D. NOISE

1. Average Noise Levels

The noise environment around an air station is typically described using a measure of cumulative noise exposure that results from all aircraft operations. These operations generally include flight activity in the immediate vicinity of the installation, plus stationary in-frame and/or out-of-frame engine run-ups associated with aircraft maintenance operations.

The descriptor used to account for this noise is referred to as the Day-Night Average Sound Level, abbreviated as DNL and symbolized by Ldn. In general, DNL can be thought of as an accumulation of all of the noise produced by individual events that occur throughout a 24-hour period. The noise of each event is accounted for by a noise metric that integrates the changing sound level over time. For example, as an aircraft approaches, flies overhead, then continues into the distance. These integrated sound levels for individual events are called Sound Exposure Levels (SELs). The logarithmic accumulation of the SELs from all operations during a 24-hour period determines the Ldn for the day at that location.

DNL also takes into account the time of day the noise events occur. The measure recognizes that events during the nighttime hours may be more intrusive, and therefore more annoying, than the same activity conducted during daytime hours, when background noise levels are higher. To account for this additional annoyance, a penalty of ten decibels (dB) is added to each event that takes place during nighttime hours, defined as 2200 to 0700 the next day.

Finally, DNL values around an air station are presented not just for a single specific 24-hour period, but rather for an annual average day or an average busy day. An "average busy day" occurs when the total daily operations are at least 50% of the annual daily average for the air station. For many air stations, this "average busy day" is equivalent to the average daily operations or the annual traffic count divided by the number of days the station is open and in full operation. For MCAS Cherry Point average annual day was representative of the environment. At MCALF Bogue Field, due to the nature of the operations, average busy day was more representative of the noise exposure when the field is in full operation..

This averaging is done to obtain a stable representation of the noise environment free of variations in day to day operations or between weekdays and weekends as well as from fluctuations in wind directions, runway use, temperature, aircraft performance, and total airfield operations (any one of which can significantly influence noise exposure levels from one day to the next). The accumulation of noise computed in this manner provides a quantitative tool for comparing overall noise environments and developing compatible land use plans. The Day-Night Average Sound Levels are represented as contours connecting points of equal value, usually in five dB increments from 60 or 65 dB up to 75 or 80 dB Ldn on the contour values.

As a minimum, DOD requires that sound level contours be plotted for Ldn values of 65, 70, 75 and 80 in AICUZ studies. Three general noise zones are defined: areas with a Ldn of less than 65; areas with a Ldn between 65 and 75; and areas with a Ldn of 75 or greater. These three areas are defined as Noise Zones 1, 2 and 3, respectively. Recently, values of 60 Ldn have been added to account for potential noise impacts in rural areas of low ambient noise levels.

Noise Zone 1 is essentially an area with low or no impact. Noise Zone 2 is an area of moderate impact where some land use controls are needed. Noise Zone 3 is the most severely impacted area and requires the greatest degree of compatible use controls.

Appendix 1 contains a discussion of noise and its effects on people and the environment.

2. Noise Contours

Following the normal practice for the Department of Defense airports, the aircraft noise survey for MCAS Cherry Point, published by Wyle in February 1998, used a series of computer programs in the preparation of the noise contours. The first program, OMEGA 10, was used to generate the Sound Exposure Levels (SELs) of the individual aircraft at different distances from the aircraft and at different engine power settings and airspeeds, each of which impact the loudness and duration of the event.

The second program, OMEGA 11, was used to generate SELs for run-ups for the modeled aircraft, taking into account engine thrust settings, and environmental conditions appropriate to run-up operations. Together with a standard military database known as NOISEFILE 6.4 (adjusted to reflect updated noise data for the AV 8B), OMEGA 10 and OMEGA 11 provide the noise data for each specific aircraft operation modeled at a given air installation. Alternatively, this data can be developed empirically from noise measurements or can be verified against actual measurements to assure accurate modeling of local conditions.

The final computations of the Day-Night Average Sound Level (DNL, or Ldn) values are accomplished with the computer program NOISEMAP, Version 6.5. This program computes Ldn values at individual grid points around the airport using the sound exposure levels calculated for aircraft types, aircraft climb profiles, and airport geometry including runway layout and flight track locations. The output data of predicted daily sound levels at points on the ground from NOISEMAP are then logarithmically added using NMPLOT to create the contours of equal daily sound levels for overlay on land use maps.

Specific data for MCAS Cherry Point and MCALF Bogue Field on aircraft power settings, altitudes, airspeeds, run-ups and climatological data, as well as, daily operations classified by runways, aircraft, flight track, and day/night period were entered in the models to generate the noise contours. The actual flight paths used at MCAS Cherry Point and MCALF Bogue Field as well as ground run-ups at Cherry Point establish the shape of the noise contours. In general, approaches and departures cause the narrow tapering portions of the contours, Touch-and-go operations determine the general contour size. Noise from engine run-up pads, if not overshadowed by flight operations, cause nearly circular arcs. The noise contours are shown in Figure D-1 for MCAS Cherry Point and in Figure D-2 for MCALF Bogue Field.

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Noise Contours

— MCAS Cherry Point —

Legend

- Noise Exposure Zone 2 (Ldn 65 to 75)
- Noise Exposure Zone 3 (Ldn greater than 75)
- Runways
- Noise Complaints
- Multiple Complaints

Sources:
1. Noise Contours - The Onyx Group and HPE Inc. in association with: Wyle Labs, 1998
2. Base Map - USGS, 1:100,000 scale quad

N 0 6000

Scale: 1" = 6000'

Figure
D-1

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Noise Contours

— MCALF Bogue —

Legend

- Noise Exposure Zone 2 (Ldn 65 to 75)
- Noise Exposure Zone 3 (Ldn greater than 75)
- Runways
- Noise Complaints
- Multiple Complaints

Sources:
1. Noise Contours - The Onyx Group and HPE Inc. in association with: Wyle Labs, 2001
2. Base Map - USGS, 1:100,000 scale quad

N 0 6000

Scale: 1" = 6000'

Figure
D-2

3. Noise Complaints

The origin and nature of noise complaints within the geographic region is often a tangible barometer of the success or failure of noise abatement procedures. There is a standing Aircraft Incident/Noise Abatement Committee chaired by the Director of Operations. Noise complaints are received by the Airfield Operations Duty Officer, recorded on a Noise Complaint Form and forwarded to Flight Clearance for further investigation. The investigation may include any or all of the following: review of flight schedules, flight strips and radar tapes; consultation with pilots and controllers on duty. The form is then sent to the Community Plans & Liaison (CP&L) Office, with copies to the Wing Safety Officer and the Director of Operations. The nature and location of the complaint is reviewed. The CP&L Officer notifies the complainant about the investigation findings and actions taken, as appropriate. The complaint forms are maintained in the CP&L Office files for future reference. Table D-1 outlines the range of noise complaints from 1997 through 2001. Figures D-1 and D-2 indicate the general location of the complaints that are in the airport environs. Many of the complaints recorded for Cherry Point involve aircraft using the R-5306A/BT-9/BT-11 areas in addition to those in the Havelock area.

Noise complaints can arise from a variety of causes, often related to the intensity and frequency of the events as well as the individual sensitivity of the person filing the complaint. They often arise outside the areas depicted by noise contours. This is often due to a single event that is unusual (a loud plane flying over an area not commonly overflown). In some cases the complaints outside the areas included in the noise contours are due to the fact that noise contours and land use recommendations are based on average annoyance responses of a population, and some people have greater noise sensitivity than others.

Table D-1

NOISE COMPLAINTS

Location (Vicinity)	1997	1998	1999	2000	2001
Cherry Point	7	36	40	31	20
Bogue Field	7	27	24	25	18

Source: MCAS Cherry Point CP&L

4. Noise at Selected School Locations

Table D-2 lists the DNL value for the four schools located near MCAS Cherry Point based on the data described in Section 3.1 for the 1998 Noise Study. The values ranged from 66 to 76 db. Using the data described in Section 3.1 the DNL values for each of four school locations near MCAS Cherry Point listed in Table D-2 below were calculated in the 1998 noise study, ranging from 66dB to 76dB. The NASMOD Study was able to predict the numbers of annual operations during typical school hours (7 a.m. to 4 p.m.) totaling approximately 62,000 operations per year. The NOISEMAP metrology was applied using the 200 days per year that the schools are in normal operation. A total of 152.27 operations on the flight tracks were used as average school day aircraft events. The resulting noise levels that would be experienced in the normal nine-hour day ($L_{eq9)}$ were calculated and range from 68dB to 80dB.

TABLE D-2

OUTDOOR NOISE EXPOSURE (DB) FOR SELECTED SCHOOLS

NEAR MCAS CHERRY POINT

Location	Outdoor Noise Levels	
	DNL	L_{eq9}
Havelock Elementary	74	77
Havelock Middle	73	76
Havelock High	76	80
Roger Bell Elementary	66	68

Source: Wyle February 1998

5. Noise Abatement Procedures

A number of noise abatement procedures have been implemented at MCAS Cherry Point and MCALF Bogue Field. Current procedures are outlined below.

5.1 Noise Abatement Procedures MCAS Cherry Point.

Noise Sensitive Areas:

Aircraft are to avoid overflying the industrial complex, densely populated areas of the Air Station, Crash Crew, and the rifle range below pattern altitudes. In addition, pilots are to avoid overflying the City of Havelock, Minnesott Beach, the Cedar Island Ferry Terminal, and the ferry. AV-8 arrivals and departures to pads will not overfly Crash Crew or rifle range.

Aircraft are to avoid overflying the following areas below the altitude indicated:

Bayboro	1,000 feet AGL	within 1 NM
Oriental	1,500 feet AGL	within 1 NM
Ward Creek	750 feet AGL	within 2 NM

Noise abatement Hours:

Although the airport is open, certain noise producing events such as high power run-ups, are normally restricted between 2200 and 0800 hours Monday through Saturday (or between 2200 and 1300 hours on Sunday).

Preferred Runway

- The instrument/calm runway is 32L.
- 05R is not used unless the wind exceeds ten knots or more, and requests for runway 05R due to aircraft limitations when wind is less than ten knots are restricted to full stops only.

FCLPs and Carrier Controlled Approaches (CCA):

- FCLPS to Runway 5R are prohibited.
- A 600’ pattern (1,000’ at night) is used for FCLPs and a 1,500 foot pattern is used for CCAs left hand pattern. FCLPs to Runway 32L are only conducted after normal school hours.

Multiple Approaches

- Break traffic (overheads), touch-and-go, low approach and practice GCA approaches are not allowed between 2300 and 0700 hours without the prior approval of the Director of Operations.

- Tactical jets not authorized practice approaches at New Bern or Michael J. Smith Airports.

Authorized Hours for Engine Maintenance Power Turn ups

- High Power Turns in run-up areas are restricted to the hours of 0700–2200 Monday – Saturday; 1300–2200 on Sunday.

- The naval aviation depot (NADEP) Hush House is the preferred location for high-power turns for AV-8 aircraft.

5.2 Noise Abatement Procedures MCALF Bogue

Hours of Operation

The airport is normally closed on weekends and holidays.

Noise Sensitive Areas.

- The left traffic pattern to Runway 05 is 1.5 miles abeam to fly outside the White Oak Elementary School at 1,000 feet.

- The downwind is extended until crossing Highway 58 at 1,000 feet, but not over the Town of Cape Carteret.

- AV-8s do not overfly populated areas below 1,000 feet within the Bogue CDSA. This includes Emerald Isle (Bogue Banks), Cape Carteret, Bayshore Park, and Swansboro, NC.

6. Changes in Noise Contours

It must be understood that this noise contour map is a planning tool, not a clear-cut, scientific determination of a drop-in noise threshold at each contour. The change in noise level may be imperceptible within a zone several hundred feet to either side of a particular contour line and can fluctuate with temperature, humidity, wind, and other environmental factors.

A comparison of the prior noise contours for these airports (circa 1988 for MCAS Cherry Point and circa 1981 for MCALF Bogue Field) with the 2001 contours are shown in Figure D-3 and D-4 respectively. While the changes at MCAS Cherry Point show an increase in noise exposure, there is a significant reduction at MCALF Bogue Field from the last AICUZ studies.

