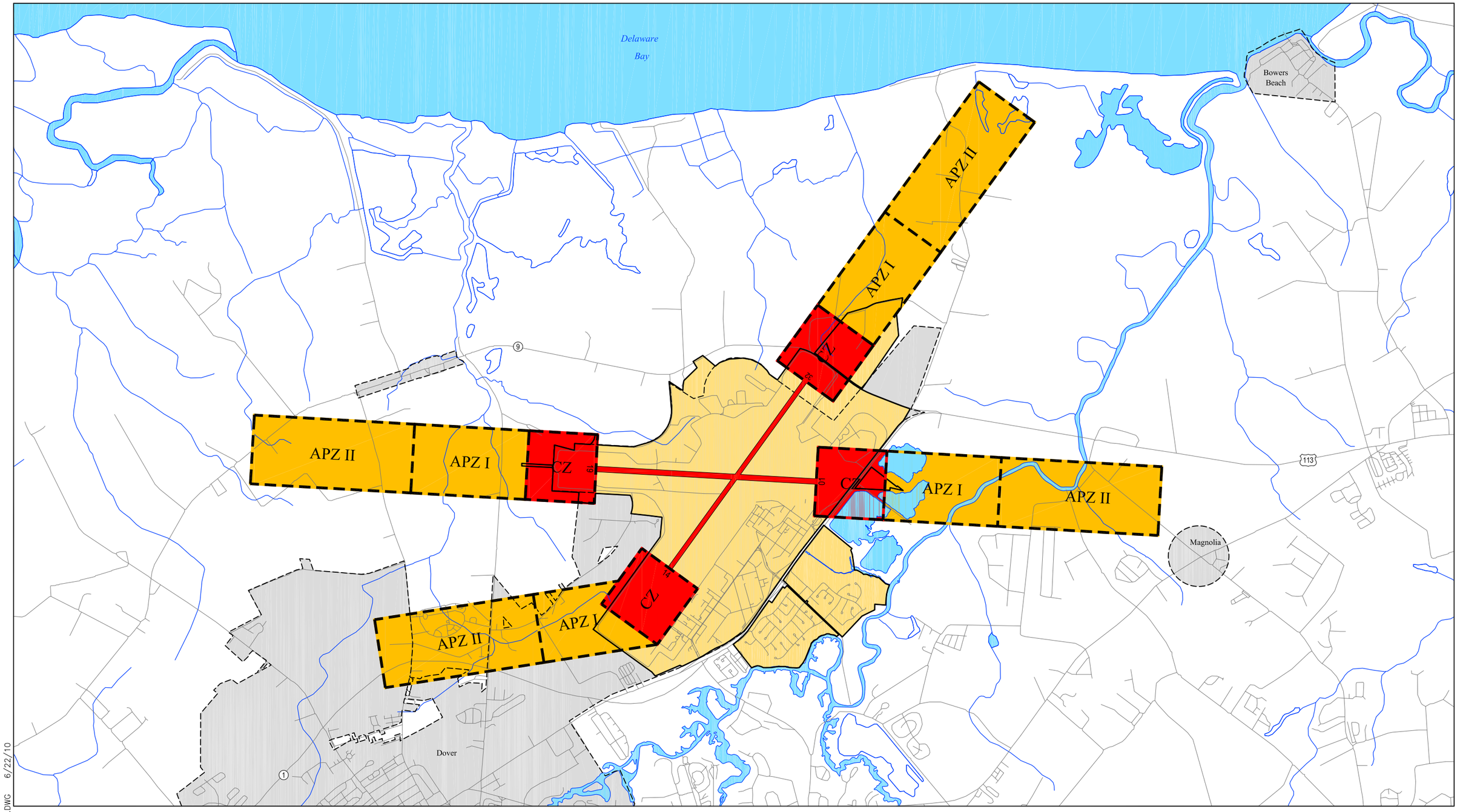


**Dover Air Force Base 2010 AICUZ**

LEGEND

- CZ — Clear Zone
- APZ — Accident Potential Zone
- Dover AFB
- Municipal Boundary
- Runway
- Roadway

N

0 4,000 Feet

# Clear Zones and Accident Potential Zones

Figure 4.5

747076 DOV10-AICUZ-CZB.DWG 6/22/10

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Accident Potential Zone I is less critical than the CZ, but still possesses a significant risk factor. This 3,000 by 5,000 feet area has land use compatibility guidelines that are sufficiently flexible to allow reasonable economic use of the land, such as industrial/manufacturing, transportation, communication/utilities, wholesale trade, open space, recreation, and agriculture. However, uses that concentrate people in small areas are not acceptable.

Accident Potential Zone II is less critical than APZ I, but still possesses potential for accidents. Accident potential zone II, also 3,000 feet wide, is 7,000 feet long extending to 15,000 feet from the runway threshold. Acceptable uses include those of APZ I, as well as low density single family residential and those personal and business services and commercial/retail trade uses of low intensity or scale of operation. High density functions such as multi-story buildings, places of assembly (*e.g.*, theaters, churches, schools, restaurants, *etc*.), and high density office uses are not considered appropriate.

Accident Potential Zones I and II at the northwestern end of Runway 14/32 are aligned to reflect the departure and arrival flight track adjustments resulting from the operations restrictions mentioned in Section 3.3 related to the hangar located off the northwestern end of the runway. Figure 4.5 depicts the adjusted APZs. The dimensions of APZs I and II at the northwestern end of Runway 14/32 are the same as those described in the two previous paragraphs.

High people densities should be limited to the maximum extent possible in APZ II. The optimum density recommended for residential usage (where it does not conflict with noise criteria) in APZ II is one dwelling per acre. For most nonresidential usage, buildings should be limited to one story and the lot coverage should not exceed 20 percent.

### 4.6.3 Land Use Compatibility Guidelines for Runways

#### *Introduction*

The DoD developed the AICUZ program for military airfields. Using this program at its installations, the DoD works to protect aircraft operational capabilities and to assist local government officials in protecting and promoting the public's health, safety, and quality of life. The goal is to promote compatible land-use development around military airfields by providing information on aircraft noise exposure and accident potential.

AICUZ reports describe three basic types of constraints that affect, or result from, flight operations. The first constraint involves areas that the FAA and the DoD identified for height limitations (see Section 4.2).

The second constraint involves noise zones based on the DNL metric and the DoD NOISEMAP methodology. Using the NOISEMAP program, which is similar to FAA's INM, the Air Force produces noise contours showing the noise levels generated by aircraft operations. The AICUZ report contains noise contours plotted in 5 dB increments, ranging from DNL 65 dBA to 80+ dBA.

The third constraint involves CZs and APZs based on statistical analysis of past DoD aircraft accidents. DoD analysis has determined that areas immediately beyond the ends of runways and along the approach and departure flight paths have greater potential for aircraft accidents. Figure 4.5 shows CZs and APZs.

### *Land-Use Compatibility Guidelines for Runways*

Each AICUZ Study contains land-use guidelines. Table 4.3 identifies land uses and possible noise exposure and accident potential combinations for Dover AFB. These noise guidelines are essentially the same as those published by the Federal Interagency Committee on Urban Noise in the June 1980 publication, *Guidelines for Considering Noise in Land-Use Planning and Control.* The U.S. Department of Transportation publication, *Standard Land Use Coding Manual (SLUCM),* has been used to identify and code land-use activities. The designations are a combination of criteria listed in the Legend and Notes at the end of the table. For example, $Y^1$ means land use and related structures are compatible without restriction at a suggested maximum density of 1-2 dwelling units per acre, possibly increased under a Planned Unit Development where lot coverage is less than 20 percent.

## 4.7 PARTICIPATION IN THE PLANNING PROCESS

The Air Force provides the AICUZ Study to local communities to assist them in preparing their local land use plans. This section discusses how the base participates in the community planning process. Section 6.3 addresses the role played by the local community in enhancing compatible land use.

Airspace obstructions, construction in the APZs, residential development, and the construction of other noise-sensitive uses near the base are of great concern to Dover AFB. The Air Force is very interested in minimizing increases in incompatible usage and in encouraging voluntary conversion of non-compatible usage to compatible usage. Applying the categories for compatible land use described in Table 4.3, the Base evaluates the impact aircraft operations have on surrounding properties and the effect new development or changes in land use might have on Dover AFB operational capabilities.

In addition to working with local governing entities and planning professionals, the 436 AMW Public Affairs Office works to address concerns expressed by community neighbors.

Dover AFB conducts active outreach to the community by meeting with various community groups and speaking with individuals as needed. The Dover AFB Civil Engineer and Public Affairs Offices work together providing public meetings and informational workshops to disseminate information about base operations, forecasts, plans, and mitigation strategies.

The Base Community Planner has been designated as the official liaison with the local community on all planning matters. This office is prepared to participate in the continuing discussion of zoning and other land use matters as they may affect, or may be affected by, Dover AFB.

## Table 4.3 Land Use Compatibility Guidelines

| Land Use | | Accident Potential Zones | | | Noise Zones in DNL dBA | | | |
|---|---|---|---|---|---|---|---|---|
| SLUCM No. | Name | Clear Zone | APZ I | APZ II | 65-69 | 70-74 | 75-79 | 80+ |
| **10** | **Residential** | | | | | | | |
| 11 | Household units | | | | | | | |
| 11.11 | Single units; detached | N | N | Y[1] | A[11] | B[11] | N | N |
| 11.12 | Single units; semidetached | N | N | N | A[11] | B[11] | N | N |
| 11.13 | Single units; attached row | N | N | N | A[11] | B[11] | N | N |
| 11.21 | Two units; side-by-side | N | N | N | A[11] | B[11] | N | N |
| 11.22 | Two units; one above the other | N | N | N | A[11] | B[11] | N | N |
| 11.31 | Apartments; walk up | N | N | N | A[11] | B[11] | N | N |
| 11.32 | Apartments; elevator | N | N | N | A[11] | B[11] | N | N |
| 12 | Group quarters | N | N | N | A[11] | B[11] | N | N |
| 13 | Residential hotels | N | N | N | A[11] | B[11] | N | N |
| 14 | Mobile home parks or courts | N | N | N | N | N | N | N |
| 15 | Transient lodgings | N | N | N | A[11] | B[11] | C[11] | N |
| 16 | Other residential | N | N | N[1] | A[11] | B[11] | N | N |
| **20** | **Manufacturing** | | | | | | | |
| 21 | Food & kindred products; manufacturing | N | N[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 22 | Textile mill products; manufacturing | N | N[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 23 | Apparel and other finished products made from fabrics, leather, and similar materials; manufacturing | N | N | N[2] | Y | Y[12] | Y[13] | Y[14] |
| 24 | Lumber and wood products (except furniture); manufacturing | N | Y[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 25 | Furniture and fixtures; manufacturing | N | Y[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 26 | Paper & allied products; manufacturing | N | Y[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 27 | Printing, publishing, and allied industries | N | Y[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 28 | Chemicals and allied products; manufacturing | N | N | N[2] | Y | Y[12] | Y[13] | Y[14] |
| 29 | Petroleum refining and related industries | N | N | Y | Y | Y[12] | Y[13] | Y[14] |
| **30** | **Manufacturing** | | | | | | | |
| 31 | Rubber and misc. plastic products, manufacturing | N | N[2] | N[2] | Y | Y[12] | Y[13] | Y[14] |
| 32 | Stone, clay and glass products manufacturing | N | N[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 33 | Primary metal industries | N | N[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 34 | Fabricated metal products; manufacturing | N | N[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 35 | Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks manufacturing | N | N | N[2] | Y | A | B | N |
| 39 | Miscellaneous manufacturing | N | Y[2] | Y[2] | Y | Y[12] | Y[13] | Y[14] |
| 40 | **Transportation, Communications and Utilities** | | | | | | | |
| 41 | Railroad, rapid rail transit and street railroad transportation | N[3] | Y[4] | Y | Y | Y[12] | Y[13] | Y[14] |
| 42 | Motor vehicle transportation | N[3] | Y | Y | Y | Y[12] | Y[13] | Y[14] |
| 43 | Aircraft transportation | N[3] | Y[4] | Y | Y | Y[12] | Y[13] | Y[14] |
| 44 | Marine craft transportation | N[3] | Y[4] | Y | Y | Y[12] | Y[13] | Y[14] |
| 45 | Highway & street right-of-way | N[3] | Y | Y | Y | Y[12] | Y[13] | Y[14] |
| 46 | Automobile parking | N[3] | Y[4] | Y | Y | Y[12] | Y[13] | Y[14] |
| 47 | Communications | N[3] | Y[4] | Y | Y | A[15] | B[15] | N |
| 48 | Utilities | N[3] | Y[4] | Y | Y | Y | Y[12] | Y[13] |
| 49 | Other transportation communications and utilities | N[3] | Y[4] | Y | Y | A[15] | B[15] | N |

**LEGEND**

**SLUCM** - Standard Land Use Coding Manual, U.S. Department of Transportation.

**Y** - (Yes) - Land use and related structures are compatible without restriction.

**N** - (N) - Land use and related structures are not compatible and should be prohibited.

**Y[x]** - (yes with restrictions) - Land use and related structures generally compatible; see notes 1-21.

**N[x]** - (no with exceptions) - See notes 1-21.

**NLR** - (Noise Level Reduction) - NLR (outdoor to indoor) to be achieved through incorporation of noise attenuation measures into the design and construction of the structures.

**A, B, or C** - Land use and related structures generally compatible; measures to achieve NLR of A (DNL 25 dB), B (DNL 30 dB), or C (DNL 35 dB) need to be incorporated into the design and construction of structures.