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Noise Contours Comparison

— MCAS Cherry Point —

Legend

- Ldn 65 — Noise Contours, 1986
- Ldn 65 — Noise Contours, Current
- Noise Exposure Zone 2 (Ldn 65 to 75)
- Noise Exposure Zone 3 (Ldn greater than 75)
- Runways

Sources:
1. Noise Contours, Current - The Onyx Group and HPE Inc. in association with: Wyle Labs, 2001
2. Noise Contours, 1986 - MCAS Cherry Point Master Plan Update, 1988
3. Base Map - USGS 1:100,000 scale quadrangle map

N 0 6000

Scale: 1" = 6000'

Figure
D-3

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Noise Contours Comparison

— MCALF Bogue —

Legend

- Noise Contours, 1981
- Current Noise Contours
- Noise Exposure Zone 2 (Ldn 65 to 75)
- Noise Exposure Zone 3 (Ldn greater than 75)
- Runways

Sources:
1. Current Noise Contours - The Onyx Group and HPE Inc. in association with: Wyle Labs, 2001
2. Noise Contours, 1981 - Cherry Point Complex Master Plan Update, 1981
3. Base Map - USGS 1:100,000 scale quadrangle map

N 0 6000

Scale: 1" = 6000'

Figure
D-4

E. SAFETY

1. General

In addition to community noise exposure, the potential for aircraft accidents near the military airfield is an important consideration of the AICUZ Program. Although it is impossible to predict an aircraft accident, a rational thought process has been applied in developing AICUZ to establish geographic Accident Potential Zones (APZs). The accident potential concept outlines the probable impact area if an accident occurs, not the probability of an accident occurring.

In planning for the protection of both civilian and military communities, both the Marine Corps and local government share the responsibility to enact reasonable safeguards. This chapter describes both the safety of pilots and their aircraft within the vertical airspace, as well as the protection of life and property on the ground from potential aircraft accidents.

2. Imaginary Surfaces

Aircraft operations are always constrained by the surrounding natural terrain and man-made features such as buildings, towers, poles, and other potential vertical obstructions to navigation. Acceptable limitations to heights of man-made or natural growth are dictated through the application of "imaginary surfaces." These zones radiate at variable, increasing heights from an airfield runway. These height limitations are discussed in both the *Naval Facilities Engineering Command* (*NAVFAC) Document P-80.3* and *Federal Aviation Regulation (FAR), Part 77(14 CFR Part 77) and FAA Advisory Circular 150/5300-13*. Specific criteria are provided for the implementation of:

(1) Primary Surface and Clear Zone Surfaces.

(2) Approach/Departure Clearance Surfaces sloping to the runways.

(3) Horizontal Clearance Surfaces – There are two horizontal clearance surfaces- the inner at an elevation of 150 feet above established airfield elevation extending outward from the runway to 7,500 feet; and the outer at an elevation of 500 feet above the airfield elevation extending outward from the runway 14,500 feet to 44,500 feet.

(4) Conical and other Transitional Surfaces to connect the Horizontal Surfaces to the Approach/Departure Clearance Surfaces and the Primary Surfaces.

In general, no aboveground structures are permitted in the Primary Surface and Clear Zone areas. The height of structures should be controlled to prevent penetration of the transitional surfaces and approach departure surfaces. These height restrictions limit the height of structures as the distance from the runway surface decreases. As one approaches the runway surface and its corresponding flight path, more stringent height limitations are imposed. Figures E-1 and E-2 reflect the imaginary surfaces for MCAS Cherry Point and MCALF Bogue Field. The elevations shown on these figures are elevations in feet above Mean Sea Level (MSL).

There are several airfield safety waivers granted by Naval Air Systems Command (NAVAIRSYSCOM) on Base for MCAS Cherry Point (see Table E-1).

Table E-1
AIRFIELD SAFETY WAIVERS

Waiver	MCAS Cherry Point
CP-1-7	Cancelled
CP-8	Permit Bldg.245 to remain NW of R/W-5-23, which penetrates 7:1 surface by 14.6 feet.
CP-9	Permit Bldg. 188 remain 925' NW of R/W 5-23, which penetrates the 7:1 transitional surface
CP-10	Permit four-(4 foot high) wheels signs on approach ends of all runways 240' off centerlines of R/W.
CP-11	Permit five obstructions marked and lighted windsocks to remain.
CP-12	Permit four crash truck pads to remain (constitute obstructions when occupied)
CP-13	Permit (meteorological equip.) (Structures 3371 & 3372) 750' SW of R/W 32 C/L at 3 locations- ceilometer @ 450' outboard R/W 32 end; 2-15' high transmissometers @ 600' & 1,100' from end.
CP-14	Permit radar reflectors 8 high to remain 500' 0utboard R/W 05/14/23/32.
CP-15	a. Permit power line extending five feet into 50:1 slope on approach end of R/W 5. b. Permit Cunningham Blvd to cross approach zone 1000' on west –2000' on east of end R/W 05
CP-16	Cancelled
CP-17	Permit Turn-Up Blast Fences (Struct. 1846 & 3747) 2,400' inboard R/W 05 end; 750'NW of C/L. Permit power check facility (Structures 3891 and 4276) to remain.
CP-18	Permit rapid refueling pits (structures 3384,3385,3386 &3387) to remain 4000-4800' inboard of end of R/W 05 and 725' NW of R/W centerline.
CP-19	To permit Roosevelt Blvd. Crossing 800' outboard of R/W 14 end to remain and traffic lights 12' high to remain 425' and 1,100' outboard of R/W 14 end and 735' SW & 600' NE of R/W C/L
CP-20	Permit Tetrahedron (Structure 3300) 10' height, 6400' inboard R/W 14 & 700' NE of R/W C/L
CP-21	Permit Bldg. 1788 (Elect. Control Shelter)–15' high to remain 750' SW of C/L at end of R/W 32.
CP-22	Cancelled
CP-23	Permit Bldg. 1799 (112' x 98' x 19'high) remain 675' E of R/W C/L & Bldg. 1791 (139' x 104' x 33' high) 675' W of R/W C/L both approx.3,000' inboard of R/W 19 to remain.
CP-24	To permit two C-9s and one C-130 to park in front of Hanger # 80 and to penetrate the 7:1 transitional surface by 11 ft. and 23 ft. respectively.
CP-26	Permit 190' tower (Structure 3886) approx. 3,500' NW of R/W C/L 22.6' into the inner horizontal
CP-29	Permit AN/FPN-63- 6,682' inboard R/W 05 threshold and 479' SE R/W 5-23 C/L plus four touchdown reflectors (one for each R/W) and 3 parallel reflectors 24' high.
CP-30	Permit air traffic control and landing systems (six shelters/antennas)
CP-31	Permit tower for automated surface observing system sensor, 300' out bound of R/W 32 (48' into the transitional surface)
CP-32	Permit air traffic control of lighting systems (five antennas/shelters)

Source MCAS Cherry Point Master Plan 1988/MCAS CP FACDEV

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Imaginary Surfaces

— MCAS Cherry Point —

Outer Horizontal Surface
Elev. 529 ft MSL

Inner Horizontal Surface
Elev. 179 ft MSL

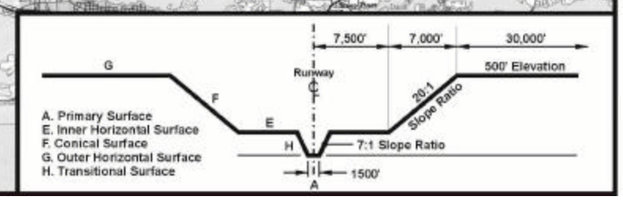
Approach / Departure Surfaces

Conical Surface

Primary Surface
Elev. 29 ft MSL

Transitional Surfaces

Clear Zones



Sources:
1. Imaginary Surfaces - The Onyx Group 2000
2. Base Map - USGS, 1:100,000 scale quad

N 0 16000

Scale: 1" = 16000'

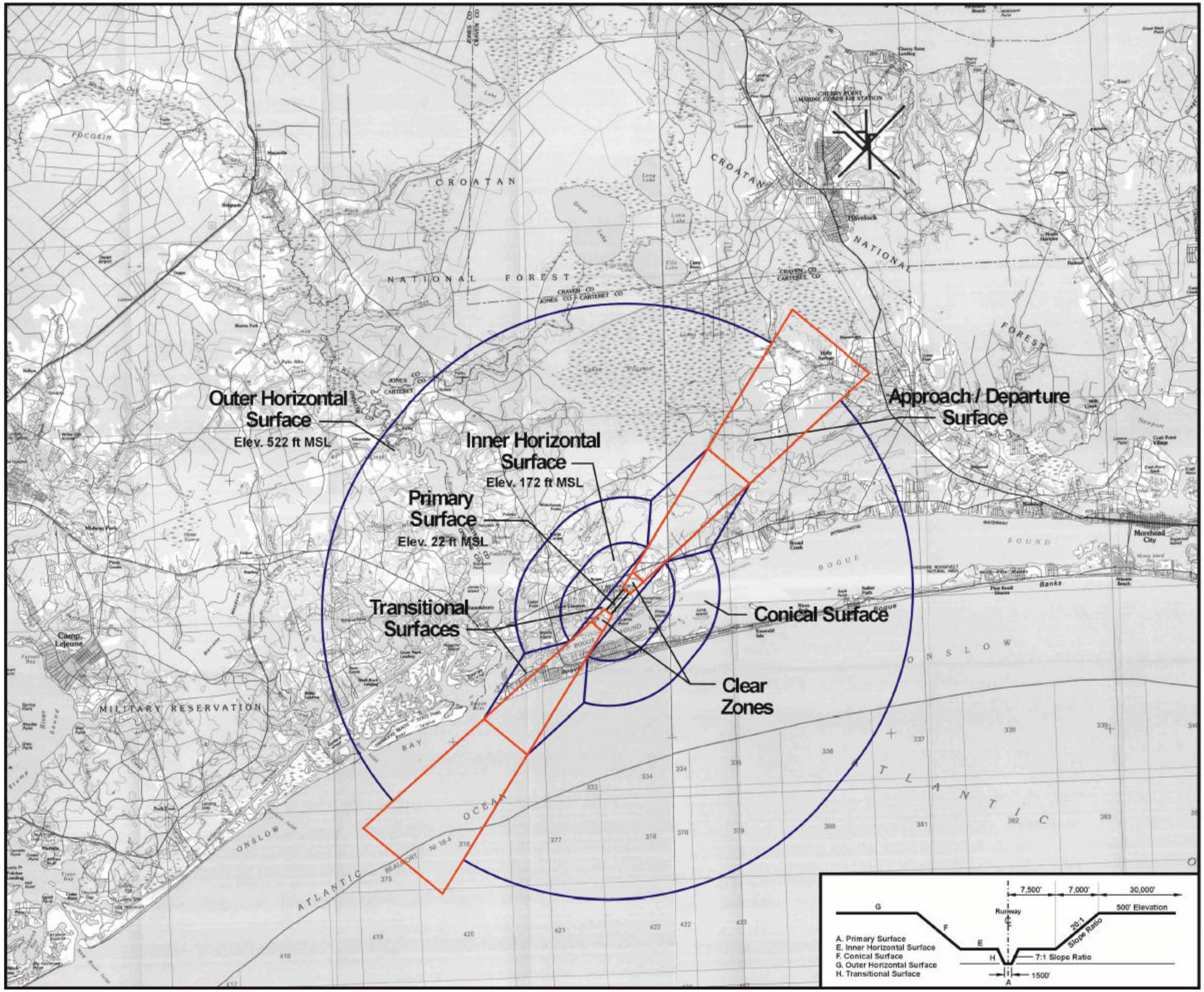
Figure
E-1

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Imaginary Surfaces

— Bogue Field —



Sources:
1. Imaginary Surfaces - The Onyx Group and HPE Inc., 2000
2. Base Map - USGS, 1:100,000 scale quad

N 0 16000

Scale: 1" = 16000'

Figure
E-2

3. Accident History

Previous AICUZ documents contained historical information on accidents as well. Since 1964 there have been fifty (50) accidents reported for MCAS Cherry Point, thirty-five (35) of which were on base, nine (9) of which were within five (5) NM and six (6) of which were beyond five (5) NM. An additional total of seventeen (17) accidents were associated with operations at Bogue Field, thirteen (13) of which were on base and four (4) of which were within five (5) NM. Accident locations in the airfield environs are shown in Figure E-3 for Cherry Point and Figure E-4 Bogue.

4. Accident Potential Zones

Accident Potential Zones (APZs) are based on historical accident and operations data throughout the military, and the application of margins of safety within those areas (which have been determined to be probable impact areas), if an accident were to occur. The APZs are based upon criteria found in *OPNAVINST 11010.36A*.

DOD fixed-wing runways are separated into two classes for the purpose of defining Accident Potential Zones. Class A runways are used primarily by light aircraft and do not have the potential for intensive use by heavy or high performance aircraft. Class B runways are all other fixed-wing runways. The concurrence of the Naval Air Systems Command and the Naval Facilities Engineering Command as well as the approval of the Office of the Chief of Naval Operations is required prior to classifying or reclassifying any runway. MCAS Cherry Point and MCALF Bogue Field Runways are designated as Class B. The U.S. Navy and Marine Corps recognize three APZs for Class B runways: The Clear Zone, APZ I, and APZ II, which are defined in *OPNAVINST 11010.36A*, as follows:

(a) Clear Zone (CZ)- The trapezoidal area lying immediately beyond the end of the runway and outward along the extended runway centerline for a distance of 3,000 feet. For U.S. Navy and Marine Corps installations, the dimensions are 1,500 feet in width at the runway threshold and 2,284 feet in width at the outer edge. The Clear Zone is required for all active runway ends.

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

(c) Accident Potential Zone II (APZ II)- The rectangular area beyond APZ I (or Clear Zone if APZ I is not used), which has a measurable potential for aircraft accidents relative to APZ I or the Clear Zone. APZ II is always provided where APZ I is required. The dimensions of APZ II are typically 3,000 feet wide by 7,000 feet in length, and as with APZ I, may be curved to correspond with the predominant flight track.

5. Changes in Accident Potential Zones

The APZs at MCAS Cherry Point and MCALF Bogue Field are based on fixed-wing criteria and were adjusted to reflect the changes in operations levels, runway and flight paths usage as reflected in the 1998 Noise Survey.

5.1 Changes in APZs at MCAS Cherry Point

There are sufficient air operations reflected in the 1998 Noise Survey to warrant retention of many of the APZ configurations included in the 1988 AICUZ for MCAS Cherry Point. Certain differences are evident in review of Figure E-5. Since a predominate use is made of the Harrier (VSTOL) Pads at MCAS Cherry Point, Clear Zones were shown for each to reflect this criteria. Similarly, Clear Zones were shown at the outboard ends of each runway consistent with the 1988 study. However, the APZs beyond the Clear Zones are shown differently due to change in flight pattern and runway usage between the 1988 AICUZ and today. The straight APZ I and APZ II are shown on the approach end of 32L recognizing the predominate use of this runway. The APZ I and APZ II on the departure end of runways 23L and 32R now curves to follow the predominate flight path usage of 3LD3 and 2RD3 respectively. Since, the majority of arrivals are break approaches to the runway and other extenuating circumstances do not appear to exist which would result in including straight out APZs on the approach ends of 23R or14L recognizing the altitudes of these over flights in what would be the outer APZ areas. Curved APZs are also depicted on patterns 2LF1 and 3RF1 reflecting the operational levels in those areas.

5.2 Changes in APZs at MCALF Bogue

A review of Figure E-6 shows the changes in APZs at Bogue Field. The prior (1981) APZs reflect the curved rectangular shaped APZs contained in the1979 Navy AICUZ Criteria. Subsequent to the development of the 1981 APZs for this airfield (contained in the 1981 AICUZ update), a change in AICUZ criteria occurred regarding APZs for FCLP operations. This criteria was published in OPNAVINST 11010.36A on 11 April 1988. As noted previously, when the Cherry Point AICUZ was updated in 1988 the operations at MCALF Bogue were not seen as sufficiently different from those outlined in 1981 to warrant an update in 1988. Since the majority of operations at Bogue Field are FCLP practice by the AV-8B Harrier, the criteria outline in the current (1988) AICUZ Instruction and the operations outlined in the 1998 Airfield and Airspace Operational Study and the 1998 Wyle Noise Study were reflected in the APZs for the current AICUZ update. Current criteria for APZs related to FCLP operations provide for the APZ II to be extended from the ends the APZ I to form the closed APZ (race track) area shown. While there are two FCLP flight patterns shown in the latest noise study, the APZ is aligned with the predominantly used flight pattern.

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Accident Potential Zones (APZ)

— MCAS Cherry Point —

Legend

- Clear Zone
- APZ I
- APZ II
- Airfield and Runways
- MCAS Cherry Point
- Accident Locations

Sources:
1. APZs - The Onyx Group and HPE Inc., 2000
2. Base Map - USGS, 1:100,000 scale quad
3. Cherry Point Complex Master Plan 1981

N 0 6000

Scale: 1" = 6000'

Figure
E-3

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Accident Potential Zones (APZ)

— MCALF Bogue —

Legend

- Clear Zone
- APZ I
- APZ II
- Runway
- MCALF Bogue
- Accident Locations

Sources:
1. APZs - The Onyx Group and HPE Inc., 2000
2. Base Map - USGS, 1:100,000 scale quad
3. Cherry Point Complex Master Plan 1981

N

0 6000

Scale: 1" = 6000'

Figure
E-4

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Accident Potential Zones (APZs) Comparison

— MCAS Cherry Point —

Legend

- Clear Zone
- APZ I
- APZ II
- MCAS Cherry Point
- 1988

Sources:
1. APZs - The Onyx Group and HPE Inc., 2000
2. APZs 1988 Master Plan MCAS Cherry Point 1988
3. Base Map - USGS, 1:100,000 scale quad

N 0 6000

Scale: 1" = 6000'

Figure
E-5

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Accident Potential Zones (APZ) Comparison

— MCALF Bogue —

Legend

- Clear Zone
- APZ I
- APZ II
- Runway
- MCALF Bogue
- 1981 APZs

Sources:
1. APZs - The Onyx Group and HPE Inc., 2000
2. APZs Cherry Point Complex Master Plan 1980/1981
3. Base Map - USGS, Swansboro 1:24000 scale quad

N 0 6000

Scale: 1" = 6000'

Figure
E-6

F. AICUZ

1. AICUZ Area

The AICUZ footprint is a combination of noise impact and Accident Potential Zones (APZs). The superimposed noise exposure levels and APZ boundaries create twelve potential subzones within an AICUZ footprint. As shown in Table F-1, these subzones contain various combinations of noise and accident potential exposure.

TABLE F-1

AICUZ COMPOSITE SUBZONES

Accident Potential	Noise Zones		
	1 Below 65 Ldn	**2** 65-75 Ldn	**3** Above 75 Ldn
Primary Surface / Clear Zone	CZ	CZ	CZ
APZ I	I-1	I-2	I-3
APZ II	II-1	II-2	II-3
Outside APZs	1	2	3

The areas of Primary Surface / Clear Zone (designated as CZ), include the areas along the runway and at the runway ends along the primary flight paths. These areas can exist in conjunction with Noise Zones 1, 2, or 3. Although due to the proximity to the runway, they are normally found in conjunction with the highest noise exposure. These areas have the greatest potential for the occurrence of aircraft accidents and should remain undeveloped. They are all designated as CZ.

APZ I is found in areas beyond the Clear Zone, which still possesses a measurable potential for accidents relative to the Clear Zone. These areas can exist in conjunction with Noise Zones 1, 2, or 3. The combinations of noise and accident potential are shown as I-3 (APZ I-Noise Zone 3) for the highest combination of noise and accident potential, I-2 (APZ I-Noise Zone 2) for areas of moderate noise exposure and measurable accident potential, and I-1 (APZ I-Noise Zone 1) for areas of measurable accident potential and low noise exposure. These areas have potential for accidents and noise impacts and land use controls are recommended in these areas.

APZ II is an area beyond APZ I, which has a measurable potential for aircraft accidents relative to APZ I or the Clear Zone. APZ II areas can exist in conjunction with Noise Zones 1, 2, or 3. These combinations of noise and accident potential are shown as II-3 (APZ II–Noise Zone 3) for the areas of highest noise exposure and measurable accident potential, II-2 (APZ II-Noise Zone 2) for areas of moderate noise exposure and measurable accident potential, and II-1 (APZ II-

Noise Zone 1) for areas of measurable accident potential and low noise exposure. These areas have potential for accidents and noise impacts and land use controls are recommended.

Noise zones vary in intensity of noise exposure and are shown as 1, 2, and 3 in the table. Noise Zone 1 (less than 65 Ldn) is an area of low impact (although some people in these areas may be annoyed by aircraft over flights), Noise Zone 2 (Ldn 65-75) is an area of moderate impact where some land use controls are needed, and Noise Zone 3 (Ldn 75 and above) is the most severely impacted area and requires the greatest degree of land use controls for noise exposure.

Figure F-1 AICUZ Footprint shows the composite AICUZ for MCAS Cherry Point and Figure F-2 -AICUZ Footprint MCALF Bogue shows the Composite AICUZ for that airport.

2. Land Use Suitability within the AICUZ

Compatible land use objectives are derived from the suggested land use compatibility tables for noise and APZs. To find the recommended suitability of a particular land use for any AICUZ subzone, locate that use on both the noise and APZ Suggested Land Use Compatibility Tables (Tables F-2 and F-3). Both tables apply, and where conflicting guidance appears, the more restrictive criteria take precedence.

3. Land Use Compatibility in Accident Potential Zones

Table F-2, "Suggested Land Use Compatibility in Accident Potential Zones" outlines these suggestions for land areas within the APZ designations for these air activities. Within the individual APZ, the specific land uses are labeled either "Y" (Yes) for compatible, often with footnoted restrictions; or "N" (No) for not compatible (meaning those land uses should be prohibited). Application of these guidelines will increase the safety of the general public but cannot provide complete protection from aircraft accidents. The recommendations are aimed at limiting the numbers or concentrations of people exposed in areas having a measurable potential for accidents near an airfield.

4. Land Use Compatibility in Noise Zones

The federal government has developed guidelines for land uses, which are acceptable within noise zones. These guidelines are contained in the Federal Interagency Committee on Urban Noise *Guidelines for Considering Noise in Land Use Planning and Control* (June 1980). This document is used by the DOD, Department of Transportation (DOT), Environmental Protection Agency (EPA), Housing and Urban Development (HUD), and the Bureau of Veterans Affairs (VA).

Standard Federal Guidelines (from *OPNAVINST 11010.36A*) for Suggested Land Use Compatibility in Noise Zones are shown in Table F-3. Within these noise zones, specific land uses are either labeled "Y" (yes); "Y*" (yes with footnoted restrictions) or "N" (no) for not compatible (meaning these land uses should be prohibited). These guidelines are aimed at reducing noise sensitive uses in high and moderate noise areas, or mitigating the impacts where possible.

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

AICUZ Footprint

— MCAS Cherry Point —

Legend

	Clear Zones	APZ I	APZ II	
Noise Zone 1 (< 65 LDN)	CZ	I-1	II-1	
Noise Zone 2 (65-75 LDN)	CZ	I-2	II-2	2
Noise Zone 3 (> 75 LDN)	CZ	I-3	N/A	3

AICUZ Footprint, 2001

Sources:
1. APZs - The Onyx Group and HPE Inc. in association with: Wyle Labs, 1999
2. Noise Contours - The Onyx Group and HPE Inc. in association with: Wyle Labs, 2001
3. Base Map - USGS 1:100,000 scale quadrangle map

N 0 6000

Scale: 1" = 6000'

Figure
F-1

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

AICUZ Footprint

— MCALF Bogue —

Legend

Noise Zone	Clear Zones	APZ I	APZ II	
Noise Zone 1 (< 65 LDN)	CZ	I	II-1	
Noise Zone 2 (65-75 LDN)	CZ	I-2	II-2	2
Noise Zone 3 (> 75 LDN)	CZ	I-3	II-3	3

AICUZ Footprint, 2001

Sources:
1. APZs - The Onyx Group and HPE Inc., 2000
2. Noise Contours - The Onyx Group and HPE Inc. in association with: Wyle Labs, 2001
3. Base Map - USGS, 1:100,000 scale quad

N 0 6000

Scale: 1" = 6000'

Figure
F-2

5. Changes in Land Use Compatibility

The previous versions of guidelines for land use compatibility described general land use categories and four classifications of compatibility. These previous classes were: Clearly Acceptable, Normally Acceptable, Normally Unacceptable, and Clearly Unacceptable.