**A[*], B[*], and C[*]** - Land use generally compatible with NLR. However, measures to achieve an overall noise level reduction do not necessarily solve noise difficulties and additional evaluation is warranted. See appropriate footnotes.

***** - The designation of these uses as "compatible" in this zone reflects individual federal agency and program consideration of general cost and feasibility factors, as well as past community experiences and program objectives. Localities, when evaluating the application of these guidelines to specific situations, may have different concerns or goals to consider.

**NOTES**

1. Suggested maximum density of 1-2 dwelling units per acre possibly increased under a Planned Unit Development where maximum lot coverage is less than 20 percent.
2. Within each land use category, uses exist where further definition may be needed due to the variation of densities in people and structures. Shopping malls and shopping centers are considered incompatible in any accident potential zone (CZ, APZ I, or APZ II).
3. The placing of structures, buildings, or aboveground utility lines in the clear zone is subject to severe restrictions. In a majority of the clear zones, these items are prohibited. See AFI 32-7063 and UFC 3-260-01 for specific guidance.
4. No passenger terminals and no major aboveground transmission lines in APZ I.
5. Factors to be considered: labor intensity, structural coverage, explosive characteristics, and air pollution.
6. Low-intensity office uses only. Meeting places, auditoriums, etc., are not recommended.
7. Excludes chapels.
8. Facilities must be low intensity.
9. Clubhouse not recommended.
10. Areas for gatherings of people are not recommended.

11A. Although local conditions may require residential use, it is discouraged in DNL 65-69 dB and strongly discouraged in DNL 70-74 dB. An evaluation should be conducted prior to approvals, indicating a demonstrated community need for residential use would not be met if development were prohibited in these zones, and there are no viable alternative locations.

11B. Where the community determines the residential uses must be allowed, measures to achieve outdoor to indoor NLR for DNL 65-69 dB and DNL 70-74 dB should be incorporated into building codes and considered in individual approvals.

11C. NLR criteria will not eliminate outdoor noise problems. However, building location and site planning, and design and use of berms and barriers can help mitigate outdoor exposure, particularly from near ground level sources. Measures that reduce outdoor noise should be used whenever practical in preference to measures which only protect interior spaces.

12. Measures to achieve the same NLR as required for facilities in the DNL 65-69 dB range must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.
13. Measures to achieve the same NLR as required for facilities in the DNL 70-74 dB range must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.
14. Measures to achieve the same NLR as required for facilities in the DNL 75-79 dB range must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.
15. If noise sensitive, use indicated NLR; if not, the use is compatible.
16. No buildings.
17. Land use is compatible provided special sound reinforcement systems are installed.
18. Residential buildings require the same NLR required for facilities in the DNL 65-69 dB range.
19. Residential buildings require the same NLR required for facilities in the DNL 70-74 dB range.
20. Residential buildings are not permitted.
21. Land use is not recommended. If the community decides the use is necessary, personnel should wear hearing protection devices.

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## Table 4.3 Land Use Compatibility Guidelines (continued)

| Land Use | | Accident Potential Zones | | | Noise Zones in DNL dBA | | | |
|---|---|---|---|---|---|---|---|---|
| **SLUCM No.** | **Name** | **Clear Zone** | **APZ I** | **APZ II** | **65-69** | **70-74** | **75-79** | **80+** |
| **50** | **Trade** | | | | | | | |
| 51 | Wholesale trade | N | Y[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 52 | Retail trade-building materials, hardware and farm equipment | N | Y[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 53 | Retail trade-general merchandise | N | N[2] | Y[2] | Y | A | B | N |
| 54 | Retail trade-food | N | N[2] | Y[2] | Y | A | B | N |
| 55 | Retail trade-automotive, marine craft, aircraft and accessories | N | Y[2] | Y[2] | Y | A | B | N |
| 56 | Retail trade-apparel and accessories | N | N[2] | Y[2] | Y | A | B | N |
| 57 | Retail trade-furniture, home furnishings and equipment | N | N[2] | Y[2] | Y | A | B | N |
| 58 | Retail trade-eating and drinking establishments | N | N | N[2] | Y | A | B | N |
| 59 | Other retail trade | N | N[2] | Y[2] | Y | A | B | N |
| **60** | **Services** | | | | | | | |
| 61 | Finance, insurance and real estate services | N | N | Y[6] | Y | A | B | N |
| 62 | Personal services | N | N | Y[6] | Y | A | B | N |
| 62.4 | Cemeteries | N | Y[7] | Y[7] | Y | Y[12] | Y[13] | Y[14,21] |
| 63 | Business services | N | Y[8] | Y[8] | Y | A | B | N |
| 64 | Repair services | N | Y[2] | Y | Y | Y[12] | Y[13] | Y[14] |
| 65 | Professional services | N | N | Y[6] | Y | A | B | N |
| 65.1 | Hospitals, nursing homes | N | N | N | A* | B* | N | N |
| 65.1 | Other medical facilities | N | N | N | Y | A | B | N |
| 66 | Contract construction services | N | Y[6] | Y | Y | A | B | N |
| 67 | Governmental services | N | N | Y[6] | Y* | A* | B* | N |
| 68 | Educational services | N | N | N | A* | B* | N | N |
| 69 | Miscellaneous services | N | N[2] | Y[2] | Y | A | B | N |
| **70** | **Cultural, Entertainment and Recreational** | | | | | | | |
| 71 | Cultural activities (including churches) | N | N | N[2] | A* | B* | N | N |
| 71.2 | Nature exhibits | N | Y[2] | Y | Y* | N | N | N |
| 72 | Public assembly | N | N | N | Y | N | N | N |
| 72.1 | Auditoriums, concert halls | N | N | N | A | B | N | N |
| 72.11 | Outdoor music shell, amphitheaters | N | N | N | N | N | N | N |
| 72.2 | Outdoor sports arenas, spectator sports | N | N | N | Y[17] | Y[17] | N | N |
| 73 | Amusements | N | N | Y[8] | Y | Y | N | N |
| 74 | Recreational activities (including golf courses, riding stables, water recreation) | N | Y[8,9,10] | Y | Y* | A* | B* | N |
| 75 | Resorts and group camps | N | N | N | Y* | Y* | N | N |
| 76 | Parks | N | Y[8] | Y[8] | Y* | Y* | N | N |
| 79 | Other cultural, entertainment and recreation | N | Y[9] | Y[9] | Y* | Y* | N | N |
| **80** | **Resources Production and Extraction** | | | | | | | |
| 81 | Agriculture (except livestock) | Y[16] | Y | Y | Y[18] | Y[19] | Y[20] | Y[20,21] |
| 81.5 to 81.7 | Livestock farming and animal breeding | N | Y | Y | Y[18] | Y[19] | Y[20] | Y[20,21] |
| 82 | Agricultural related activities | N | Y[5] | Y | Y[18] | Y[19] | N | N |
| 83 | Forestry activities and related services | N[5] | Y | Y | Y[18] | Y[19] | Y[20] | Y[20,21] |
| 84 | Fishing activities and related services | N[5] | Y[5] | Y | Y | Y | Y | Y |
| 85 | Mining activities and related services | N | Y[5] | Y | Y | Y | Y | Y |
| 89 | Other resources production and extraction | N | Y[5] | Y | Y | Y | Y | Y |

**LEGEND**

**SLUCM** - Standard Land Use Coding Manual, U.S. Department of Transportation.

**Y** - (Yes) - Land use and related structures are compatible without restriction.

**N** - (N) - Land use and related structures are not compatible and should be prohibited.

**Y[x]** - (yes with restrictions) - Land use and related structures generally compatible; see notes 1-21.

**N[x]** - (no with exceptions) - See notes 1-21.

**NLR** - (Noise Level Reduction) - NLR (outdoor to indoor) to be achieved through incorporation of noise attenuation measures into the design and construction of the structures.

**A, B, or C** - Land use and related structures generally compatible; measures to achieve NLR of A (DNL 25 dB), B (DNL 30 dB), or C (DNL 35 dB) need to be incorporated into the design and construction of structures.

**A*, B*, and C*** - Land use generally compatible with NLR. However, measures to achieve an overall noise level reduction do not necessarily solve noise difficulties and additional evaluation is warranted. See appropriate footnotes.

***** - The designation of these uses as "compatible" in this zone reflects individual federal agency and program consideration of general cost and feasibility factors, as well as past community experiences and program objectives. Localities, when evaluating the application of these guidelines to specific situations, may have different concerns or goals to consider.

**NOTES**

1. Suggested maximum density of 1-2 dwelling units per acre possibly increased under a Planned Unit Development where maximum lot coverage is less than 20 percent.
2. Within each land use category, uses exist where further definition may be needed due to the variation of densities in people and structures. Shopping malls and shopping centers are considered incompatible in any accident potential zone (CZ, APZ I, or APZ II).
3. The placing of structures, buildings, or aboveground utility lines in the clear zone is subject to severe restrictions. In a majority of the clear zones, these items are prohibited. See AFI 32-7063 and UFC 3-260-01 for specific guidance.
4. No passenger terminals and no major aboveground transmission lines in APZ I.
5. Factors to be considered: labor intensity, structural coverage, explosive characteristics, and air pollution.
6. Low-intensity office uses only. Meeting places, auditoriums, etc., are not recommended.
7. Excludes chapels.
8. Facilities must be low intensity.
9. Clubhouse not recommended.
10. Areas for gatherings of people are not recommended.

11A. Although local conditions may require residential use, it is discouraged in DNL 65-69 dB and strongly discouraged in DNL 70-74 dB. An evaluation should be conducted prior to approvals, indicating a demonstrated community need for residential use would not be met if development were prohibited in these zones, and there are no viable alternative locations.

11B. Where the community determines the residential uses must be allowed, measures to achieve outdoor to indoor NLR for DNL 65-69 dB and DNL 70-74 dB should be incorporated into building codes and considered in individual approvals.

11C. NLR criteria will not eliminate outdoor noise problems. However, building location and site planning, and design and use of berms and barriers can help mitigate outdoor exposure, particularly from near ground level sources. Measures that reduce outdoor noise should be used whenever practical in preference to measures which only protect interior spaces.

12. Measures to achieve the same NLR as required for facilities in the DNL 65-69 dB range must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.
13. Measures to achieve the same NLR as required for facilities in the DNL 70-74 dB range must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.
14. Measures to achieve the same NLR as required for facilities in the DNL 75-79 dB range must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.
15. If noise sensitive, use indicated NLR; if not, the use is compatible.
16. No buildings.
17. Land use is compatible provided special sound reinforcement systems are installed.
18. Residential buildings require the same NLR required for facilities in the DNL 65-69 dB range.
19. Residential buildings require the same NLR required for facilities in the DNL 70-74 dB range.
20. Residential buildings are not permitted.
21. Land use is not recommended. If the community decides the use is necessary, personnel should wear hearing protection devices.

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# SECTION 5
# LAND USE ANALYSIS

## 5.1 INTRODUCTION

Land use planning and control is a dynamic, rather than static process. The specific characteristics of land use determinants will always reflect, to some degree, the changing conditions of the economic, social, and physical environment of a community, as well as changing public concern. The planning process accommodates this fluidity in which decisions are normally not based on boundary lines, but rather on more generalized area designations.

Dover AFB was originally established in a relatively undeveloped area in Kent County, Delaware. In recent years, however, development increased northwest of the Base, particularly in the City of Dover, in residential areas west of the Base, and southwest in the vicinity of the Town of Magnolia.

Improvements in computer technology have enabled the Air Force to more precisely display its flight tracks and noise contours for land use planning purposes. These technical improvements reveal the extent of the Dover AFB region of influence into the counties and surrounding nearby cities and towns.

For the purpose of this study, existing and future land uses on the figures in this section are generalized into one of the following six categories:

Residential: Includes all types of residential activity, such as single and multi-family residences and mobile homes, at a density greater than one dwelling unit per acre.

Commercial: Includes offices, retail, restaurants, and other types of commercial establishments.

Industrial: Includes manufacturing, warehousing, and other similar uses.

Public/Quasi-Public: Includes publicly owned lands and/or land to which the public has access, including military reservations and training grounds, public buildings, schools, churches, cemeteries, and hospitals.

Recreational: Includes land areas designated for recreational activity, including parks, wilderness areas and reservations, conservation areas, and areas designated for trails, hikes, camping, etc.

Open/Agricultural/Low Density: Includes undeveloped land areas, agricultural areas, grazing lands, and areas with residential activity at densities less than or equal to one dwelling unit per acre.