The former charts were general in nature, and in response to local government requests for more detailed land use criteria, Marine Corps guidance set forth in *OPNAVINST 11010.36A* now includes a more detailed version of the federal land use compatibility guidelines. The terms "Normally Acceptable" and "Normally Unacceptable" have been replaced and the listing of land uses has been expanded. These more precise guidelines also include a detailed listing of land uses and are reflected in this Update.

6. Application of the Guidelines

The *Federal Land Use Planning Guidelines* contained in this study are nationwide in scope. Since many air installations are in urban areas, these guidelines assume an urban environment with higher levels of ambient "background" noise than exists in rural or suburban areas. These compatibility guidelines are, therefore, sometimes modified at the local government level to address a specific local noise environment.

The City of Havelock, as well as Craven, and Carteret Counties have partially addressed established AICUZ guidelines within their planning and regulatory processes in the past. The *City of Havelock Zoning Ordinance* adopted July 29,1975 established zoning regulations for the city within its incorporated limits and extraterritorial jurisdiction. The city has adopted a highway commercial-air installation compatible use zone (HC-AICUZ) and light industrial-air installation compatible use zone (LI-AICUZ) as part of its zoning ordinance. These two zones address special considerations for lands in APZ-1 and APZ-2 as identified in MCAS Cherry Point's AICUZ Program. The City also requires issuance of a *Disclosure Statement* as part of property sales for properties located within the AICUZ.

Craven County does not have county wide zoning; however, in 1989 the County adopted as Appendix D of the Craven County Code, a Marine Corps Air Station Zoning Ordinance convening the areas of APZ 1 and APZ 2 of Runways 23 and 32 east of the airport. The ordinance addresses the County's land use objectives, conditions for development, and limitations to development for lands within APZs and noise zones. Craven County has also included the requirement for a *Disclosure Statement* in this Ordinance.

The *Zoning Ordinance for Carteret County*, adopted June 15, 1990, covers the area surrounding MCALF Bogue Field, which are not within areas that have been incorporated, unless the cities contract with the County for planning, zoning, and building inspection services.

Table F-4, which incorporates suggestions from Tables F-2 and F-3, outlines Land Use Compatibility suggestions for the AICUZ areas at MCAS Cherry Point and MCALF Bogue Field shown in Figure F-1 and Figure F-2 respectively.

TABLE F-2

SUGGESTED LAND USE COMPATIBILITY IN ACCIDENT POTENTIAL ZONES

(Source OPNAVINST 11010.36A)

SLUCM No.	LAND USE NAME	CLEAR ZONE	APZ-I	APZ-II
10	***Residential***			
11	Household units			
11.11	Single units; detached	N	N	Y[1]
11.12	Single units; semidetached	N	N	N
11.13	Single units; attached row	N	N	N
11.21	Two units; side-by-side	N	N	N
11.22	Two units; one above the other	N	N	N
11.31	Apartments; walk up	N	N	N
11.32	Apartments; elevator	N	N	N
12	Group quarters	N	N	N
13	Residential hotels	N	N	N
14	Mobile home parks or courts	N	N	N
15	Transient lodgings	N	N	N
16	Other residential	N	N	N
20	***Manufacturing***			
21	Food & kindred products manufacturing	N	N[2]	Y
22	Textile mill products manufacturing	N	N[2]	Y
23	Apparel and other finished products made from fabrics, leather, and similar materials manufacturing	N	N	N[2]
24	Lumber and wood products (except furniture); manufacturing	N	Y[2]	Y
25	Furniture and fixtures manufacturing	N	Y[2]	Y
26	Paper & allied products manufacturing	N	Y[2]	Y
27	Printing, publishing, and allied industries	N	Y[2]	Y
28	Chemicals and allied products; manufacturing	N	N	N[2]
29	Petroleum refining and related industries	N	N	N
30	***Manufacturing (cont'd)***			
31	Rubber and misc. plastic products; manufacturing	N	N[2]	N[2]
32	Stone, clay and glass products; manufacturing	N	N[2]	Y

TABLE F-2

SUGGESTED LAND USE COMPATIBILITY IN ACCIDENT POTENTIAL ZONES

(Continued)

SLUCM No.	LAND USE NAME	CLEAR ZONE	APZ-I	APZ-II
33	Primary metal industries	N	N[2]	Y
34	Fabricated metal products manufacturing	N	N[2]	Y
35	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks manufacturing	N	N	N[2]
39	Miscellaneous manufacturing	N	Y[2]	Y[2]
40	***Transportation, communications and utilities***			
41	Railroad, rapid rail transit and street railway transportation	N[3]	Y[4]	Y
42	Motor vehicle transportation	N[3]	Y	Y
43	Aircraft transportation	N[3]	Y[4]	Y
44	Marine craft transportation	N[3]	Y[4]	Y
45	Highway & street right of way	N[3]	Y	Y
46	Automobile parking	N[3]	Y[4]	Y
47	Communication	N[3]	Y[4]	Y
48	Utilities	N[3]	Y[4]	Y
49	Other transportation, communication and utilities	N[3]	Y[4]	Y
50	***Trade***			
51	Wholesale trade	N	Y[2]	Y
52-	Retail trade - building materials, hardware and farm equipment	N	Y[2]	Y
53	Retail trade - general merchandise	N	N[2]	Y[2]
54	Retail trade - food	N	N[2]	Y[2]
55	Retail trade automotive, marinecraft, aircraft and accessories	N	Y[2]	Y
56	Retail trade - apparel and accessories	N	N[2]	Y[2]
57	Retail trade - furniture, home furnishings and equipment	N	N[2]	Y[2]
58	Retail trade - eating and drinking establishments	N	N	N[2]
59	Other retail trade	N	N[2]	Y[2]

TABLE F-2
SUGGESTED LAND USE COMPATIBILITY IN ACCIDENT POTENTIAL ZONES
(Continued)

SLUCM No.	LAND USE NAME	CLEAR ZONE	APZ-I	APZ-II
60	***Services***			
61	Finance, insurance and real estate services	N	N	Y[6]
62	Personal services	N	N	Y[6]
62.4	Cemeteries	N	Y[7]	Y[7]
63	Business services .	N	Y[8]	Y[8]
64	Repair services	N	Y[2]	Y
65	Professional services	N	N	Y[6]
65.1	Hospitals, nursing homes	N	N	N
65.1	Other medical facilities	N	N	N
66	Contract construction	N	Y[6]	Y
67	Governmental services	N	N	Y[6]
68	Educational services	N	N	N
69	Miscellaneous services	N	N[2]	Y[2]
70	***Cultural, Entertainment and Recreational***			
71	Cultural activities (including churches)	N	N	N[2]
71.2	Nature exhibits	N	Y[2]	Y
72	Public assembly	N	N	N
72.1	Auditoriums, concert halls	N	N	N
72.11	Outdoor music shells, amphitheaters	N	N	N
72.2	Outdoor sports, spectator sports	N	N	N
73	Amusements	N	N	Y[8]
74	Recreational activities (Incl. Golf courses, riding stables. Water recreation)	N	Y[8,9,10]	Y
75	Resorts and group camps	N	N	N
76	Parks	N	Y[8]	Y[8]
79	Other cultural, entertainment and recreation	N	Y[9]	Y[9]
80	***Resource production and extraction***			
81	Agriculture (except live-stock)	Y	Y	Y
81.5 81.7	Livestock farming and animal breeding	N	Y	Y
82	Agricultural related activities	N	Y[5]	Y
83	Forestry activities and related services	N[5]	Y	Y
84	Fishing activities and related services	N[5]	Y[5]	Y
85	Mining activities and related services	N	Y[5]	Y
89	Other resource production and extraction	N	Y[5]	Y

NOTES TO TABLE F-2

The notation of Y (Yes), Y^x (Yes see note), N (No), N^x (No but see notes below) designation for compatible land use is to be used only for gross comparison. Within each, uses exist where further definition may be needed as to whether it is clear or normally acceptable/ unacceptable owing to variations in densities of people and structures.

1. Suggested maximum density 1-2 dwelling units per acre, possibly increased under a Planned Unit Development (PUD) where maximum lot coverage is less than 20 percent.

2. Within each land use category, uses exist where further evaluation may be needed due to the variation of densities of people and structures. For example, where a small neighborhood retail store may be compatible in APZ-II, a shopping center or strip shopping mall would be incompatible due to the density of development and concentration of people.

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 *NAVFAC P-80.3* 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., not recommended.

7. Excludes chapels.

8. Facilities must be low intensity.

9. Clubhouse not recommended.

10. Large classes not recommended.

TABLE F-3.
SUGGESTED LAND USE COMPATIBILITY IN NOISE ZONES
(Source OPNAVINST 11010.36A)

LAND USE		NOISE ZONES DNL Levels in Ldn						
SLUCM		1		2			3	
NO.	NAME	0-55	55-65	65-70	70- 75	75-80	80-85	85+
10	***Residential***							
11	*Household units*							
11.11	Single units detached	Y	Y*	25[1]	30[1]	N	N	N
11.12	Single units; semidetached	Y	Y*	25[1]	30[1]	N	N	N
11.13	Single units; attached row	Y	Y*	25[1]	30[1]	N	N	N
11.21	Two units; side-by-side	Y	Y*	25[1]	30[1]	N	N	N
11.22	Two units; one above the other	Y	Y*	25[1]	30[1]	N	N	N
11.31	Apartments; walk up	Y	Y*	25[1]	30[1]	N	N	N
11.32	Apartments; elevator	Y	Y*	25[1]	30[1]	N	N	N
12	Group quarters	Y	Y*	25[1]	30[1]	N	N	N
13	Residential hotels	Y	Y*	25[1]	30[1]	N	N	N
14	Mobile home parks or courts	Y	Y*	N	N	N	N	N
15	Transient lodgings	Y	Y*	25[1]	30[1]	35[1]	N	N
16	Other residential	Y	Y*	25[1]	30[1]	N	N	N
20	***Manufacturing***							
21	Food ~ kindred products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
22	Textile mill products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
23	Apparel and other finished products made from fabrics, leather, and similar materials; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
24	Lumber and wood products (except furniture); manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
25	Furniture and fixtures; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
26	Paper & allied products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
27	Printing, publishing, and allied industries	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
28	Chemicals and allied products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
29	Petroleum refining and related industries	Y	Y	Y	Y[2]	Y[3]	Y[4]	N

* The designation of these uses as "compatible" in this Zone reflects individual federal agencies' 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 (*Guidelines for Considering Noise in Land Use Planning and Control*, June 1980).

TABLE F-3.
SUGGESTED LAND USE COMPATIBILITY IN NOISE ZONES
(Continued)

LAND USE		NOISE ZONES DNL Levels in Ldn						
SLUCM		1		2		3		
NO.	NAME	0-55	55-65	65-70	70-75	75-80	80-84	85+
30	***Manufacturing (cont'd)***							
31	Rubber and misc. plastic products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
32	Stone, clay and glass products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
33	Primary metal industries	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
34	Fabricated metal products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
35	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks manufacturing	Y	Y	Y	25	30	N	N
39	Miscellaneous manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
40	***Transportation, communication and utilities***							
41	Railroad, rapid rail transit and street railway transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
42	Motor vehicle transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
43	Aircraft transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
44	Marine craft transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
45	Highway & street right-of way	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
46	Automobile parking	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
47	Communication	Y	Y	Y	25[5]	30[5]	N	N
48	Utilities	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
49	Other transportation, communication and utilities	Y	Y	Y	25[5]	30[5]	N	N
50	***Trade***							
51	Wholesale trade	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
52	Retail trade – building materials, hardware and farm equipment	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
53	Retail trade – general merchandise	Y	Y	Y	25	30	N	N
54	Retail trade – food	Y	Y	Y	25	30	N	N
55	Retail trade – automotive, marine craft, aircraft and accessories	Y	Y	Y	25	30	N	N
56	Retail trade – apparel and accessories	Y	Y	Y	25	30	N	N
57	Retail trade – furniture, home furnishings and equipment	Y	Y	Y	25	30	N	N
58	Retail trade – eating and drinking establishments	Y	Y	Y	25	30	N	N
59	Other retail trade	Y	Y	Y	25	30	N	N

TABLE F-3.
SUGGESTED LAND USE COMPATIBILITY IN NOISE ZONES
(Continued)

LAND USE		NOISE ZONES DNL Levels in Ldn						
SLUCM		1			2		3	
NO.	NAME	0-55	55-65	65-70	70-75	75-80	80-85	85+
60	***Services***							
61	Finance, insurance and real estate services	Y	Y	Y	25	30	N	N
62	Personal services	Y	Y	Y	25	30	N	N
62.4	Cemeteries	Y	Y	Y	Y[2]	Y[3]	Y[4,11]	Y[6,11]
63	Business services	Y	Y	Y	25	30	N	N
64	Repair services	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
65	Professional services	Y	Y	Y	25	30	N	N
65.1	Hospitals, nursing homes	Y	Y*	25*	30*	N	N	N
65.1	Other medical facilities	Y	Y	Y	25	30	N	N
66	Contract construction services	Y	Y	Y	25	30	N	N
67	Governmental services	Y	Y*	Y*	25*	30*	N	N
68	Educational services	Y	Y*	25*	30*	N	N	N
69	Miscellaneous services	Y	Y	Y	25	30	N	N
70	***Cultural, entertainment and recreational***							
71	Cultural activities (including churches)	Y	Y*	25*	30*	N	N	N
71.2	Nature exhibits	Y	Y*	Y*	N	N	N	N
72	Public assembly	Y	Y	Y	N	N	N	N
72.1	Auditoriums, concert halls	Y	Y	25	30	N	N	N
72.11	Outdoor music shells, amphitheaters	Y	Y*	N	N	N	N	N
72.2	Outdoor sports, spectator sports	Y	Y	Y[7]	Y[7]	N	N	N
73	Amusements	Y	Y	Y	Y	N	N	N
74	Recreational activities (incl. Golf courses, riding stables, water recreation)	Y	Y*	Y*	25*	30*	N	N
75	Resorts and group camps	Y	Y*	Y*	Y*	N	N	N
76	Parks	Y	Y*	Y*	Y*	N	N	N
79	Other cultural, entertainment and recreation	Y	Y*	Y*	Y*	N	N	N
80	***Resource production and extraction***							
81	Agriculture (except live-stock)	Y	Y	Y[8]	Y[9]	Y[10]	Y[10,11]	Y[10,11]
81.5 81.7	Livestock farming and animal breeding	Y	Y	Y[8]	Y[9]	N	N	N
82	Agricultural related activities	Y	Y	Y[8]	Y[9]	Y[10]	Y[10,11]	Y[10,11]
83	Forestry activities and related services	Y	Y	Y[8]	Y[9]	Y[10]	Y[10,11]	Y[10,11]
84	Fishing activities and related services	Y	Y	Y	Y	Y	Y	Y

TABLE F-3.
SUGGESTED LAND USE COMPATIBILITY IN NOISE ZONES
(Continued)

LAND USE		NOISE ZONES DNL Levels in Ldn						
SLUCM		1		2			3	
NO.	NAME	0-55	55-65	65-70	70-75	75-80	80-85	85+
85	Mining activities and related services	Y	Y	Y	Y	Y	Y	Y
89	Other resource production and extraction	Y	Y	Y	Y	Y	Y	Y

NOTES FOR TABLE F-3

1.

a) Although local conditions regarding the need for housing may require residential use in these zones, residential use is discouraged in DNL 65-70 and strongly discouraged in DNL 70-75. The absence of viable alternative development options should be determined and an evaluation should be conducted prior to approvals indicating that a demonstrated community need for the residential use would not be met if development were prohibited in these zones.

b) Where the community determines that residential uses must be allowed, measures to achieve outdoor to indoor Noise Level Reduction (NLR) of at least 25 dB (DNL 65-70) and 30 dB (DNL 70-75) should be incorporated into building codes and be considered in individual approvals. Normal construction can be expected to provide a NLR of 20 dB, thus the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year round. Additional consideration should be given to modifying NLR levels based on peak noise levels or vibrations.

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

2. Measures to achieve NLR of 25 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.

3. Measures to achieve NLR of 30 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.

4. Measures to achieve NLR of 35 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.

5. If project or proposed development is noise sensitive, use indicated NLR; if not, land use is compatible without NLR.

6. No buildings.

7. Land use compatible provided special sound reinforcement systems are installed.

8. Residential buildings require a NLR of 25

9. Residential buildings require a NLR of 30.

10. Residential buildings not permitted.

11. Land use not recommended, but if community decides use is necessary, personnel should wear hearing protection devices.

KEY TO TABLE F-3

SLUCM	Standard Land Use Coding Manual
Y (Yes)	Land Use and related structures compatible without restrictions.
N (No)	Land Use and related structures are not compatible and should be prohibited.
NLR (Noise Level Reduction)	Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.
Y^x (Yes with restrictions)	Land Use and related structures generally compatible; see notes-1 through 11.
25, 30, or 35	The numbers refer to Noise Level Reduction levels. Land Use and related structures generally compatible; measures to achieve NLR of 25, 30 or 35 must be incorporated into design and construction of structure.
25*, 30* or 35*	The numbers refer to Noise Level Reduction levels. Land Use generally compatible with NLR; however, measures to achieve an overall noise reduction do not necessarily solve noise difficulties and additional evaluation is warranted.
DNL	Day-Night Average Sound Level.
Ldn	Mathematical symbol for DNL.

Table F-4.
SUGGESTED LAND USE RESTRICTIONS IN AICUZ ZONES

	LAND USE	AICUZ ZONE* (APZ –Noise Zone)								
SLUCM	CATEGORY	**CZ**	**I-3**	**I-2**	**I-1**	**II-3**	**II-2**	**II-1**	**3**	**2**
CODE										
	1. RESIDENTIAL									
11.1	SINGLE FAMILY						1,2	2		2
11.2	TWO-FOUR FAMILY									2
11.3	MULTI-FAMILY APARTMENTS									2
12	GROUP QUARTERS									2
13	RESIDENTIAL HOTELS									2
14	MOBILE HOME PARKS/COURTS									2
15	TRANSIENT LODGING								3	2
	2. And 3. MANUFACTURING									
21	FOOD & KINDRED PRODUCTS					4	5		4	5
22	TEXTILE MILL PRODUCTS					4	5		4	5
23	APPAREL & SIMILAR PRODUCTS					4	5		4	5
24	LUMBER & WOOD PRODUCTS		4	5		4	5		4	5
25	FURNITURE & FIXTURES		4	5		4	5		4	5
26	PAPER & ALLIED PRODUCTS		4	5		4	5		4	5
27	PRINTING & PUBLISHING		4	5		4	5		4	5
28	CHEMICALS & ALLIED PRODUCTS								4	5
29	PETROLEUM REFINING & RELATED IND.								4	5
31	RUBBER & PLASTIC PRODUCTS		4	4	4	4	5		4	5
32	STONE, CLAY GLASS		4	4	4	4	5		4	5
33	PRIMARY METAL INDUSTRIES		4	4	4	4	5		4	5
34	FABRICATED METAL PRODUCTS		4	4	4	4	5		4	5
35	PROF. & SCIENTIFIC INSTRUMENTS						4		4	5
	4. TRANSPORTATION, COMMUNICATION & UTILITIES									
41	RR, AND RAIL TRANSPORTATION									
42	MOTOR VEHICLE TRANSPORTATION									
44	MARINE CRAFT TRANSPORTATION									
45	HWY. & STREET RIGHT-OF-WAY									
46	AUTOMOBILE PARKING									
47	COMMUNICATIONS		4	5		4	5		4	5
48	UTILITIES	6								
49	Other Trans./Comm.& Util. (Including landfills)		16	16	16	16	16	16	16	16

	NO NEW DEVELOPMENT
1-16*	RESTRICTED NEW DEVELOPMENT
	NO RESTRICTIONS

* See notes on page following this chart

Table F-4
LAND USE RESTRICTIONS IN AICUZ ZONES
(cont.)

LAND USE		AICUZ ZONE* (APZ –Noise Zone)								
SLUCM CODE	CATEGORY	**CZ**	**I-3**	**I-2**	**I-1**	**II-3**	**II-2**	**II-1**	**3**	**2**
	5. TRADE									
51	WHOLESALE TRADE		7	8					7	8
52	RETAIL TRADE-BLDG., MRLS, HDW. &					7	8		7	7
	FARM EQUIPMENT									
53	RETAIL TRADE – GEN. MDSE.					7	8		7	8
54	RETAIL TRADE – FOOD					7	8		7	8
55	RETAIL TRADE – AUTO., MARINE CRAFT					7	8		7	8
	AIRCRAFT					7	8		7	8
56	RETAIL TRADE – APPAREL & ASSESS.					7	8		7	8
57	RETAIL TRADE – FURN., HOME FURN., &					7	8		7	8
	EQUIPMENT									
58	RETAIL TRADE – EATING & DRINKING					7	8		7	8
	6. SERVICES									
61	FINANCE, INS. & REAL EST. SERVICES					7	8		7	8
62	PERSONAL SERVICES					7	8		7	8
63	BUSINESS SERVICES					7	8		7	8
64	REPAIR SERVICES					7	8		7	8
651	MEDICAL & HEALTH SERVICES								7	8
652-9	PROFESSIONAL SERVICES					7	8		7	8
66	CONTRACT CONSTRUCTION SERVICES					7	8		7	8
671	GOVERNMENT OFFICES						8		7	8
674	CORRECTIONAL INSTITUTIONS									8
68	EDUCATION SERVICES									7
691	RELIGIOUS ACTIVITIES								3	8
	7. CULTURAL ENTERTAINMENT AND RECREATION									
711	CULTURAL ACTIVITIES									7
712	NATURE EXHIBITS			11		11			11	11
721	ENTERTAINMENT ASSEMBLY									
722	SPORTS ASSEMBLY								11	11
723	PUBLIC ASSEMBLY (AUDITORIUMS)								3	7
73	AMUSEMENTS (OUTDOORS)									
741	SPORTS ACTIVITIES		12	12	12	12	12	12		
743-4	WATER BASED ACTIVITIES		12	12	12	12	12	12	11	
75	RESORTS & GROUP CAMPS								11	
761	PLAYGROUNDS & NEIGHBORHOOD PARKS						9	9		
762-4	COMMUNITY PARKS		10	10	10	10	10	10		

	NO NEW DEVELOPMENT
1-16*	RESTRICTED NEW DEVELOPMENT
	NO RESTRICTIONS

* See notes on page following this chart.

Table F-4
LAND USE RESTRICTIONS IN AICUZ ZONES
(cont.)