## 5.2 EXISTING LAND USE

Existing land uses in the vicinity of Dover AFB are shown in Figure 5.1. As previously described, Dover AFB is located in central Kent County, southeast of the City of Dover. The installation's airfield activities primarily impact areas to the northwest and south; these areas include the City of Dover and unincorporated portions of Kent County. Existing land use adjacent to the Base is primarily a mix of commercial, residential, and open space. Smaller

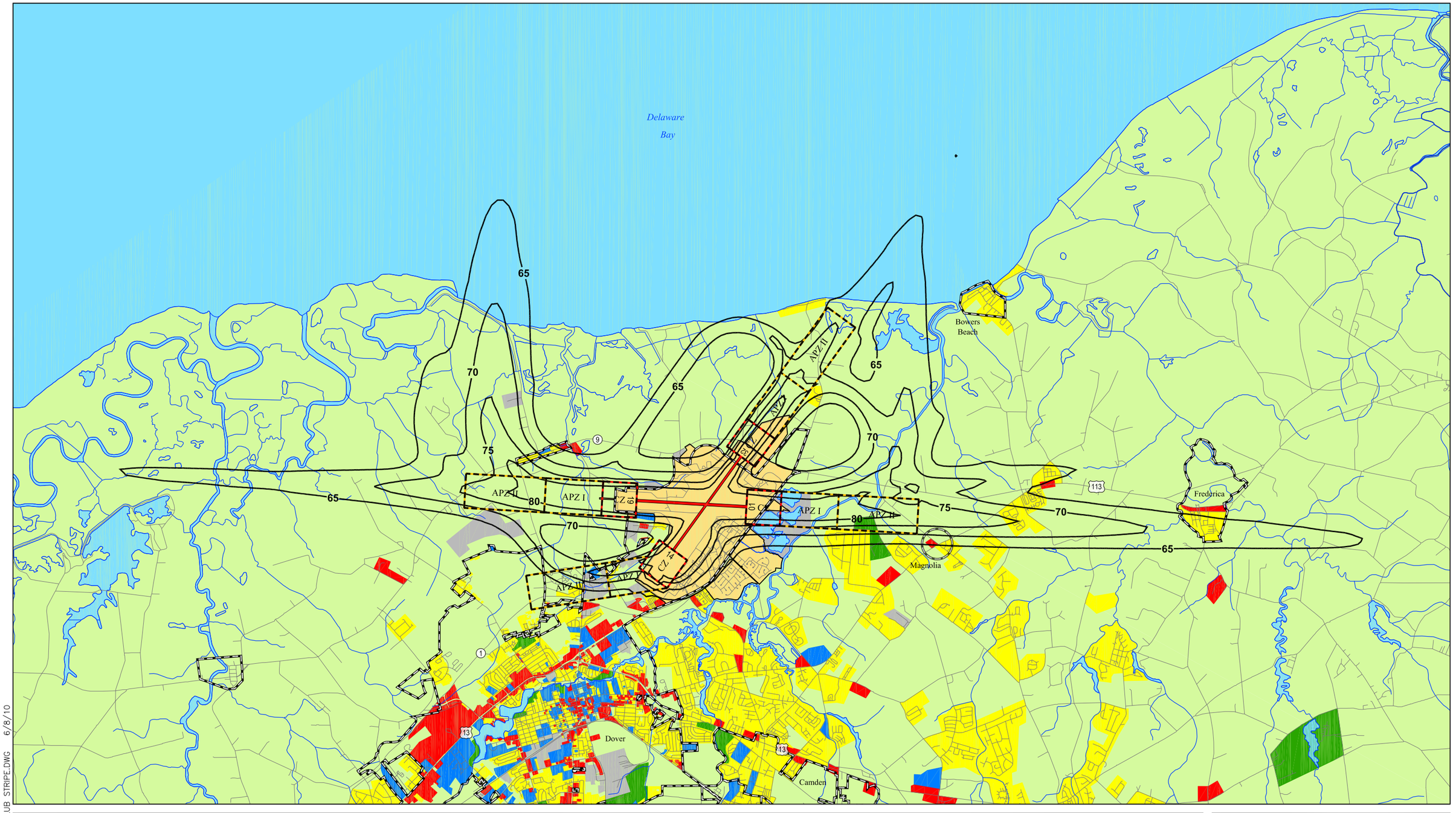
areas of industrial and public uses are interspersed throughout the area. Moderate density residential is prevalent in the City of Dover, with pockets of low-density rural residential scattered throughout unincorporated Kent County. Land to the northeast, east, and south of the Base is largely undeveloped, agricultural, or conservation areas, with pockets of residential use within the municipalities of Camden, Magnolia, Frederica, Little Creek, and Bowers Beach.

Land within the City of Dover comprises a mixture of uses, with suburban residential and commercial uses prevalent. The downtown business district, in the vicinity of Governors Avenue and Division Street, consists of a mix of uses, including public, commercial, and residential. Several residential subdivisions are interspersed among land uses in Dover, northwest of the Base. Commercial land uses are primarily located along major arterial roadways and within the traditional downtown business district. Dover Downs and several commercial mall developments dominate the northern Dupont Highway corridor, with strip commercial buildings common from the Base to Dover Downs. Public land uses are extensive throughout the City of Dover, including the State Capitol, Bayhealth Medical Center, Wesley College, Delaware State University, Delaware Technical and Community College, and the Wilmington University. Delaware State University is located directly to the west of Dover Downs, across Dupont Highway. The Delaware Technical and Community College is located adjacent to the university.

Major industrial land uses lie along the Norfolk Southern railroad line adjoining Dover AFB. Numerous vacant developable tracts of land are distributed fairly evenly throughout the city limits. The land areas east of SR-1 within the City of Dover have remained predominantly agricultural.

The areas south and southeast of the Base are less developed, with small clusters of developed areas within the municipalities of Camden, Magnolia, Frederica, Little Creek, and Bowers Beach. Several recently constructed residential subdivisions exist south of the Base. Many of these developments contain larger lots that are less than one dwelling unit per acre. A sand and gravel operation that includes water and dredging activities is classified as industrial and is located directly south of the Base.

Figure 5.1 presents the existing land uses for the area that surrounds Dover AFB and within the DNL 65 dBA and greater noise exposure area.




**Dover Air Force Base 2010 AICUZ**

LEGEND

- Dover AFB
- Residential
- Commercial
- Industrial
- Public/Quasi-Public
- Recreational
- Open/Agriculture/Low Density
- Municipal Boundary
- DNL Contours
- Runway
- Roadway
- Accident Potential Zone
- Clear Zone

N

0 8,000 Feet

**Generalized Existing Land Use**

Figure 5.1

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Table 5.1 summarizes the acreage by land use category exposed to noise levels of DNL 65 dBA and greater. Note that these acreages represent only the area outside the Dover AFB boundaries.

**Table 5.1 Generalized Existing Land Use Within DNL 65 dBA and Greater Noise Exposure Area (Off-Base)**

| Category | Acreage |
|---|---|
| Residential | 729 |
| Commercial | 20 |
| Industrial | 738 |
| Public/Quasi-public | 43 |
| Recreational | 70 |
| Open/Agricultural/Low Density | 17,721 |
| **Total** | **19,321** |

The analysis also includes land use within the Dover AFB CZs and APZs. Inclusion of the CZs and APZs in the evaluation shows 51 acres of residential land within the Dover AFB CZs and APZs. Table 5.2 reflects the land use (outside the Dover AFB boundaries) within the Dover AFB CZs and APZs.

**Table 5.2 Generalized Existing Land Use Within the Dover AFB Clear Zones and Accident Potential Zones (Off-Base)**

| Category | Acreage |
|---|---|
| Residential | 51 |
| Commercial | 3 |
| Industrial | 385 |
| Public/Quasi-public | 17 |
| Recreational/Open/Agricultural/ Low Density | 2,914 |
| **Total** | **3,370** |

## 5.3 CURRENT ZONING

Figure 5.2 overlays the 2010 noise contours and APZs on a map displaying the current zoning in the vicinity of Dover AFB. The zoning classifications identified on Figure 5.2 have been generalized for AICUZ planning purposes. As described in the preceding existing land use section, the area of influence includes the City of Dover, unincorporated portions of Kent County, and several small municipalities to the south/southwest of the Base. Kent County has jurisdiction over land in the unincorporated areas of the county, and the municipalities have jurisdiction over land use within their respective municipal boundaries. Zoning within the AICUZ area of influence generally reflects existing land use patterns.

Kent County and the City of Dover both recently completed comprehensive plan updates, with the county plan adopted in October 2008 and the City of Dover plan adopted by the City Council in February 2009. Both plans include goals and recommendations to protect Dover AFB from encroachment that may impact mission operations. The City's plan includes a goal to, "Create a favorable and compatible environment for Dover Air Force Base through a resolute commitment to provide all reasonable planning accommodations to protect the Base." Kent County's plan includes a policy recommendation to, "Continue the positive working relationship between the County and the Dover Air Force Base and maintain zoning requirements that protect the Base from incompatible land uses."

Also, Kent County and the City of Dover both adopted an Airport Environs Overlay Zone (AEOZ), creating a specific overlay zone with regulations to address sound attenuation from noise resulting from the Base and its operations. Kent County adopted an amendment to subdivision regulations requiring that for any new subdivision within the AICUZ environs, a note must be placed on the plat indicating the property is located "in the vicinity of aircraft operations…which may result in high noise disturbances or the potential for an aircraft accident." Additionally, Kent County and the City adopted zoning ordinances that require sound attenuating materials to be used in new construction within Dover AFB AICUZ noise contours. The City of Dover also enacted restrictions on building heights around the Base.

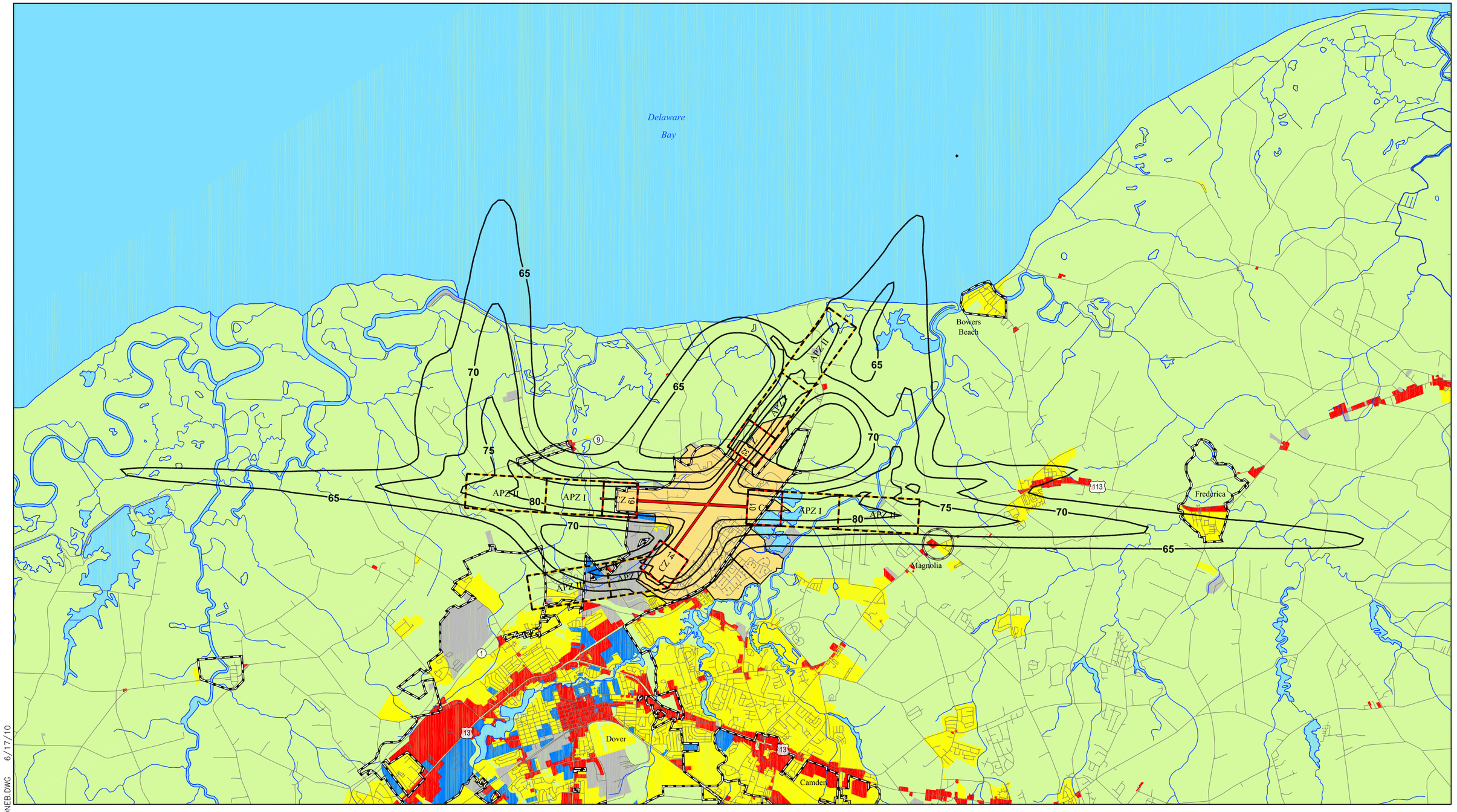
Clearly, local jurisdictions recognize the importance of maintaining the capability of Dover AFB by protecting it from urban encroachment and have developed a strong working relationship with Dover AFB in matters of development planning. Kent County and the City of Dover have taken steps to incorporate the mission of Dover AFB by adopting land use plans and zoning controls that limit encroachment into the flight paths and operations of the airfield. Continued maintenance of the land use and zoning restrictions currently in place will ensure the viability of Dover AFB while helping to provide valuable information to the owners and potential owners of impacted properties.

Analysis of the current zoning maps for these jurisdictions was performed to determine the acreage of each zoning designation within the DNL 65 dBA and greater noise area. For this analysis, zoning designations were generalized into residential, commercial, industrial, public/quasi-public, and recreational/open/agricultural/low density categories. Figure 5.2 shows the results of the compilation, and Table 5.3 provides a breakdown of the generalized zoning (areas outside Dover AFB only and outside CZs and APZs) within the DNL 65 dBA and greater noise area.

**Table 5.3 Generalized Zoning Within DNL 65 dBA and Greater Noise Exposure Area (Off-Base outside CZs and APZs)**

| Category | Acreage |
|---|---|
| Residential | 367 |
| Commercial | 39 |
| Industrial | 319 |
| Public/Quasi-public | 27 |
| Recreational/Open/Agricultural/Low Density | 15,501 |
| **Total** | **16,253** |

Source: *Dover Zoning Map and Kent County Zoning Map*




**Dover Air Force Base 2010 AICUZ**

LEGEND

- Dover AFB
- Residential
- Commercial
- Industrial
- Public/Quasi-Public
- Recreational
- Open/Agriculture/Low Density
- Municipal Boundary
- DNL Contours
- Runway
- Roadway
- Accident Potential Zone
- Clear Zone

N

0 8,000 Feet

## Generalized Zoning

Figure 5.2

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A similar analysis was performed to determine the acreage of each generalized zoning category within the Dover AFB CZs and APZs and is shown on Table 5.4.