	LAND USE	AICUZ ZONE* (APZ – Noise Zone)								
SLUCM	CATEGORY	**CZ**	**I-3**	**I-2**	**I-1**	**II-3**	**II-2**	**II-1**	**3**	**2**
CODE										
8. RESOURCE PRODUCTION AND EXTRACTION										
814	AGRI. EXCEPT LIVESTOCK	6	13	13	13	2,14	14,15	14	2	15
815	LIVESTOCK FARMING	6								
816-17	ANIMAL BREEDING									
82	AGRICULTURAL RELATED ACTIVITIES		16	16	16	16	16	16		
83	FORESTRY ACT. & RELATED SVCS.									
84	FISHING ACTIVITIES AND RELATED SVCS.									
85	MINING ACTIVITIES & RELATED SVCS.									
9. UNDEVELOPED LAND AND WATER AREAS										
91	UNDEVELOPED, UNUSED LAND,	16	16	16	16	16	16	16		
	EXCLUDE, NON-COMMERCIAL FOREST									
92	NON-COMMERCIAL FORESTS									
93	WATER AREAS									

	NO NEW DEVELOPMENT
1-16*	RESTRICTED NEW DEVELOPMENT * See notes on page following this chart.
	NO RESTRICTIONS

LEGEND for Table F-4
AICUZ COMPOSITE SUBZONES COMPOSITION

Accident Potential		**Noise Zones**		
		1 **Below Ldn 65** *(Lowest Noise)*	**2** **Ldn 65- Ldn 75** *(Moderate Noise)*	**3** **Above Ldn 75** *(High Noise)*
(Greatest Potential)	**Primary Surface / Clear Zone**	**CZ**	**CZ**	**CZ**
	APZ I	**I-1**	**I-2**	**I-3**
	APZ II	**II-1**	**II-2**	**II-3**
(Less Potential)	**Outside APZs**	**1**	**2**	**3**

NOTES FOR LAND USE TABLE F-4

1. Development is subject to the condition that the maximum density not exceed two (2) dwelling units per acre.

2. Compatible development is conditioned on dwelling design and construction providing for a noise level reduction (NLR) of 30 DBA and location of outdoor activity areas such as balconies and patios on the side of the building, which is sheltered from aircraft flight paths.

3. Compatible development is conditioned on design and construction providing a NLR of 35 DBA throughout the facility.

4. Compatible development is conditioned on design and construction providing a NLR of 30 DBA in the reception, office, retail and employee lounge areas.

5. Compatible development is conditioned on design and construction providing a NLR of 25 DBA in the reception, office, retail and employee lounge areas.

6. No structures (except airfield lighting), buildings, or above ground utility lines shall be located in the Clear Zone.

7. Compatible development is conditioned on design and construction providing a NLR of 30 DBA throughout the facility.

8. Compatible development is conditioned on design and construction providing a NLR of 25 DBA throughout the facility.

9. Development is subject to the condition that the park is oriented to forest trails and similar activities, which do not concentrate groups greater than fifty (50) within the park. Playgrounds are not permitted.

10. Development is subject to the condition that spectator stands are not built as part of this land use.

11. Compatible development is conditioned on design and construction providing a NLR of 30 DBA in permanent structures.

12. Development is subject to the condition that clubhouses are not built as part of this land use.

13. Residential structures are not permitted.

14. Development is subject to the condition that maximum density does not exceed one (1) dwelling unit per five (5) acres.

15. Compatible development is conditioned on dwelling design and construction providing a NLR of 25 DBA throughout the facility.

16. Activities that attract birds should be avoided.

G. IMPACT ANALYSIS

1. Introduction

This section attempts to identify existing and future land use or development incompatibilities within the AICUZ environment of MCAS Cherry Point and MCALF Bogue Field. Such an analysis is a necessary step in the evolution of recommended strategies and implementation.

2. Areas Impacted

A comparison of the areas in Noise Zones 2 and 3 at MCAS Cherry Point and MCALF Bogue Field are outlined in Table G-1. The areas impacted are described for the environs of each installations in the following subsections.

Table G-1
Off Base Areas Encumbered by Noise Zones (in Acres)
MCAS Cherry Point and MCALF Bogue

MCAS Cherry Point	**1988 AICUZ**	**2001 AICUZ**
Ldn 75 or Greater	321	1,350
Between Ldn 65-75	5,265	8,950
Totals	5,586	10.300
MCALF Bogue	**1981**	**2001 AICUZ**
Ldn 75 or Greater	1,410	696
Between Ldn of 65-75	5,410	3,458
Totals	6,828	4,850

Source: Onyx 2001, Cherry Point Complex Plan 1980/1981

2.1 MCAS Cherry Point.

MCAS Cherry Point is composed of approximately 13,144 acres, and lies within Noise Zones 1, 2 and 3. Within Noise Zone 3 on Station, the primary land use is airfield operational support including areas occupied by the four runways, Clear Zones, APZs, flight line, hangers and other operational and industrial areas.

The majority of the developed area of the installation is within Noise Zone 2 (those areas exposed to noise levels from Ldn 65 to Ldn 75). New construction for uses normally considered incompatible with the sound levels in those areas would need to incorporate sound attenuation to reduce noise levels inside the buildings. As major repairs or replacements to facilities in high noise areas are designed and constructed,

sound attenuation should routinely be included to reduce the interior noise levels in these buildings to correspond to the appropriate criteria.

The majority of the areas impacted off the Base at MCAS Cherry Point are along and to either side of the extended runway centerlines. The areas to the southwest are largely developed areas in the City of Havelock. The areas to the southeast include large areas of the Croatan National Forest.

2.2 MCALF Bogue.

MCALF Bogue is composed of approximately 837 acres, and lies within Noise Zones 1, 2 and 3. Within Noise Zone 2 & 3 on the MCALF, the primary land use is airfield operational support including areas occupied by the runways, clear zones, APZs, and other operational areas.

Most of the areas impacted off the MCALF are along and to either side of the extended runway centerline and under the FCLP patterns. Much of the noise areas to the south include water areas of Bogue Sound and portions of the largely developed resort area of Emerald Isle. Towards the north, noise impacts extend over parts of the Town of Bogue and adjacent areas.

3. Political Jurisdictions

MCAS Cherry Point lies within the political sphere of influence of the City of Havelock and Craven County North Carolina (Figure G-1). MCALF Bogue Field is within the political sphere of influence of Carteret County, as well as, the Towns of Bogue, Cape Carteret, and Emerald Isle (Figure G-2). The primary impacts of Noise and Accident Potential Areas from aircraft operating from these two airfields also lie in these jurisdictions.

While there are recommendations for height limitations and land use controls (which would extend into other jurisdictions) further from the airport, the focus of the discussion herein will be on the jurisdictions outlined above. Each political jurisdiction enforces its own development regulations, and determines its own zoning decisions. Figures G-3 provides the Zoning Map of the Cherry Point environs and Figure G-4 provides the Zoning Map for the area surrounding Bogue Field.

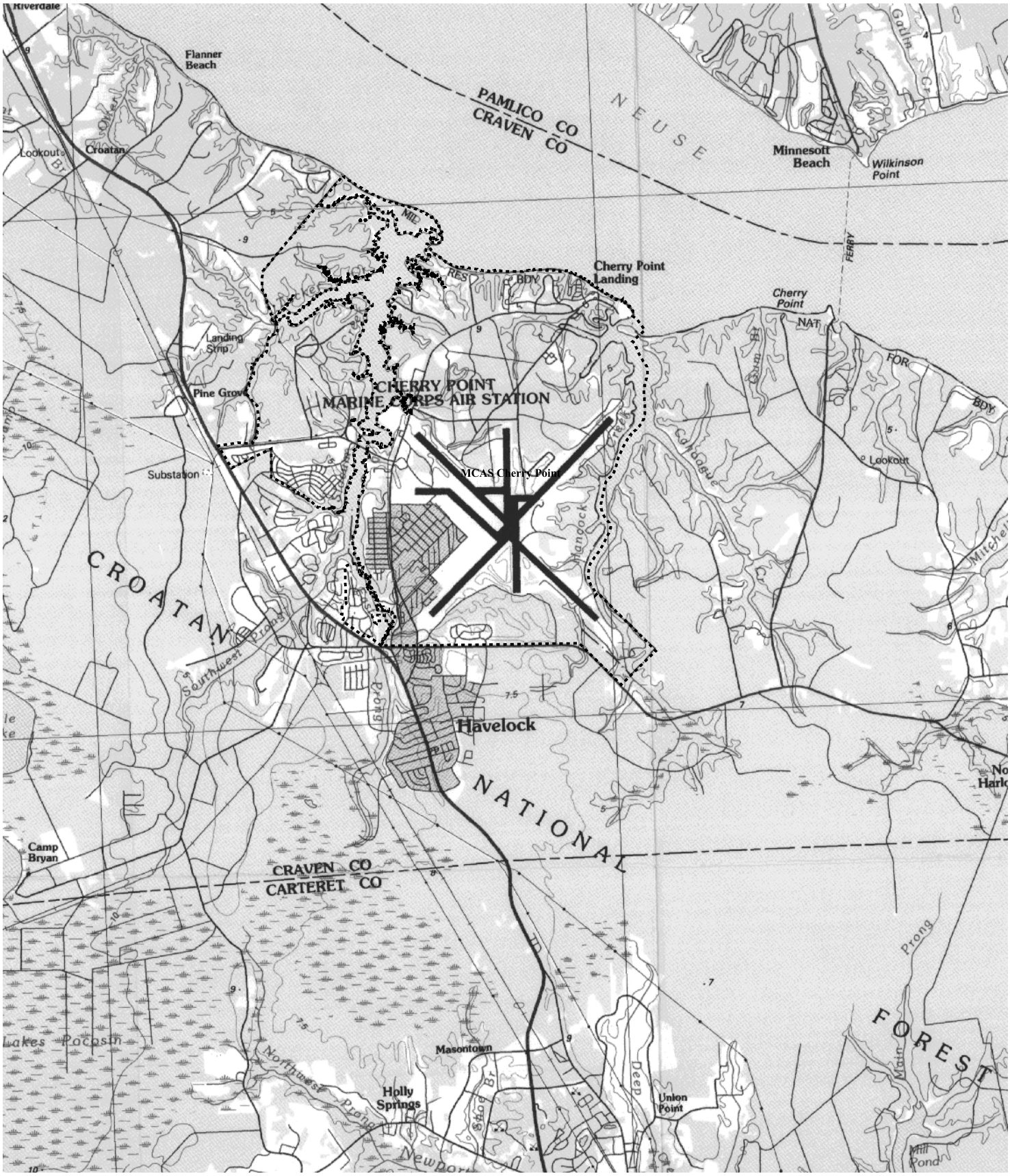
Residential classifications can be interpreted according to the following groupings:

Low Density Residential	less than 3du/acre
Medium Density Residential	3 to 6 du/acre
High Density Residential	more than 6 du/acre

Table G-2 outlines existing zoning classifications in the majority of these jurisdictions.

4. Current Land Use Controls in AICUZ Areas

The City of Havelock, as well as Craven, and Carteret Counties have partially addressed the AICUZ guidelines, established in the MCAS Cherry Point AICUZ Study within their planning and regulatory processes in the past. *The City of Havelock Zoning Ordinance* adopted July 29,1975 established zoning regulations for the city within its incorporated limits and



Marine Corps Air Station **Cherry Point, NC** **AICUZ Update**		— MCAS Cherry Point — **Political Jurisdictions Spheres of Influence** N 0 3000 6000 Feet	Figure G-1

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

— MCALF Bogue —

Political Jurisdictions
Sphere of Influence

0 3000 6000 Feet

Figure

G-2

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Zoning Map
Cherry Point Environs

— MCAS Cherry Point —

Legend

- Commercial
- Industrial
- Low Density Housing
- Medium Density Housing
- High Density Housing
- Planned Unit Development
- AICUZ Footprint, 2001
- Base Boundary
- Airfield

Sources:
1. Havelock zoning map
2. Craven County zoning map

N 0 6000

Scale: 1" = 6000'

Figure
G-3

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Zoning Map
Bogue Environs

— MCALF Bogue —

Legend

- Commercial
- Industrial
- Low Density Housing
- Medium Density Housing
- High Density Housing
- Institutional
- Planned Unit Development
- Open Space / Agricultural
- AICUZ Footprint, 2001
- Base Boundary
- Airfield

Sources:
1. Emerald Isle zoning map
2. Carteret County zoning map

N 0 6000

Scale: 1" = 6000'

Figure
G-4

extraterritorial jurisdiction. The City has adopted overlay districts for clear zones and APZs that restrict the density and height of commercial and business industrial zones. Noise zones identified in the AICUZ are not addressed in the zoning ordinance. The ordinance identifies the following AICUZ related zones: a Highway Commercial-Air Installation Compatible Use Zone (HC-AICUZ) and Light Industrial-Air Installation Compatible Use Zone (LI-AICUZ) as part of its zoning ordinance. These two zones address special considerations for lands in APZ-1 and APZ-2 as identified in MCAS Cherry Point's AICUZ program. The City also requires issuance of a *Disclosure Statement* as part of property sales for properties located within the AICUZ. The premise of the *Disclosure Statement* is that no person shall sell or lease, or offer for sale, any property within the MCAS Cherry Point AICUZ Footprint unless the prospective buyer has been notified of restrictions on development and use of the property.

Craven County does not have county-wide zoning; however, in 1989 the County adopted as *Appendix D of the Craven County Code*, a *Marine Corps Air Station Zoning Ordinance* convening the areas of APZ 1 and APZ II of Runways 23 and 32 east of the airport. The ordinance addresses the County's land use objectives, conditions for development, and limitations to development for lands within APZs and noise zones. The APZs of Runway 05 extend into lands regulated by the City. APZ 1 lands are zoned highway commercial and light industrial with some areas of residential. The APZ II lands are primarily zoned residential with some areas of light industrial and commercial zoning. In general, the residential zoning in these areas reflects existing conditions. This Ordinance also includes the requirement for a *Disclosure Statement* in these areas.

The Zoning Ordinance for Carteret County, adopted June 15, 1990, covers the area surrounding MCALF Bogue which are not within incorporated areas, unless the individual municipalities contract with the County for planning, zoning, and building inspection services. The *Carteret County Zoning Ordinance* does not include any references or requirements for proposed development to be compatible with the current AICUZ recommendations. The *Zoning Ordinances for the Towns of Bogue, Cape Carteret,* and *Emerald Isle* similarly do not contain such references.

The Carteret County 1996 Land Use Plan states that they "Oppose any low-level military training flights that are not in compliance with minimum safe altitudes for military aircraft operations as described in FAA regulations." There is a requirement for a statement of noise conditions to be printed on the recorded subdivision plat but no requirement for *Disclosure Statements*.

Table G-2 Zoning Summary

Residential

Zoning Districts	Density Per Dwelling Unit	Principal Permitted Uses	Special Uses
City of Havelock			
R20, Single-Family Residential	20,000 s.f.	Accessory buildings; estate auction; dwelling single-family; home care unit; government services i.e., library, recreation facilities; home occupation; private recreation club or swimming club activities; pumps, electric substations; signs.	Cemetery; church; day care center; golf courses; marinas; schools, telecommunications tower.
R15, Single-Family Residential	15,000 s.f.	Accessory buildings; estate auction; dwelling single-family; home care unit; government services i.e., library, recreation facilities; home occupation; private recreation club or swimming club activities; pumps, electric substations; signs.	Cemetery; church; day care center; golf courses; marinas; schools, telecommunications tower.
R13, Single-Family Residential	13,000 s.f.	Accessory buildings; estate auction; dwelling single-family; home care unit; government services i.e., library, recreation facilities; home occupation; private recreation club or swimming club activities; pumps, electric substations; signs.	Cemetery; church; day care center; golf courses; marinas; schools, telecommunications tower.
R12, Single-Family Residential	12,000 s.f.	Accessory buildings; estate auction; dwelling single-family; home care unit; government services i.e., library, recreation facilities; home occupation; private recreation club or swimming club activities; pumps, electric substations; signs.	Cemetery; church; day care center; golf courses; marinas; schools, telecommunications tower.
R10, Single-Family Residential	10,000 s.f.	Accessory buildings; estate auction; dwelling single-family; home care unit; government services i.e., library, recreation facilities; home occupation; private recreation club or swimming club activities; pumps, electric substations; signs.	Cemetery; church; day care center; golf courses; marinas; schools, telecommunications tower.
R7, Single-Family Residential	7,000 s.f.	Accessory buildings; estate auction; dwelling single-family; home care unit; government services i.e., library, recreation facilities; home occupation; private recreation club or swimming club activities; pumps, electric substations; signs.	Cemetery; church; day care center; golf courses; marinas; schools, telecommunications tower.
RM, Multifamily Residential	900 s.f. of heated interior space	Accessory buildings; estate auction; dwelling single-family, two-family, multi-family; home care unit; government services i.e., library, recreation facilities; home occupation; private recreation club or swimming club activities; pumps, electric substations; signs.	Cemetery; church; day care center; golf courses; marinas; schools, telecommunications tower.
RMHA, Manufactured Home Class A Overlay	Variable, but basically on a typical residential lot	Dwelling single-family; home care unit; government services i.e., library	Cemetery; church; day care center; marinas; schools; manufactured home parks; mini storage warehouse; recreation vehicle park; telecommunication tower.
Town of Emerald Isle			
R1, Single-Family Residential	Seven thousand (7,000) square feet for lots recorded prior to June 11, 1977; twelve thousand five hundred (12,500) square feet for lots recorded after June 11, 1977	Accessory buildings; auto parking; church; golf course; dwelling single-family; garden; government use; grounds and facilities open air games; incidental home occupations; nonconforming uses and buildings; public park; police and fire stations; public utilities; yacht basins, docks, ramps.	Athletic club and facilities.
R2, Single-Family Residential	Seven thousand (7,000) square feet for lots recorded prior to June 11, 1977; twelve thousand five hundred (12,500) square feet for lots recorded after June 11, 1977	Accessory buildings; auto parking; assembly halls; banks, day nurseries and kindergartens; dwelling two-family, multi-family; church; golf course; dwelling single-family; garden; government use; group housing; grounds and facilities open air games; incidental home occupations; nonconforming uses and buildings; planned unit development; public park; police and fire stations; public utilities; yacht basins, docks, ramps.	Athletic club and facilities.

Table G-2 Zoning Summary (continued)

Zoning Districts	Density Per Dwelling Unit	Principal Permitted Uses	Special Uses
Town of Emerald Isle (cont'd)			
RMF, Residential Multi-Family	Seven thousand (7,000) square feet for lots recorded prior to June 11, 1977; twelve thousand five hundred (12,500) square feet for lots recorded after June 11, 1977	Accessory buildings; auto parking; church; golf course; dwelling single-family; garden; government use; grounds and facilities open air games; incidental home occupations; nonconforming uses and buildings; public park; police and fire stations; public utilities; yacht basins, docks, ramps.	Amusement enterprises e.g., pool hall; antique store; arcade; art supply; athletic club and facilities; barber shop; book store; carwash; racquetball club and facilities; tennis club and facilities.
RMH, Residential Multi-Family or Hotel/Motel	Seven thousand (7,000) square feet for lots recorded prior to June 11, 1977; twelve thousand five hundred (12,500) square feet for lots recorded after June 11, 1977	Church; dwelling single-family, two-family, multi-family; golf course; garden; government uses; grounds and facilities for open air games; hotel/motel; public park; planned unit development; police and fire station; public utilities; yacht basins, docks, ramps.	none listed
MH1, Mobile Home	Six thousand (6,000) square feet for lots recorded prior to June 11, 1977; twelve thousand five hundred (12,500) square feet for lots recorded after June 11, 1977	Auto parking; church; golf course; dwelling single-family, two-family, multi-family, condos, townhouses; fishing pier; garden; government use; hotel/motel; incidental home occupation; public park; planned unit development; police and fire station; public utilities; yacht basins, docks, ramps.	Convenience store; racquetball club and facilities; real estate rental and sales; hotel/motel restaurant; tennis club and facilities.
Inst, Institutional	Seven thousand (7,000) square feet for lots recorded prior to June 11, 1977; twelve thousand five hundred (12,500) square feet for lots recorded after June 11, 1977	Accessory building; professional services; liquor store; amusement enterprises e.g., pool hall; appliance sales; arcade; art supply; assembly hall; bank; barber shop; bar, lounge; bicycle sales and repair; building supplies; carwash; church; nursing home; golf course; day nurseries and kindergarten; doctor and dentist office; dwelling single-family, two-family, multi-family; florist, greenhouse; garden; government use; grounds and facilities for open air games; hospital; hardware store; ice manufacturing; incidental home occupation; lock and gunsmith; newsstands; office equipment and supply; public park; planned unit development;	Athletic club and facilities; bar or lounge; campers; clothing sales; grocery store; hotel/motel; performing arts events (indoor); outdoor commercial activities and amusements; pet shop; racquetball club and facilities; tennis club and facilities.
Town of Bogue			
RA, Rural Agricultural	50,000 s.f.	Accessory building; agricultural use; aquacultural use; bed and breakfast; boarding house; boat launching ramp; camp, seasonal; cemetery; church; club or lodge; country club and related uses; dock or pier (private); duplexes and triplexes; dwelling, single-family; efficiency unit; family care home; fruit or vegetable stand; golf course; government services; home occupation; manufactured home; non-profit recreational facility; public or private school; public utility station; private stables; private swimming pool; private tennis court.	Chicken hatchery; day care center; family day care center; floating structures; funeral home, mortuary, crematorium; group care facility; group home; kennel; library, museum, art gallery; mausoleum; model unit marketing center; swine production; public stables; public or commercial swimming pool; temporary residential mobile home; public or commercial tennis courts; residential marina; septage/sludge removal.
R35, Single-Family Residential	35,000 s.f.	Accessory building; agricultural use; aquacultural use; bed and breakfast; boarding house; boat launching ramp; camp, seasonal; cemetery; church; club or lodge; country club and related uses; dock or pier (private); duplexes and triplexes; dwelling, single-family; efficiency unit; family care home; fruit or vegetable stand; golf course; home occupation; non-profit recreational facility; public or private school; public utility station; private swimming pool; private tennis court.	Day care center; family day care center; floating structures; funeral home, mortuary, crematorium; group care facility; group home; kennel; library, museum, art gallery; mausoleum; model unit marketing center; public and private stables; public or commercial swimming pool; public or commercial tennis courts.
R20, Single-Family Residential	20,000 s.f.	Accessory building; agricultural use; aquacultural use; bed and breakfast; boat launching ramp; camp, seasonal; cemetery; church; dock or pier (private); duplexes and triplexes; dwelling, single-family; efficiency unit; family care home; golf course; non-profit recreational facility; public or private school; public utility station; private swimming pool; private tennis court.	Boarding house; camp, seasonal; club or lodge; country club; day care center; family day care center; floating structures; fruit or vegetable stand; funeral home, mortuary, crematorium; government uses; group care facility; group home; home occupation; kennel; library, museum, art gallery; mausoleum; model unit marketing center; private stables; public or commercial swimming pool; public or commercial tennis courts.