**Table 5.4 Generalized Zoning Within the Dover AFB Clear Zones and Accident Potential Zones (Off-Base)**

| Category | Acreage |
|---|---|
| Residential | 75 |
| Commercial | 10 |
| Industrial | 369 |
| Public/Quasi-public | 27 |
| Recreational/Open/Agricultural/Low Density | 2,889 |
| **Total** | **3,370** |

Source: *Dover Zoning Map and Kent County Zoning Map*

## 5.4 FUTURE LAND USE

Figure 5.3 shows generalized future land use predicted for the Dover AFB environs based on local zoning maps, comprehensive plans, and local development proposals. Kent County and the City of Dover are expected to continue to develop at a moderate pace over the next several years.

Kent County created a Growth Overlay Zone in 1996 (modified in 2002), which is the County's primary growth management strategy. The zone serves to encourage more intense development and infrastructure investment in and around existing developed areas. The County has experienced significant residential development in the past several years, with commercial and industrial development primarily occurring in municipalities. Growth in the Dover AFB vicinity is expected to focus on expansion of developed areas to the south of the Base and within the Growth Overlay Zone. As discussed in Subsection 5.3, for those areas within AICUZ noise zones and where the local government has granted development approval, new residences are required to have sound attenuation installed.

The City of Dover maintains an official policy of considering SR-1 an urban boundary by keeping the lands east of SR-1 for agricultural uses. Consequently, a significant amount of the City is expected to remain predominately agricultural. Commercial and public/quasi public uses have dominated new development within the City of Dover in recent years, with moderate amounts of residential development primarily in the western portion of the City. North and west of the Base, future development is expected to predominantly consist of infill development along U.S. 113 and Alternate U.S. 13. Moderate industrial development is occurring north of the Base and is anticipated to continue in the future.

The Delaware Agricultural Lands Preservation Act, signed into law on July 8, 1991, established a long term program for preserving agricultural lands within the State. Kent County has subsequently taken proactive steps to promote agricultural preservation, including the adoption of a number of policies designed to promote the continued existence of farmland within the county. The law has been a contributing factor in encouraging farmers adjacent to

the Base to join the preservation program. The acquisition of farmland development rights will further serve to ensure incompatible development does not occur close to the Base.

The land use planning and zoning enacted by Kent County and the City of Dover ensure that significant land use incompatibilities in the Dover environs will be avoided in the future. The positive relationship among the Base and local jurisdictions and planning agencies will continue to minimize the expansion of undeveloped areas surrounding the Base.

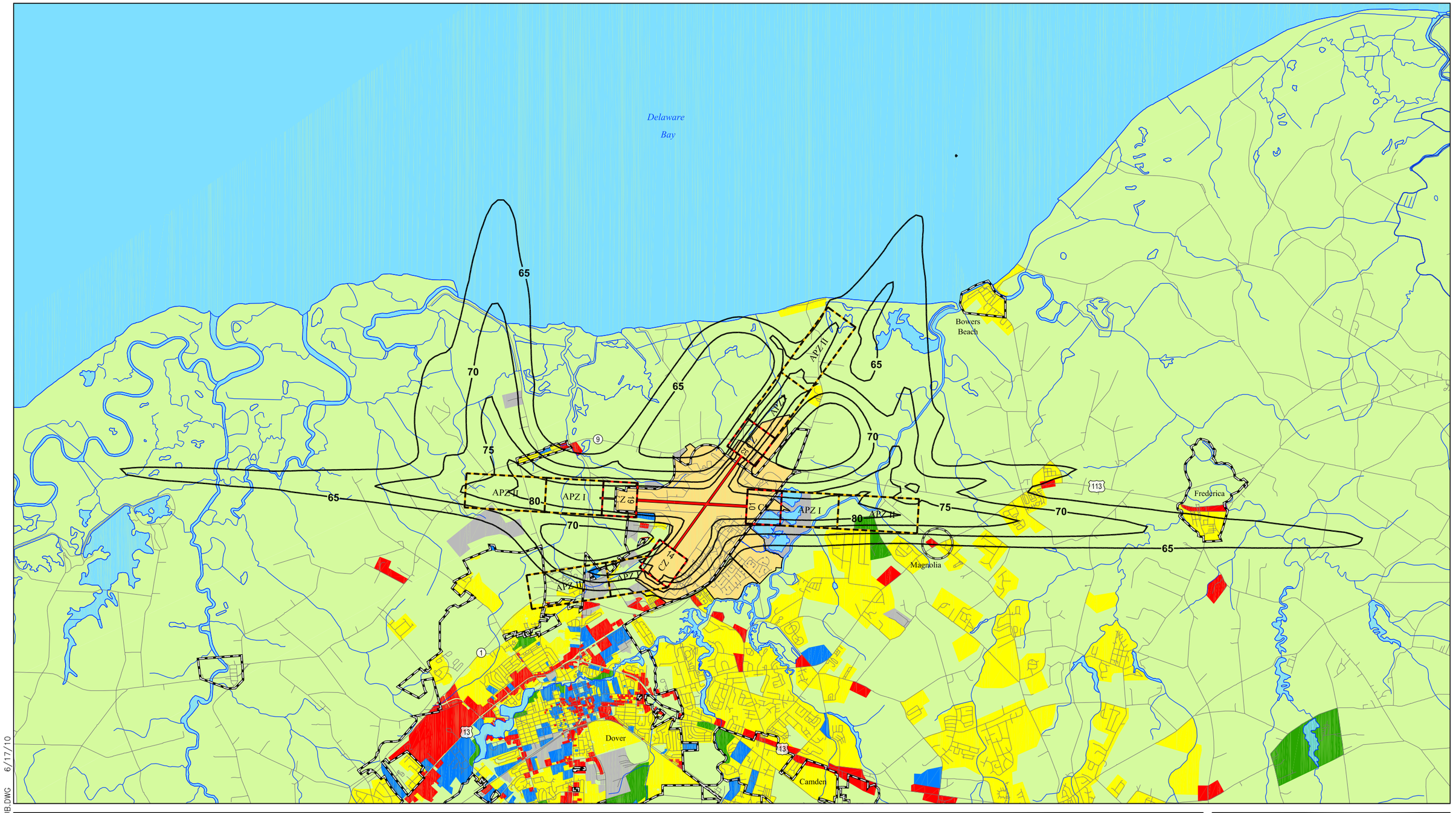
## 5.5 INCOMPATIBLE LAND USES

Table 5.5 shows land use compatibility as it is applied to existing land use within the Dover AFB area of influence. For a land use area to be considered compatible, it must meet criteria for its category for both noise and accident potential as shown in Table 5.5. The compatibility guidelines shown in Table 5.5 were combined with the existing land use data presented on Figure 5.1 to determine land use compatibility associated with aircraft operations at Dover AFB. Results of this analysis are shown numerically in Table 5.5, and graphically on Figure 5.4. There are land uses to the north and south of Dover AFB that are considered to be incompatible with Base operations.

**Table 5.5 Incompatible Land Use for Runways 01/19 and 14/32 at Dover AFB**

| | Acreage Within CZs and APZs | | | Acreage Within Noise Zones, Not Included in CZs and APZs | | | | |
|---|---|---|---|---|---|---|---|---|
| **Category** | **CLEAR ZONE** | **APZ I** | **APZ II** | **65-69** | **70-74** | **75-79** | **80+** | **Total** |
| Residential | 0 | 9 | 12 | 460 | 216 | 21 | 0 | **718** |
| Commercial | 0 | 0 | • | • | • | • | 0 | **0** |
| Industrial | 69 | • | • | • | • | • | • | **69** |
| Public/Quasi-public | 0 | 0 | 17 | • | 0 | 11 | 8 | **36** |
| Recreation/Open/ Agricultural/Low Density | • | • | • | • | • | • | • | **0** |
| **Total** | **69** | **9** | **29** | **460** | **216** | **32** | **8** | **823** |

• *Represents compatible land use*




**Dover Air Force Base 2010 AICUZ**

LEGEND

- Dover AFB
- Residential
- Commercial
- Industrial
- Public/Quasi-Public
- Recreational
- Open/Agriculture/Low Density
- Municipal Boundary
- DNL Contours
- Runway
- Roadway
- Accident Potential Zone
- Clear Zone

N

0 8,000 Feet

**Generalized Future Land Use**

Figure 5.3

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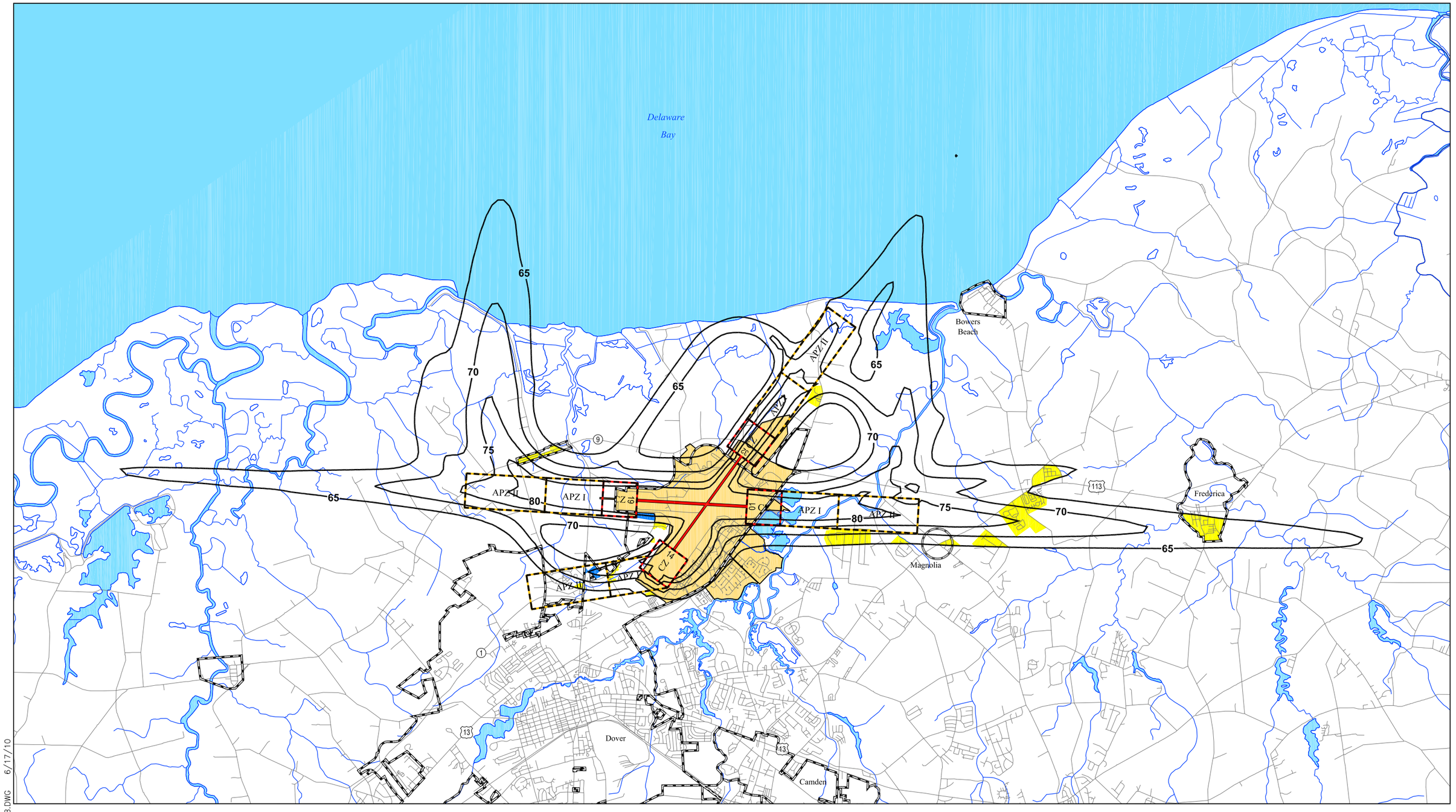


**Dover Air Force Base 2010 AICUZ**

LEGEND

- Dover AFB
- Residential
- Industrial
- Public/Quasi-Public
- Municipal Boundary
- DNL Contours
- Runway
- Roadway
- Accident Potential Zone
- Clear Zone

N

0 8,000 Feet

# Incompatible Land Use

Figure 5.4

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### 5.5.1 Runways 01 and 19 Clear Zones and Accident Potential Zones

#### *Runway 01 Clear Zone (South of the Airfield)*

Dover AFB owns approximately 130 acres of the Runway 01 CZ. This discussion applies to that portion of the CZ outside the Base boundary (approximately 76 acres). Any land use other than vacant or limited agricultural use is incompatible with the safety criteria established for a CZ. A sand and gravel operation (industrial) is located south of the Base and although a majority of the land within the CZ is water, the activity is considered incompatible with CZ criteria.

#### *Runway 01 Accident Potential Zone I (South of the Airfield)*

Only industrial and recreational/open land uses are compatible with the safety criteria established for APZ I. Although there are no incompatible land uses associated with the Runway 01 APZ I, the sand and gravel operation located there represents a safety concern since birds are attracted to the water body (Bird Aircraft Strike Hazard potential).

#### *Runway 01 Accident Potential Zone II (South of the Airfield)*

Any land use other than public is compatible with the safety criteria established for APZ II, as long as residential development is limited to a maximum density of one dwelling unit per acre. There are no incompatible land uses associated with the Runway 01 APZ II.

#### *Runway 19 Clear Zone (North of the Airfield)*

Dover AFB owns approximately 96 acres of the Runway 19 CZ. This discussion applies to that portion of the CZ outside of the Base boundary (approximately 110 acres). Any land uses other than vacant are incompatible with the safety criteria established for a CZ. There are no incompatible land uses associated with the Runway 19 CZ.

#### *Runway 19 Accident Potential Zone I (North of the Airfield)*

In general, industrial, recreational, vacant, and agricultural/open land uses are compatible with the safety criteria established for APZ I. Compatibility of commercial uses within APZ I is dependent on densities and intensity of uses. There are no incompatible land uses associated with the Runway 19 APZ I.

#### *Runway 19 Accident Potential Zone II (North of the Airfield)*

Most categories of land use are compatible with the safety criteria established for APZ II with the exception of public/quasi-public and some densities of residential. If residential densities are greater than one dwelling unit per acre, these land uses would be incompatible. There are no incompatible land uses associated with the Runway 19 APZ II.

### 5.5.2 Runways 14 and 32 Clear Zones and Accident Potential Zones

#### *Runway 14 Clear Zone (Northwest of the Airfield)*

Dover AFB owns approximately 182 acres of the Runway 14 CZ. This discussion applies to that portion of the CZ that occurs outside of the Base boundary (approximately 24 acres). Any land uses other than vacant is incompatible with the safety criteria established for a CZ. There are no incompatible land uses associated with the Runway 14 CZ.

#### *Runway 14 Accident Potential Zone I (Northwest of the Airfield)*

Accident Potential Zone I for Runway 14 turns to a northerly direction to follow prevalent flight patterns and overlays portions of incorporated areas of the City of Dover. In general, industrial, recreational, vacant, and agricultural/open land uses are compatible with the safety criteria established for APZ I. Compatibility of commercial uses within APZ I is dependent on densities and intensity of uses. A small area of incompatible existing residential development exists along Horsepond Road and Lafferty Lane.

#### *Runway 14 Accident Potential Zone II (Northwest of the Airfield)*

Most categories of land use are compatible with the safety criteria established for APZ II with the exception of public/quasi-public and some densities of residential. If residential densities are greater than one dwelling unit per acre, these land uses would be incompatible. The APZ II includes areas of public, commercial, industrial, and residential uses. Incompatible land uses include small areas of residential and public (health center).

#### *Runway 32 Clear Zone (Southeast of the Airfield)*

Dover AFB owns approximately 143 acres of the Runway 32 CZ. This discussion applies to that portion of the CZ outside the Base boundary (approximately 63 acres). Any land use other than vacant or limited agricultural use is incompatible with the safety criteria established for a CZ. There are no incompatible land uses associated with the Runway 32 CZ.

#### *Runway 32 Accident Potential Zone I (Southeast of the Airfield)*

Only industrial and recreational/open land uses are compatible with the safety criteria established for APZ I. There are no incompatible land uses associated with the Runway 32 APZ I.

#### *Runway 32 Accident Potential Zone II (Southeast of the Airfield)*

Any land use other than public is compatible with the safety criteria established for APZ II, as long as residential development is limited to a maximum density of one dwelling unit per acre. There are no incompatible land uses associated with the Runway 32 APZ II.

## 5.6 NOISE ZONES

At noise levels between DNL 65-69 dB, the only incompatible land use type is residential without noise level reduction (NLR) materials. Residential uses exist within the DNL 65-69 dB noise contours northwest of the Base adjacent to the Runway 14 end and to the south of the Base in the vicinity of U.S. 113, including a portion of the Town of Frederica. A small portion of residential development exists in the 65-69 dB noise contours along Fox Road north of the Runway 14 end. One area of residential development falls within both the DNL 65-69 dB and DNL 70-74 dB noise contours southeast of the Base adjacent to Kitts Hummock Road. Residential uses also exist in the DNL 70-74 dB and DNL 75-79 dB noise contours along Horsepond Road and Lafferty Lane.

Incompatible residential areas exist within the DNL 70-74 dB noise contours near James Road, between the ends of Runways 14 and 19. The majority of these residential areas were constructed prior to adoption of noise compatible zoning regulations and are assumed to be incompatible. More recently constructed homes south of the Base may have had NLR measures incorporated into their construction and would be considered compatible. Additionally, two small areas of public land north of the airfield are within the DNL 75-79 dB and DNL 80+ dB noise contours and are considered incompatible.

## 5.7 AIR INSTALLATION COMPATIBLE USE ZONE STUDY UPDATES

AICUZ noise contours describe the noise characteristics of a specific operational environment and, as such, will change if a significant operational change is made. An AICUZ Study should be evaluated for an update if the noise exposure map changes by DNL 2 dB or more in noise sensitive areas from the noise contour map in the last publicly released AICUZ Study. With this in mind, this AICUZ Study updates the 1999 AICUZ Study and provides flight track, APZ and noise zone information in this report, which reflects the most accurate picture of the Base's aircraft activities as of December 2009.

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# SECTION 6
# IMPLEMENTATION

## 6.1 INTRODUCTION

Implementation of the AICUZ Study must be a joint effort between the Air Force and adjacent communities. The role of the Air Force is to minimize impact on the local communities by Dover AFB aircraft operations. The role of the communities is to ensure that development in the surrounding area is compatible with accepted planning and development principles and practices.

## 6.2 AIR FORCE RESPONSIBILITIES

In general, the Air Force perceives its AICUZ responsibilities as encompassing the areas of flying safety, noise abatement, and participation in the land use planning process.

Well-maintained aircraft and well-trained aircrews do a great deal to assure that aircraft accidents are avoided. Despite the best aircrew training and aircraft maintenance intentions, history clearly shows that accidents do occur. It is imperative flights be routed over sparsely populated areas as regularly as possible to reduce the exposure of lives and property to a potential accident.

Commanders are required by Air Force policy to periodically review existing traffic patterns, instrument approaches, weather minima, and operating practices, and evaluate these factors in relationship to populated areas and other local situations. This requirement is a direct result and expression of Air Force policy that all AICUZ plans must include an analysis of flying and flying-related activities designed to reduce and control the effects of such operations on surrounding land areas. Noise is generated from aircraft both in the air and on the ground. In an effort to reduce the noise effects of Dover AFB operations on surrounding communities, the Base routes flight tracks to avoid populated areas.

Preparation and presentation of this Dover AFB AICUZ Study is one phase of continuing Air Force participation in the local planning process. It is recognized that as the local community updates its land use plans, the Air Force must be ready to provide additional input when needed.

It is also recognized that the AICUZ program is an ongoing activity even after compatible development plans are adopted and implemented. Dover AFB personnel are prepared to participate in the continuing discussion of zoning and other land use matters as they may affect, or may be affected by the Base. Base personnel are also available to provide information, criteria, and guidelines to state, regional, and local planning bodies, civic associations, and similar groups.

Participation in land-use planning can take many forms. The simplest of these is straightforward, consistent two-way discussion and information sharing with both professionals and neighbors. Copies of the AICUZ Study, including maps, will be provided to regional planning departments and zoning administrators. Through this communication process, the Base reviews applications for development or changed use of properties within

the noise impact and safety areas, as well as other nearby parcels. The Base coordinates closely with surrounding communities and counties on zoning and land-use issues.

## 6.3 LOCAL COMMUNITY RESPONSIBILITIES

Residents in the area surrounding Dover AFB and Base personnel have a long history of working together for mutual benefit of the area around the airfield. Local jurisdictions have taken a proactive approach to incorporating land use regulations into local plans and ordinances that consider Dover AFB flying operations when considering development proposals. Adoption of the following recommendations will strengthen this relationship, increase the health and safety of the public, and help protect the integrity of the Dover AFB flying mission:

- Continue to incorporate AICUZ policies and guidelines into the comprehensive plans of Kent County and the City of Dover. Continue to use overlay maps of the AICUZ noise contours and Air Force Land Use Compatibility Guidelines to evaluate existing and future land use proposals.
- Review the boundaries of the AEOZ and update if necessary to coincide with the updated noise contours produced in this study.
- Kent County and the City of Dover should continue to enforce the sound attenuation requirements for new buildings located within DNL of 65 dBA, 70 dBA, 75 dBA, and/or 80 dBA noise areas.
- Continue to review and modify existing zoning ordinances and subdivision regulations if needed to support the compatible land uses outlined in this study.
- Develop a working group representing city, county, and base planners to address AICUZ concerns and major development proposals that could affect airfield operations.
- Continue to inform Dover AFB of planning and zoning actions that have the potential to affect Base operations.

# APPENDIX A

# THE AICUZ CONCEPT, PROGRAM, METHODOLOGY, AND POLICIES

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# THE AICUZ CONCEPT, PROGRAM, METHODOLOGY, AND POLICIES

## A.1 Concept

Federal legislation, national sentiment, and other external forces that directly affect the Air Force mission, serve to increase the role of the Air Force in environmental and planning issues. Problems of airfield encroachment from incompatible land uses surrounding installations, as well as air and water pollution and socioeconomic impact, require continued and intensified Air Force involvement. The nature of these problems dictates direct Air Force participation in comprehensive community and land use planning. Effective, coordinated planning that bridges the gap between the federal government and the community requires establishment of good working relationships with local citizens, local planning officials, and state and federal officials. This depends on creating an atmosphere of mutual trust and helpfulness. The AICUZ concept was developed in an effort to:

- protect local citizens from noise exposure and accident potential associated with flying activities; and
- prevent degradation of the capability of the Air Force to achieve its mission by promoting compatible land use planning.

The land use guidelines developed herein are a composite of a number of other land use compatibility studies that have been refined to fit the Dover AFB aviation environment.

## A.2 Program

Installation commanders establish and maintain active programs to promote the maximum feasible land use compatibility between air installations and neighboring communities. The program requires that all appropriate government bodies and citizens be fully informed whenever AICUZ or other planning matters affecting the installation are under consideration. This includes positive and continuous programs designed to:

- provide information, criteria, and guidelines to federal, state, regional, as well as local planning bodies, civic associations, and similar groups;
- inform such groups of the requirements of the flying activity, noise exposure, aircraft accident potential, and AICUZ plans;
- describe the noise reduction measures being used; and
- ensure that all reasonable, economical, and practical measures are taken to reduce or control the impact of noise-producing activities. These measures include such considerations as proper location of engine test facilities, provision of sound suppressors where necessary, and adjustment of flight patterns and/or techniques to minimize the noise impact on populated areas. This must be done without jeopardizing safety or operational effectiveness.

## A.3 Methodology

The AICUZ consists of land areas upon which certain land uses may obstruct the airspace or otherwise be hazardous to aircraft operations, and land areas that are exposed to the health, safety, or welfare hazards of aircraft operations. The AICUZ includes:

- Accident Potential Zones (APZ) and Clear Zones (CZ) based on past Air Force aircraft accidents and installation operational data (see Appendix B);
- Noise zones produced by the computerized DNL modeling of the noise created by aircraft flight and maintenance operations (see Appendix C); and
- The area designated by the FAA and the Air Force for purposes of height limitations in the approach and departure zones of the base (see Section 4 of the Study).

The APZ, CZ, and noise zones are the basic building blocks for land use planning with AICUZ data. Compatible land uses are specified for these zones, and recommendations on building materials and standards to reduce interior noise levels inside structures are provided in Section A.7.

As part of the AICUZ Program, the only real property acquisition for which the Air Force has requested and received Congressional authorization, and for which the installation and major commands request appropriation, are the areas designated as the CZ. Dover AFB does not own all property in the CZs. Compatible land use controls for the remaining airfield area of influence should be accomplished through the community land use planning processes.

## A.4 AICUZ Land Use Development Policies

The basis for any effective land use control system is development of, and subsequent adherence to, policies that serve as the standard by which all land use planning and control actions are evaluated. Dover AFB recommends the following policies be considered for incorporation into the comprehensive plans of agencies in the vicinity of the Base's area of influence:

### A.4.1 Policy 1

To promote the public health, safety, peace, comfort, convenience, and general welfare of the inhabitants in the airfield area of influence, it is necessary to:

- guide, control, and regulate future growth and development;
- promote orderly and appropriate use of land;
- protect the character and stability of existing land uses;
- prevent destruction or impairment of the airfield and the public investment therein;
- enhance the quality of living in the areas affected; and
- protect the general economic welfare by restricting incompatible land use.

### A.4.2 Policy 2

In furtherance of Policy 1, it is appropriate to:

- establish guidelines of land use compatibility;

- restrict or prohibit incompatible land use;
- prevent establishment of any land use that would unreasonably endanger aircraft operations and continued use of the airfield;
- incorporate the AICUZ concept into community land use plans, modifying them when necessary; and
- adopt appropriate ordinances to implement airfield area of influence land use plans.

### A.4.3 Policy 3

Within the boundaries of the AICUZ, certain land uses are inherently incompatible. Those not in the public interest and must be restricted or prohibited, are land uses that:

- release into the air any substance, such as steam, dust, or smoke that would impair visibility or otherwise interfere with the operation of aircraft;
- produce light emissions, either direct or indirect (reflective), that would interfere with pilot vision;
- produce electrical emissions that would interfere with aircraft communication systems or navigation equipment;
- attract birds or waterfowl, such as operation of sanitary landfills, maintenance or feeding stations, or growth of certain vegetation; and
- provide for structures within 10 feet of aircraft approach-departure and/or transitional surfaces.

### A.4.4 Policy 4

Certain noise levels of varying duration and frequency create hazards to both physical and mental health. A limited, though definite, danger to life exists in certain areas adjacent to airfields. Where these conditions are sufficiently severe, it is not consistent with public health, safety, and welfare to allow the following land uses:

- residential;
- retail business;
- office buildings;
- public buildings (schools, churches, etc.); and
- recreation buildings and structures.

### A.4.5 Policy 5

Land areas below takeoff and final approach flight paths are exposed to significant danger of aircraft accidents. The density of development and intensity of use must be limited in such areas.

### A.4.6 Policy 6

Different land uses have different sensitivities to noise. Standards of land use acceptability should be adopted, based on these noise sensitivities. In addition, a system of Noise Level Reduction Guidelines (Appendix C) for new construction should be implemented to permit certain uses where they would otherwise be prohibited.

### A.4.7 Policy 7

Land use planning and zoning in the airfield area of influence cannot be based solely on aircraft-generated effects. Allocation of land used within the AICUZ should be further refined by consideration of:

- physiographic factors;
- climate and hydrology;
- vegetation;
- surface geology;
- soil characteristics;
- intrinsic land use capabilities and constraints;
- existing land use;
- land ownership patterns and values;
- economic and social demands;
- cost and availability of public utilities, transportation, and community facilities; and
- other noise sources.

## A.5 Basic Land Use Compatibility

Research on aircraft accident potential, noise, and land use compatibility is ongoing at a number of federal and other agencies. These and all other compatibility guidelines must not be considered inflexible standards. They are the framework within which land use compatibility questions can be addressed and resolved. In each case, full consideration must be given to local conditions such as:

- previous community experience with aircraft accidents and noise;
- local building construction and development practices;
- existing noise environment due to other urban or transportation noise sources;
- time periods of aircraft operations and land use activities;
- specific site analysis; and
- noise buffers, including topography.

These basic guidelines cannot resolve all land use compatibility questions, but they do offer a reasonable framework within which to work.

## A.6 Accident Potential

Each end of Runways 01/19 and 12/30 at Dover AFB has a 3,000-foot by 3,000-foot CZ and two APZs (Section 5). Accident potential on or adjacent to the runway or within CZ is so high that the necessary land use restrictions would prohibit reasonable economic use of land. As stated previously, it is Air Force policy to request Congress to authorize and appropriate funds for the necessary real property interests in this area to prevent incompatible land uses.

Accident Potential Zone I is less critical than the CZ, but still possesses a significant risk factor. This 3,000-foot by 5,000-foot area has land use compatibility guidelines sufficiently flexible to allow reasonable economic use of the land, such as industrial/manufacturing, transportation, communication/utilities, wholesale trade, open space, recreation, and agriculture. However, uses that concentrate people are not acceptable.

Accident Potential Zone II is less critical than APZ I, but still possesses potential for accidents. Accident potential zone II, also 3,000 feet wide, is 7,000 feet long extending to 15,000 feet from the runway threshold. Acceptable uses include those of APZ I, as well as low density single family residential and those personal and business services and commercial/retail trade uses of low intensity or scale of operation. High-density functions such as multistory buildings, places of assembly (theaters, churches, schools, restaurants, *etc*.), and high density office uses are not considered appropriate.

High density populations should be limited to the maximum extent possible. The optimum density recommended for residential usage (where it does not conflict with noise criteria) in APZ II is one dwelling per acre. For most nonresidential usage, buildings should be limited to one story, and the lot coverage should not exceed 20 percent.

Land use guidelines for the two APZs are based on a hazard index system that compares the relationship of accident occurrence for five areas:

- on or adjacent to the runway;
- within the CZ;
- in APZ I;
- in APZ II; and
- in all other areas within a 10 nautical mile radius of the runway.

Accident potential on or adjacent to the runway or within the CZ is so high that few uses are acceptable. The risk outside APZ I and APZ II, but within the 10 nautical mile radius area, is significant, but is acceptable if sound engineering and planning practices are followed.

Land use guidelines for APZs I and II have been developed. The main objective has been to restrict all people-intensive uses because there is greater risk in these areas. The basic guidelines aim at prevention of uses that:

- have high density residential characteristics;
- have high labor intensity;
- involve above-ground explosives, fire, toxic, corrosive, or other hazardous characteristics;
- promote population concentrations;
- involve utilities and services required for area-wide population, where disruption would have an adverse impact (telephone, gas, etc.);
- concentrate people who are unable to respond to emergency situations, such as children, elderly, handicapped, etc.; and
- pose hazards to aircraft operations.

There is no question that these guidelines are relative. Ideally, there should be no people-intensive uses in either of these APZs. The free market and private property systems prevent this where there is a demand for land development. To go beyond these guidelines, substantially increases risk by placing more people in areas where there may ultimately be an aircraft accident.

## A.7 Noise

Nearly all studies analyzing aircraft noise and residential compatibility recommend no residential uses in noise zones above DNL 75 dB. Usually, no restrictions are recommended below noise zone DNL 65 dB. There is currently no consensus between DNL 65-74 dB. These areas may not qualify for federal mortgage insurance in residential categories according to United States Department of Housing and Urban Development (HUD) Regulation 24 CFR 51B. In many cases, HUD approval requires noise attenuation measures, the Regional Administrator's concurrence, and an Environmental Impact Statement. The United States Department of Veterans Affairs also has airfield noise and accident restrictions that apply to its home loan guarantee program. Whenever possible, residential land use should be located below DNL 65 dB according to Air Force land use recommendations. Residential buildings within the DNL 65-70 dB noise contours should contain noise level reduction in accordance with the Air Force land use compatibility guidelines in the AICUZ Study, Table 4.3.

Most industrial/manufacturing uses are compatible in the airfield area of influence. Exceptions are uses such as research or scientific activities that require lower noise levels. Noise attenuation measures are recommended for portions of buildings devoted to office use, receiving the public, or where the normal background noise level is low.

The transportation, communications, and utilities categories have a high noise level compatibility because they generally are not people-intensive. When people use land for these purposes, the duration is generally very short. Where buildings are required for these uses, additional evaluation is warranted.

The commercial/retail trade and personal and business services categories are compatible without restriction up to DNL 70 dB; however, they are generally incompatible above DNL 80 dB. Between DNLs 70-79 dB, noise level reduction measures should be included in the design and construction of buildings.

The nature of most uses in the public and quasi-public services category requires a quieter environment, and attempts should be made to locate these uses below DNL 65 dB (an Air Force land use recommendation), or else provide adequate noise level reduction.

Although recreational use has often been recommended as compatible with high noise levels, recent research has resulted in a more conservative view. Above DNL 75 dB, noise becomes a factor that limits the ability to enjoy such uses. Where the requirement to hear is a function of the use (*e.g.*, music shell, *etc*.), compatibility is limited. Buildings associated with golf courses and similar uses should be noise attenuated.

With the exception of forestry activities and livestock farming, uses in the resources production, extraction, and open space category are compatible almost without restrictions.

# APPENDIX B
# CLEAR ZONES AND ACCIDENT POTENTIAL ZONES

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# CLEAR ZONES AND ACCIDENT POTENTIAL ZONES

## B.1 Guidelines For Accident Potential

Areas around airports are exposed to the possibility of aircraft accidents even with well-maintained aircraft and highly trained aircrews. Despite stringent maintenance requirements and countless hours of training, history makes it clear that accidents do happen.

When the AICUZ Program began, there were no current comprehensive studies on accident potential. To support the program, the Air Force completed a study of Air Force aircraft accidents that occurred between 1968 and 1972 within 10 nautical miles of airfields. The study of 369 accidents revealed that 75 percent of aircraft accidents occurred on or adjacent to the runway (1,000 feet to each side of the runway centerline) and in a corridor 3,000 feet (1,500 feet either side of the runway centerline) wide, extending from the runway threshold along the extended runway centerline for a distance of 15,000 feet. The Air Force updated these studies and this information is presented later in this section.

The CZ, APZ I, and APZ II were established based on crash patterns. The CZ starts at the end of the runway and extends outward 3,000 feet. It has the highest accident potential of the three zones. The Air Force adopted a policy of acquiring property rights to areas designated as CZs because of the high accident potential. APZ I extends from the CZ an additional 5,000 feet. It includes an area of reduced accident potential. APZ II extends from APZ I an additional 7,000 feet in an area of further reduced accident potential.

Research in accident potential conducted by the Air Force was the first significant effort in this subject area since 1952 when the President's Airport Commission published "The Airport and Its Neighbors," better known as the "Doolittle Report." The recommendations of this earlier report were influential in the formulation of the APZ concept.

The risk to people on the ground being killed or injured by aircraft accidents is small. However, an aircraft accident is a high consequence event, and when a crash does occur, the result is often catastrophic. Because of this, the Air Force does not attempt to base its safety standards on accident probabilities. Instead, the Air Force approaches this safety issue from a land use planning perspective.

## B.2 Guidelines For Accident Potential

Military aircraft accidents differ from commercial air carrier and general aviation accidents because of the variety of aircraft used, the type of missions, and the number of training flights. In 1973, the Air Force performed a service-wide aircraft accident hazard study to identify land near airfields with significant accident potential. Accidents studied occurred within 10 nautical miles of airfields.

The study reviewed 369 major Air Force accidents during 1968-1972, and found that 61 percent of those accidents were related to landing operations, and 39 percent were takeoff related. It also found that 70 percent occurred in daylight, and that fighter and training aircraft accounted for 80 percent of the accidents.

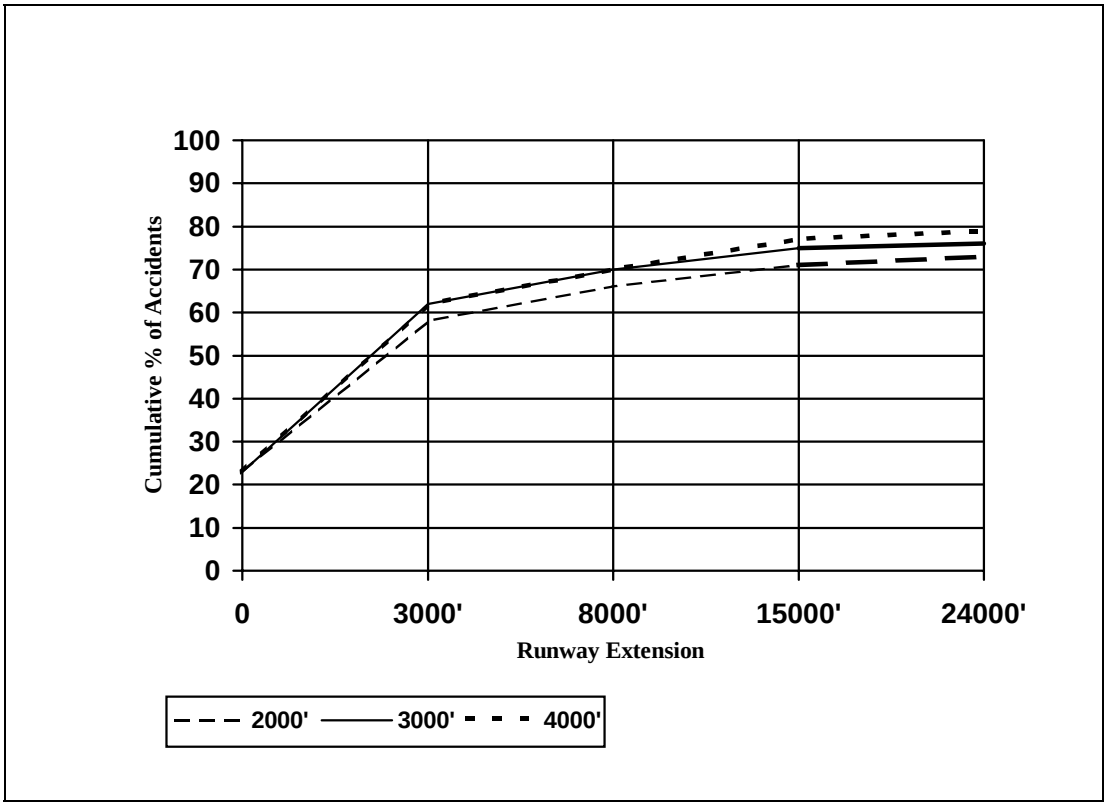
Because the purpose of the study was to identify accident hazards, the study plotted each of the 369 accidents in relation to the airfield. This plotting found that the accidents clustered along the runway and its extended centerline. To further refine this clustering, a tabulation was prepared that described the cumulative frequency of accidents as a function of distance from the runway centerline along the extended centerline. This analysis was done for widths of 2,000, 3,000, and 4,000 total feet. Table B.1 reflects the location analysis.

**Table B.1 Location Analysis**

| | Width of Runway Extension (feet) | | |
|---|---|---|---|
| **Length From Both Ends of Runway (feet)** | **2,000** | **3,000** | **4,000** |
| **Percent of Accidents** | | | |
| On or Adjacent to Runway (1,000 feet to each side of runway centerline) | 23 | 23 | 23 |
| 0 to 3,000 | 35 | 39 | 39 |
| 3,000 to 8,000 | 8 | 8 | 8 |
| 8,000 to 15,000 | 5 | 5 | 7 |
| **Cumulative Percent of Accidents** | | | |
| On or Adjacent to Runway (1,000 feet to each side of runway centerline) | 23 | 23 | 23 |
| 0 to 3,000 | 58 | 62 | 62 |
| 3,000 to 8,000 | 66 | 70 | 70 |
| 8,000 to 15,000 | 71 | 75 | 77 |

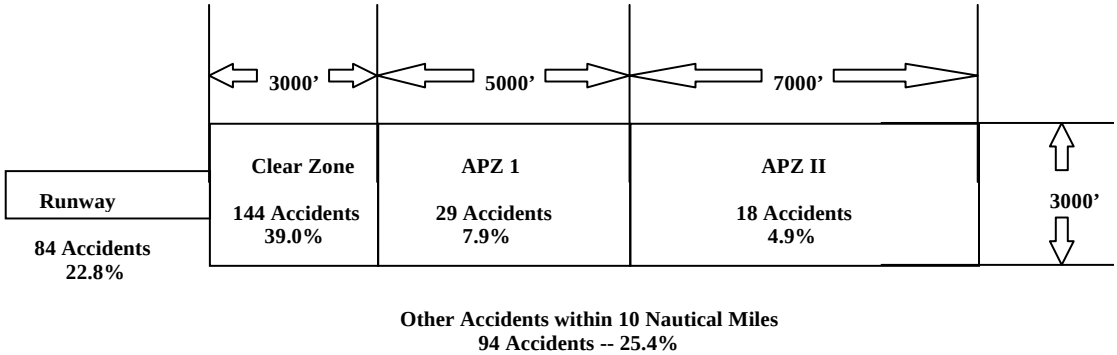
Figure B.1 indicates that the cumulative number of accidents rises rapidly from the end of the runway to 3,000 feet, rises more gradually to 8,000 feet, then continues at about the same rate of increase to 15,000 feet, where it levels off rapidly. The location analysis also indicates 3,000 feet as the optimum runway extension width and the width that includes the maximum percentage of accidents in the smallest area.

**Figure B.1 Distribution of Air Force Aircraft Accidents (369 Accidents - 1968 - 1972)**



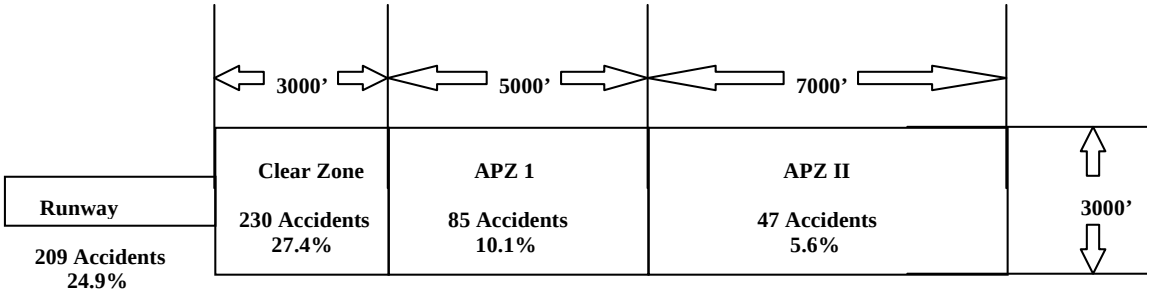

Using the optimum runway extension width, 3,000 feet, and the cumulative distribution of accidents from the end of the runway, zones were established that minimized the land area included and maximized the percentage of accidents included. The zone dimensions and accident statistics for the 1968-1972 study are shown in Figure B.2.

**Figure B.2 Air Force Aircraft Accident Data (369 Accidents - 1968 - 1972)**



The original study was updated to include accidents through September 1995. This updated study includes 838 accidents during the 1968-1995 period. Using the optimum runway extension width of 3,000 feet, the accident statistics of the updated study are shown in Figure B.3.

**Figure B.3 Air Force Aircraft Accident Data (838 Accidents - 1968 - 1995)**




**Other Accidents within 10 Nautical Miles**
**267 Accidents -- 31.9%**

Using the designated zones and accident data, it is possible to calculate a ratio of percentage of accidents to percentage of area size. These ratios indicate the CZ, with the smallest area size and the highest number of accidents, has the highest ratio, followed by the runway and adjacent area, APZ I, and then APZ II. Table B.2 reflects these data.

**Table B.2 Accident to Area Ratio**

**Ratio of Percentage of Accidents to Percentage of Area**

**(Air Force Accident Data 1968 - 1995)**

| | Area[1] (Acres) | Number[2] Accident | Accident Per Acre | Percent of Total Area | Percent of Total Accidents | Ratio:[3] % Accidents to % Area |
|---|---|---|---|---|---|---|
| Runway Area | 487 | 209 | 1 Per 2.3 acres | 0.183 | 24.9 | 136 |
| Clear Zone | 413 | 230 | 1 Per 1.8 acres | 0.155 | 27.4 | 177 |
| APZ I | 689 | 85 | 1 Per 8.1 acres | 0.258 | 10.1 | 39 |
| APZ II | 964 | 47 | 1 Per 20.5 acres | 0.362 | 5.6 | 16 |
| Other Area | 264,053 | 267 | 1 Per 989 acres | 99.042 | 31.9 | 0.3 |

1 Area includes land within 10 nautical miles of runway.

2 Total number of accidents is 838 (through 1995).

3 Percent total accidents divided by percent total area.

Additional accident data for 1986 through July 1995 has been analyzed. Specific location data for some of the 1986-1995 accidents was not available and these were not included in the analysis. Table B.3 compares the 1968-1985 data with the data through July 1995.

**Table B.3 Additional Accident Data**

| | 1968-1985 | | 1968-1995 | |
|---|---|---|---|---|
| ZONE | Accidents | % of Total | Accidents | % of Total |
| On-Runway | 197 | 27.1 | 209 | 24.9 |
| Clear Zone | 210 | 28.8 | 230 | 27.4 |
| APZ I | 57 | 7.8 | 85 | 10.1 |
| APZ II | 36 | 5.0 | 47 | 5.7 |
| Other (Within 10 nautical miles) | 228 | 31.3 | 267 | 31.9 |
| Total | 728 | 100.0 | 838 | 100.0 |

Analysis shows that the cumulative changes evident in accident location through July 1995 reconfirm the dimensions of the CZs and APZs.

## B.3 Definable Debris Impact Areas

The Air Force also determined which accidents had definable debris impact areas, and in what phase of flight the accident occurred. Overall, 75 percent of the accidents had definable debris impact areas, although they varied in size by type of accident. The Air Force used weighted averages of impact areas, for accidents occurring only in the approach and departure phase, to determine the following average impact areas:

Average Impact Areas for Approach and Departure Accidents

| | |
|---|---|
| Overall Average Impact Area | 5.06 acres |
| Fighter, Trainer, and Misc. Aircraft | 2.73 acres |
| Heavy Bomber and Tanker Aircraft | 8.73 acres |

## B.4 Findings

Designation of safety zones around the airfield and restriction of incompatible land uses can reduce the public's exposure to safety hazards.

Air Force accident studies have found that aircraft accidents near Air Force installations occurred in the following patterns:

- 61% were related to landing operations.
- 39% were related to takeoff operations.
- 70% occurred in daylight.
- 80% were related to fighter and training aircraft operations.
- 25% occurred on the runway or within an area extending 1,000 feet out from each side of the runway.

- 27% occurred in an area extending from the end of the runway to 3,000 feet along the extended centerline and 3,000 feet wide, centered on the extended centerline.
- 15% occurred in an area between 3,000 and 15,000 feet along the extended runway centerline and 3,000 feet wide, centered on the extended centerline.

Air Force aircraft accident statistics found 75% of aircraft accidents resulted in definable impact areas. The size of the impact areas were:

- 5.06 acres overall average.
- 2.73 acres for fighters and trainers.
- 8.73 acres for heavy bombers and tankers.

# APPENDIX C
# NOISE AND NOISE LEVEL REDUCTION GUIDELINES

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# NOISE AND NOISE LEVEL REDUCTION GUIDELINES

## C.1 General

Noise, often defined as unwanted sound, is one of the most common environmental issues associated with aircraft operations. Of course, aircraft are not the only sources of noise in an urban or suburban surrounding, where noise from interstate and local roadway traffic, rail, industrial, and neighborhood sources also intrude on the everyday quality of life. Nevertheless, aircraft are readily identifiable to those affected by their noise and are typically singled out for special attention and criticism. Consequently, aircraft noise problems often dominate analyses of environmental impacts.

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.*, aircraft noise) depends largely on the listener's current activity, past experience, and attitude toward the source of that sound. It is often true that one person's music is another person's noise.

The measurement and human perception of sound involves two basic physical characteristics - intensity and frequency. Intensity is a measure of the acoustic energy of the sound vibrations and is expressed in terms of sound pressure. The higher the sound pressure, the more energy carried by the sound and the louder the perception of that sound. The second important physical characteristic is sound frequency, that 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 loudest sounds, which can be detected comfortably by the human ear, have intensities that are a trillion times larger than those of sounds that can be detected at the lower end of the spectrum. Because of this vast range, any attempt to represent the intensity of sound using a linear scale becomes very unwieldy. As a result, a logarithmic unit known as the decibel (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 and eventually pain at still higher levels.

Because of the logarithmic nature of the decibel unit, sound levels cannot be added or subtracted directly 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. Thus, for example:

60 dB + 60 dB = 63 dB, and

80 dB + 80 dB = 83 dB.

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 behaves differently than that of ordinary numbers, such an addition is often referred to as "decibel addition" or "energy addition." The latter term arises from the fact that what is really happening when decibel values are added is each decibel value is first converted to its corresponding acoustic energy, then the energies are added using the normal rules of addition, and finally the total energy is converted to its decibel equivalent.

An important facet of decibel addition arises later when the concept of time-average sound levels is introduced to explain Day-Night Average A-Weighted Sound Level (DNL). Because of the logarithmic units, the louder levels that occur during the averaging period dominate the time-average sound levels. As a simple example, consider a sound level that is 100 dB and lasts for 30 seconds, followed by a sound level of 50 dB that also lasts for 30 seconds. The time-average sound level over the total 60-second period is 97 dB, not 75 dB.

Sound frequency is measured in terms of cycles per second (cps), or hertz (Hz), which is the preferred scientific 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 are not heard equally well by the human ear, which is most sensitive to frequencies in the 1000 to 4000 Hz range. In measuring community noise, this frequency dependence is taken into account by adjusting the sound levels of the very high and low frequencies to approximate the human ear's lower sensitivity to those frequencies. This is called "A-weighting" and is commonly used in measurements of community environmental noise.

Sound levels measured using A-weighting are most properly called A-weighted sound levels while sound levels measured without any frequency weighting are most properly called sound levels. However, since most environmental impact analysis documents deal only with A-weighted sound levels, the adjective "A-weighted" is often omitted, and A-weighted sound levels are referred to simply as sound levels. In some instances it will be indicated that the sound levels have been A-weighted by using the abbreviation dBA or dB(A), rather than the abbreviation dB, for decibel. As long as the use of A-weighting is understood to be used, there is no difference implied by the terms "sound level" and "A-weighted sound level" or by the units dB, dBA, and dB(A).

In this document and most AICUZ documents, all sound levels are A-weighted sound levels and the adjective "A-weighted" has been omitted and dB is used for the decibel units.

Sound levels do not represent instantaneous measurements but rather averages over short periods. Two measurement time periods are most commonly used - one second and one-eighth of a second. Most environmental noise studies use slow response measurements, and the adjective "slow response" is usually omitted. It is easy to understand why the proper descriptor "slow response A-weighted sound level" is usually shortened to "sound level" in environmental impact analysis documents.

## C.2 Noise Metrics

A "metric" is defined as something "of, involving, or used in measurement." In environmental noise analyses, a metric refers to the unit or quantity that quantitatively measures the effect of noise on the environment. Noise studies have typically involved a

confusing proliferation of noise metrics as individual researchers have attempted to understand and represent the effects of noise. As a result, past literature describing environmental noise abatement has included many different metrics.

Various federal agencies involved in environmental noise mitigation agree on common metrics for environmental impact analysis documents, and both the Department of Defense (DoD) and the FAA specified those that should be used for federal aviation noise assessments. These metrics are as follows.

### C.2.1 Maximum Sound Level

The highest A-weighted sound level measured during a single event in which the sound level changes value as time goes on (*e.g.*, an aircraft overflight) is called the maximum A-weighted sound level or maximum sound level, for short. It is usually abbreviated by $L_{max,}$ or $L_{Amax}$.

### C.2.2 Sound Exposure Level

Individual time-varying noise events have two main characteristics - a sound level which changes throughout the event and a period of time during which the event is heard. Although the maximum sound level, described above, provides some measure of the intrusiveness of the event, it alone does not completely describe the total event. The period of time during which the sound is heard is also significant. The Sound Exposure Level (abbreviated SEL or $L_{AE}$) combines both of these characteristics into a single metric.

Sound Exposure Level is a logarithmic measure of the total acoustic energy transmitted to the listener during the event. Mathematically, it represents the sound level of the constant sound that would, in one second, generate the same acoustic energy as did the actual time-varying noise event. Since aircraft overflights usually last longer than one second, the SEL of an overflight is usually greater than the $L_{max}$ of the overflight.

Note that sound exposure level is a composite metric that represents both the intensity of a sound level of the constant sound and its duration. It does not directly represent the sound level heard at any given time, but rather provides a measure of the net impact of the entire acoustic event. It is well-established in the scientific community that SEL measures this impact much more reliably than just the $L_{max}$.

Because the SEL and the $L_{max}$ are both A-weighted sound levels expressed in decibels, there is sometimes confusion between the two, so the specific metric used should be clearly stated.

### C.2.3 Day-Night Average Sound Level

Time-average sound levels are measurements of sound levels that are averaged over a specified length of time. These levels provide a measure of the average sound energy during the measurement period.

For the evaluation of community noise effects, and particularly aircraft noise effects, the DNL (mathematically represented as $L_{dn}$) is used. DNL averages aircraft sound levels at a location over a complete 24-hour period, with a 10-dB adjustment added to those noise events that take place between 10:00 p.m. and 7:00 a.m. (local time). This 10-dB "penalty" represents 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.

DNL does not represent the sound level heard at any particular time. DNL provides a single measure of overall noise impact, but does not provide specific information on the number of noise events or the individual sound levels that occur during the day. For example, a DNL of 65 dB could result from a very few noisy events, or a large number of quieter events.

Scientific studies and social surveys conducted to evaluate community annoyance to all types of environmental noise have found the DNL to be the best measure to predict annoyance. Its use is endorsed by the scientific community (See References C.1 through C-5 at the end of this section).

There is a remarkable consistency in the results of attitudinal surveys about aircraft noise conducted in different countries to find the percentages of groups of people who express various degrees of annoyance when exposed to different levels of DNL.

Reference C.6 was published in 1978. A more recent study has reaffirmed this relationship (Reference C.7). 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. Nevertheless, findings substantiate that community annoyance to aircraft noise can be predicted quite reliably using DNL.

This relation between community annoyance and DNL has been confirmed, even for infrequent aircraft noise events. Reference C.8 reported the reactions of individuals in a community to daily helicopter overflights correlated quite well with the daily time-average sound levels over this range of numbers of daily noise events.

The use of DNL 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 principle that people inherently react more to single noise events and not as much to “meaningless” time-average sound levels.

In fact, a time-average noise metric, such as DNL, takes into account both the noise levels of all individual events which occur during a 24-hour period and the number of times those events occur. As described briefly above, 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 in daytime during a 24-hour period, creating a sound level of 100 dB for 30 seconds. During the remaining 23 hours, 59 minutes, and 30 seconds of the day, the ambient sound level is 50 dB. The DNL for this 24-hour period is 65.5 dB. Assume, as a second example, that 10 such 30-second overflights occur in daytime hours during the next 24-hour period, with the same ambient sound level of 50 dB during the remaining 23 hours and 55 minutes of the day. The DNL for this 24-hour period is 75.4 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. This is the basic concept of a time-average sound metric, and specifically the DNL.

## C.3 Noise Effects

### C.3.1 Hearing Loss

Noise-induced hearing loss is probably the best-defined of the potential effects of human exposure to excessive noise. 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 averaged over a 16-hour period. An outdoor DNL of 75 dBA is considered the threshold above which the risk of hearing loss should be evaluated. Following guidelines recommended by the Committee on Hearing, Bioacoustics, and Biomechanics of the National Research Council, the average change in the threshold of hearing for people exposed to DNL equal to or greater than 75 dBA was evaluated. Results indicated that an average of 1 dBA hearing loss could be expected for people exposed to DNL equal to or greater than 75 dBA. For the most sensitive 10 percent of the exposed population, the maximum anticipated hearing loss would be 4 dBA. These hearing loss projections must be considered conservative as the calculations are based on an average daily outdoor exposure of 16 hours (7:00 a.m. to 10:00 p.m.) over a 40-year period. Since it is unlikely that airport neighbors will remain outside their homes 16 hours per day for extended periods of time, there is little possibility of hearing loss below a DNL of 75 dB, and this level is extremely conservative.

### C.3.2 Nonauditory Health Effects

Nonauditory health effects of long-term noise exposure, where noise may act as a risk factor, have never been found to occur at levels below those protective against noise-induced hearing loss, described above. Most studies attempting to clarify such health effects have found that noise exposure levels established for hearing protection will also protect against any potential nonauditory health effects, at least in workplace conditions. The best scientific summary of these findings is contained in the lead paper at the National Institute of Health Conference on Noise and Hearing Loss, held on 22-24 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 eight-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." (Reference C.9; parenthetical wording added for clarification.)

Although these findings were directed specifically at noise effects in the work place, 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 which purport to find such health effects use time-average noise levels of 75 dB and higher for their research.

For example, in an often-quoted paper, two University of California at Los Angeles (UCLA) researchers apparently found a relationship between aircraft noise levels under the approach path to Los Angeles International Airport and increased mortality rates among the exposed residents by using an average noise exposure level greater than 75 dB for the "noise-exposed" population (Reference C.10). Nevertheless, three other UCLA professors analyzed those same data and found no relationship between noise exposure and mortality rates (Reference C.11).

In summary, there is no scientific basis for a claim that potential health effects exist for aircraft DNL below 75 dB.

### C.3.3 Annoyance

The primary effect of aircraft noise on exposed communities is one of annoyance. Noise annoyance is defined by the U.S. Environmental Protection Agency (USEPA) as any negative subjective reaction on the part of an individual or group (Reference C.3). As noted in the discussion of DNL above, community annoyance is best predicted by that metric.

It is often suggested that a lower DNL, such as 60 or 55 dB, be adopted as the threshold of community noise annoyance for airport environmental analysis documents. While there is no technical reason why a lower level cannot be measured or calculated for comparison purposes, a DNL of 65 dB:

- provides a valid basis for comparing and assessing community noise effects;
- represents a noise exposure level which is normally dominated by aircraft noise and not other community or nearby highway noise sources; and
- reflects the FAA's threshold for grant-in-aid funding of airport noise mitigation projects.
- United States Department of Housing and Urban Development also establishes a DNL standard of 65 dB for eligibility for federally guaranteed home loans.

### C.3.4 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. Research has shown that "whenever intrusive noise exceeds approximately 60 dB indoors, there will be interference with speech communication" (Reference C.5). A steady A-weighted background sound level of 60 dB will produce 93 percent intelligibility; that of 70 dB will produce 66 percent intelligibility; and that of 75 dB will produce 2 percent intelligibility (Figure D-1 in Reference C.3).

### C.3.5 Sleep Interference

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 louder noise level than does a change in sleep stage.

A recent analysis sponsored by the Air Force summarized 21 published studies concerning the effects of noise on sleep (Reference C.14). The analysis concluded that a lack of reliable studies in homes, combined with large differences among the results from the various laboratory studies and the limited in-home studies, did not permit development of an acceptable 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 was of sufficiently long duration to determine any effects of habituation, such as those that would occur under normal community conditions.

Nevertheless, some guidance is available in judging sleep interference. The U.S. EPA identified an indoor DNL of 45 dB as necessary to protect against sleep interference (Reference C.3). Assuming a very conservative structural noise insulation of 20 dB for typical dwelling units, this corresponds to an outdoor DNL of 65 dB as minimizing sleep interference.

The Federal Interagency Committee on Noise (Reference C.5) reviewed the sleep disturbance issue and presented an Air Force-developed sleep disturbance dose-response prediction curve, which is based on data from Reference C.14, as an interim tool for analysis of potential sleep disturbance. This interim curve shows that for an indoor SEL of 65 dB, approximately 15 percent or less of those exposed should be awakened.

### C.3.6 Noise Effects on Domestic Animals and Wildlife

Animal species differ greatly in their responses to noise. Each species has adapted, physically and behaviorally, to fill its ecological role in nature, and its hearing ability usually reflects that role. Animals rely on their 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. Secondary effects may include nonauditory effects similar to those exhibited by humans - stress, hypertension, and other nervous disorders. Tertiary effects may include interference with mating and resultant population declines.

Many scientific studies are available regarding the effects of noise on wildlife and some anecdotal reports of wildlife "flight due to noise." Few of these studies or reports include any reliable measures of the actual noise levels involved.

In the absence of definitive data on the effect of noise on animals, the Committee on Hearing, Bioacoustics, and Biomechanics proposed that protective noise criteria for animals be taken to be the same as for humans (Reference C.16).

### C.3.7 Effects of Noise-Induced Vibration on Structures and Humans

The sound from an aircraft overflight travels from the exterior to the interior of the house in one of two ways: through the solid structural elements and directly through the air. The

sound transmission starts with noise impinging on the wall exterior. Some of this sound energy will be reflected away and some will make the wall vibrate. The vibrating wall radiates sound into the airspace, which in turn sets the interior finish surface vibrating, with some of the energy lost in the airspace. This surface then radiates sound into the dwelling interior. Vibrational energy also bypasses the air cavity by traveling through the studs and edge connections.

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 pressure impinging on the structure is normally sufficient to determine the possibility of damage. In general, at sound levels above 130 dB, there is the possibility of structural damage. While certain frequencies (such as 30 Hz for window breakage) may be of more concern than other frequencies, conservatively, only sounds lasting more than 1 second above a sound level of 130 dB are potentially damaging to structural components (Reference C.17).

In terms of average peak particle velocity of wall or ceiling vibration, the thresholds for structural damage (Reference C.20) are:

- 0.1 in/sec—threshold of risk of damage to sensitive structures (e.g., ancient monuments); and
- 0.4 – 0.5 in/sec—threshold of risk of damage to normal dwellings (e.g., houses with plaster ceilings and walls).

Noise-induced structural vibration may also cause annoyance to dwelling occupants because of induced secondary vibrations, or "rattle," of objects within the dwelling - hanging pictures, dishes, plaques, and bric-a-brac. Loose window panes may also vibrate noticeably when exposed to high levels of aircraft noise, causing homeowners to fear breakage. In general, such noise-induced vibrations occur at sound levels above those considered normally compatible with residential land use. Thus, assessments of noise exposure levels for compatible land use should also be protective of noise-induced secondary vibrations.

In the assessment of vibrations on humans, the following factors determine if a person will perceive and possibly react to building vibrations:

- Type of excitation: steady state, intermittent, or impulsive vibration;
- Frequency of the excitation. ISO 2631-2 (Reference C.18) recommends a frequency range of 1 to 80 Hz for the assessment of vibration on humans;
- Orientation of the body with respect to the vibration;
- The use of the occupied space; and
- Time of day.

### C.3.8 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 structures, especially in mountainous areas, causing landslides or avalanches. There are no known instances of such effects, and it is considered improbable that such effects will result from routine, subsonic aircraft operations.

### C.3.9 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. Again, 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 (Reference C.19). There was a 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 normal structures, assessments of noise exposure levels for normally compatible land uses should also be protective of historic and archaeological sites.

## C.4 Noise Level Reduction Guidelines

A study that provides in-depth, state-of-the-art noise level reduction guidelines was prepared for the Naval Facilities Engineering Command in April 2005. The title of the document is *Guidelines for the Sound Insulation of Residences Exposed to Aircraft Operations* (Reference C.21).

## C.5 References

C.1. "Sound Level Descriptors for Determination of Compatible Land Use," American National Standards Institute Standard ANSI S3.23-1980.

C.2. "Quantities and Procedures for Description and Measurement of Environmental Sound, Part 1," American National Standards Institute Standard ANSI S12.9-1988.

C.3. "Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare With an Adequate Margin of Safety," U.S. Environmental Protection Agency Report 550/9-74-004, March 1972.

C.4. "Guidelines for Considering Noise in Land-Use Planning and Control," Federal Interagency Committee on Urban Noise, June 1980.

C.5. "Federal Agency Review of Selected Airport Noise Analysis Issues," Federal Interagency Committee on Noise, August 1992.

C.6. Schultz, T.J. "Synthesis of Social Surveys on Noise Annoyance," J. Acoust. Soc. Am., 64, 377-405, August 1978.

C.7. Fidell, S., D.S. Barger, and T.J. Schultz, "Updating a Dosage-Effect Relationship for the Prevalence of Annoyance Due to General Transportation Noise," J. Acoust. Soc. Am., 89, 221-233, January 1991.

C.8. "Community Reactions to Helicopter Noise: Results from an Experimental Study," J. Acoust. Soc. Am., 82,479-492, August 1987.

C.9. Von Gierke, H.R., "The Noise-Induced Hearing Loss Problem," NIH Consensus Development Conference on Noise and Hearing Loss, Washington D.C., 22-24 January 1990.

C.10. Meacham, W.C., N. and Shaw, "Effects of Jet Noise on Mortality Rates," British J. Audiology, 77-80, August 1979.

C.11. Frericks, R.R., *et al*., "Los Angeles Airport Noise and Mortality: Faulty Analysis and Public Policy," Am J. Public Health, 357-362, April 1980.

C.12. Jones, F.N., and J. Tauschr, "Residence Under an Airport Landing Pattern as a Factor in Teratism," Archives of Environmental Health, 10-12 Jan/Feb 1978.

C.13. Edmonds, L.D., *et al*., "Airport Noise and Teratogenesis," Archives of Environmental Health, 243-247, July/August 1979.

C.14. Pearsons, K.S., D.S. Barber, and B.G. Tabachick, "Analyses of the Predictability of Noise-Induced Sleep Disturbance," USAF Report HSD-TR-89-029, October 1989.

C.15. Kryter, K.D., "Physiological, Psychological, and Social Effects of Noise," NASA Reference Publication 1115, 446, July 1984.

C.16. "Guidelines for Preparing Environmental Impact Statements on Noise," Committee on Hearing, Bioacoustics and Biomechanics, The National Research Council, National Academy of Sciences, 1977.

C.17. Von Gierke, H.E., and W.D. Ward, "Criteria for Noise and Vibration Exposure," Handbook of Acoustical Measurements and Noise Control, Third Edition, 1991.

C.18. "Evaluation of Human Exposure to Whole-Body Vibration - Part 2: Continuous and Shock-Induced Vibration in Buildings (1 to 80 Hz)", International Organization for Standardization, Standards 2631-2, February 1989.

C.19. Wesler, J.E., "Concorde Operations at Dulles International Airport," NOISEEXPO '77, Chicago, IL, March 1977.

C.20 American Association of State Highway and Transportation Officials (AASHTO), "Standard Recommended Practice for Evaluation of Transportation-related Earthborn Vibration," Washington, DC, 1990.

C.21 *Guidelines for the Sound Insulation of Residences Exposed to Aircraft Operations*. Department of the Navy, Naval Facilities Engineering Command, April 2005.