Table G-2 Zoning Summary (continued)

Zoning Districts	Density Per Dwelling Unit	Principal Permitted Uses	Special Uses
Town of Bogue (cont'd)			
R15, Single-Family Residential	15,000 s.f.	Refer to R20, with the addition of manufactured home.	Refer to R20
R15M, Single-Family Residential (allows manufactured homes)	15,000 s.f.	Refer to R20	Refer to R20
R10, Single-Family Residential	10,000 s.f.	Accessory building; agricultural use; aquacultural use; apartment; boat launching ramp; cemetery; church; dock or pier (private); duplexes and triplexes; dwelling, single-family; efficiency unit; family care home; golf course; non-profit recreational facility; public or private school; public utility station; private stables; private swimming pool; private tennis court; townhouse.	Bed and breakfast; boarding house; camp, seasonal; club or lodge; country club; day care center; efficiency unit; family day care center; floating structure; funeral home, mortuary, crematorium; government uses; group care facility; group home; home occupation; kennel; library, museum, art gallery; mausoleum; model unit marketing center; public or commercial swimming pool; public or commercial tennis courts.
CC, Church Campus	5 acres (217,800 s.f.)	Accessory building; agricultural use; aquacultural use; camp, seasonal; cemetery; church; dock or pier (private); government uses; libraries, museums, art galleries; mausoleum; offices; parsonage; public or private school; public utility station; private swimming pool; private tennis court; theater, indoor, outdoor; vending machines located outdoors.	Colleges and related facilities.
MC, Planned Mobile Home and Camp Park	3 acres (130,680 s.f.)	Accessory building; agricultural use; aquacultural use; campground; private dock or pier; fishing camps; government offices; manufactured home; manufactured home park; offices; public or private school; public utility substation; private swimming pool; private tennis courts.	Day care center; floating structures; fruit or vegetable stand.
PUD, Planned Unit Development	Variable, but density shall not exceed 2.9 units per acre for project's net acreage.	Variable	Variable
Town of Cape Carteret			
R10, Single-Family Residential	10,000 s.f.	See Town of Bogue, R10.	See Town of Bogue, R10.
R10M, Multi-Family Residential	10,000 s.f.	See Town of Bogue, R10, with the addition of manufactured home.	See Town of Bogue, R10.
R20, Single-Family Residential	20,000 s.f.	See Town of Bogue, R20.	See Town of Bogue, R20.
R30, Single-Family Residential	30,000 s.f.	See Town of Bogue, R35.	See Town of Bogue, R35.
Carteret County			
RA, Rural Agricultural	50,000 s.f.	Accessory building; agricultural use; aquacultural use; bed and breakfast; boarding house; boat launching ramp; camp, seasonal; cemetery; church; club or lodge; country club and related uses; dock or pier (private); duplexes and triplexes; dwelling, single-family; efficiency unit; family care home; fruit or vegetable stand; golf course; government services; home occupation; manufactured home; non-profit recreational facility; public or private school; public utility station; private stables; private swimming pool; private tennis court.	Chicken hatchery; day care center; family day care center; floating structures; funeral home, mortuary, crematorium; group care facility; group home; kennel; library, museum, art gallery; mausoleum; model unit marketing center; swine production; public stables; public or commercial swimming pool; temporary residential mobile home; public or commercial tennis courts; residential marina; septage/sludge removal.

Table G-2 Zoning Summary (continued)

Zoning Districts	Density Per Dwelling Unit	Principal Permitted Uses	Special Uses
Carteret County (cont'd)			
R35, Single-Family Residential	35,000 s.f.	Refer to RA	Day care center; family day care center; floating structures; funeral home, mortuary, crematorium; group care facility; group home; kennel; library, museum, art gallery; mausoleum; model unit marketing center; swine production; public stables; public or commercial swimming pool; public or commercial tennis courts.
R20, Single-Family Residential	20,000 s.f.	Accessory building; agricultural use; aquacultural use; bed and breakfast; boat launching ramp; camp, seasonal; cemetery; church; dock or pier (private); duplexes and triplexes; dwelling, single-family; efficiency unit; family care home; golf course; non-profit recreational facility; public or private school; public utility station; private stables; private swimming pool; private tennis court.	Boarding house; camp, seasonal; club or lodge; country club; day care center; family day care center; floating structures; fruit or vegetable stand; funeral home, mortuary, crematorium; government uses; group care facility; group home; home occupation; kennel; library, museum, art gallery; mausoleum; model unit marketing center; private stables; public or commercial swimming pool; public or commercial tennis courts.
R15, Single-Family Residential	15,000 s.f.	Refer to R20, with the addition of manufactured home.	Refer to R20
R15M, Single-Family Residential (allows manufactured homes)	15,000 s.f.	Accessory building; agricultural use; aquacultural use; bed and breakfast; boat launching ramp; camp, seasonal; cemetery; church; dock or pier (private); duplexes and triplexes; dwelling, single-family; efficiency unit; family care home; golf course; manufactured home; non-profit recreational facility; public or private school; public utility station; private stables; private swimming pool; private tennis court.	Refer to R20
R10, Single-Family Residential	10,000 s.f.	Accessory building; agricultural use; aquacultural use; apartment; boat launching ramp; cemetery; church; dock or pier (private); duplexes and triplexes; dwelling, single-family; efficiency unit; family care home; golf course; non-profit recreational facility; public or private school; public utility station; private stables; private swimming pool; private tennis court; townhouse.	Bed and breakfast; boarding house; camp, seasonal; club or lodge; country club; day care center; efficiency unit; family day care center; floating structure; funeral home, mortuary, crematorium; government uses; group care facility; group home; home occupation; kennel; library, museum, art gallery; mausoleum; model unit marketing center; public or commercial swimming pool; public or commercial tennis courts.
CC, Church Campus	5 acres (217,800 s.f.)	Accessory building; agricultural use; aquacultural use; camp, seasonal; cemetery; church; dock or pier (private); government uses; libraries, museums, art galleries; mausoleum; offices; parsonage; public or private school; public utility station; private swimming pool; private tennis court; theater, indoor, outdoor; vending machines located outdoors.	Colleges and related facilities.
MC, Planned Mobile Home and Camp Park	3 acres (130,680 s.f.)	Accessory building; agricultural use; aquacultural use; campground; private dock or pier; fishing camps; government offices; manufactured home; manufactured home park; offices; public or private school; public utility substation; private swimming pool; private tennis courts.	Day care center; floating structures; fruit or vegetable stand.
PUD, Planned Unit Development	Variable, but density shall not exceed 2.9 units per acre for project's net acreage.	Variable	Variable

Table G-2 Zoning Summary (continued)

Commercial

Zoning Districts	Density Per Dwelling Unit	Principal Permitted Uses	Special Uses
City of Havelock			
HC, Highway Commercial	None	Liquor store; antique store; appliance sales; art gallery; barber shop; convenience store; department store; grocery store; hospital; hotel/motel; offices for professional and business services; restaurant; shoe repair; wholesale operations.	Adult establishment; animal hospital; auction sales; bulk storage of flammable materials; builders supply and hardware; dwellings; farm supplies; industrial sales; LP gas sales; nurseries; produce stands.
LI, Light Industrial	60,000 s.f.	Assembly halls; bakeries; book binding; bulk storage of flammable materials; bus repair; dry cleaning; flexible storage space; fuel oil dealers; hotel/motel; ice manufacturing.	Auction sales; borrow pit; builders supply and hardware; medical clinics; day care center; junk yard; landfill; monument works; solid waste disposal.
HI, Heavy Industrial	90,000 s.f.	Bulk storage of flammable materials; bus repair; candy making; concrete facility; contractor equipment and storage; farm equipment and sales; freight station; industrial sales; manufacturing; pumps; tire recapping; warehouse.	Off-street parking; borrow pit; mobile offices; solid waste disposal; storage of explosives; telecommunications tower.
IA, Industrial and Agricultural Use	90,000 s.f.	Agricultural/farm use; farm supplies; animal hospital; auction sales; bakeries; blueprinting services; builders supply; candy making; cemetery; dry cleaning services; dwellings (single and multi-family); farmer's market; flea market; fuel oil dealer; ice sales; industrial sales; manufacturing; monument works; nurseries; open air markets; produce stands; pumps; warehouse.	Aquaculture activities; bed and breakfast; borrow pit; circus; fairground; kennel; solid waste disposal; telecommunications tower.
IP, Industrial Park	n/a	Accessory building; auction estate; bakeries; book binding; candy making; government services; ice manufacturing; laboratory research; manufacturing; monument works; newspaper publishing; pharmaceutical sales and manufacturing; pumps; signs; wholesale operations.	Bulk storage of flammable materials; day care center; dry cleaning and laundry; mobile offices; telecommunication towers.
HC APZ I, Accident Potential Zone I	Uses underlying district	Accessory building; auction estate; golf course; public safety facilities; pumps; signs.	Agricultural/farm supply; liquor store; antique store; appliance sales; art gallery; barber shop; cemetery; convenience store (w/out gas sales); department store; grocery store; offices for professional and business services; restaurant; shoe repair; wholesale operations.
HC APZ II, Accident Potential Zone II	Uses underlying district	Liquor store; antique store; appliance sales; art gallery; barber shop; convenience store; grocery store; hospital; hotel/motel; offices for professional and business services; restaurant; shoe repair; wholesale operations.	Adult establishment; animal hospital; auction sales; bulk storage of flammable materials; builders supply and hardware; dwellings; farm supplies; department store; entertainment theater; industrial sales; LP gas sales; nurseries; produce stands.
Town of Emerald Isle			
B1, Business 1	None	Accessory building; professional services; antique store; auto parking; bicycle sales and repair; carwash; church; clothing sales; nursing home; day nursery or kindergarten; drug store; dry cleaners; florist, greenhouse; garden; hardware store; hospital; hotel/motel; jewelry store; laundry mat; lock and gunsmith; marina; mobile homes; music store; newstand; office building; public park; pet store; theatres.	Convenience store; mobile homes; motel; outdoor commercial activities and amusements; racquetball club and facilities; recreational vehicle park; restaurant; hotel/motel restaurant; tennis club and facilities.

Table G-2 Zoning Summary (continued)

Zoning Districts	Density Per Dwelling Unit	Principal Permitted Uses	Special Uses
Town of Emerald Isle (cont'd)			
B2, Business 2	None	Auto parking; barber shop; campers; church; nursing home; convenience store; doctor or dentist office; drug store; dwelling single-family, two-family; fishing pier; garden; government use; grounds and facilities for open air games; incidental home occupation; jewelry store; mobile homes; music store; office building; public park; photograph studio; planned unit development; restaurant.	Arcade; athletic club and facilities; barber shop; bed and breakfast lodging; mobile home park; racquetball club and facilities; tennis club and facilities.
B3, Business 3	None	Accessory building; auto parking; church; golf course; doctor or dentist office; dwelling single-family; fishing pier; garden; government use; grounds and facilities for open air games; mobile home park; office building; public park; police and fire stations; public utilities; recreational vehicle park; yacht basins, docks, ramps.	Antique store; art supply; athletic club and facilities; grocery store; marina; outdoor commercial activities and amusements; hotel/motel restaurant.
C, Camp	None	Church; golf course; fishing pier; garden; government use; grounds and facilities for open air games; public park; police and fire stations; public utilities; yacht basins, docks, ramps.	None Listed
Town of Bogue			
OP, Office and Professional	30,000 s.f.	Accessory building; agricultural uses; aquacultural uses; armories for meeting and military training; assembly hall; auto parking deck; banks and other financial institutions; civic center; colleges and related facilities; convalescent home; day care center; dock or pier, private; funeral home, mortuary, crematorium; government offices; hospital, health, sanitarium care; laboratory: medical, dental, optical; laboratory, research; libraries, museums, art galleries; motel, hotel, motor court; non-profit recreational facility; offices; public or private school; public utility office; public utility substation; residential hotel; restaurant, not drive-in; TV, radio broadcasting studio; TV, radio transmitting tower; vending machines located outdoors.	Group care facility; floating structure.
B3, Planned Business	30,000 s.f.	ABC store; accessory building; agricultural uses; aquacultural uses; armories for meeting and military training; assembly hall; auto parking deck; banks and other financial institutions; barber shop; billiard or pool hall; building materials; church; civic center; contractor's office; dock or pier, private; dry cleaning/laundry; fruit or vegetable stand; general merchandise store; government offices; hospital, health, sanitarium care; mail order house; marine equipment store; misc retail; offices; motor vehicle service station; public or private school; public utility office; public utility substation; residential hotel; restaurant, drive-in; restaurant, not drive-in; sale of alcoholic beverages in retail establishments; theater, indoor; vending machines located outdoors.	Ambulance service; animal hospital/veterinary clinic; auction sales; circus, carnival, fair; entertainment facilities (bars, discos); floating structures; for-profit recreational facility; kennels; printing and publishing; theater, outdoor; TV, radio broadcasting studio; TV, radio transmitting tower.

Table G-2 Zoning Summary (continued)

Zoning Districts	Density Per Dwelling Unit	Principal Permitted Uses	Special Uses
Town of Bogue (cont'd)			
B2, Marine Business	10,000 s.f.	Accessory building; agricultural uses; aquacultural uses; auto parking deck; boat launching ramp; boat sales, service, repair; boat storage yard; business residence; cemetery; club or lodge; dock or pier, private; drystack boat storage; electrical repair shop; entertainment facilities (bar, disco); fishing pier; fishing ranch; government offices; laboratory research; libraries, museums, art galleries; marine equipment store; marine railway yard; marine research facility; motel, hotel, motor court; offices; public or private school; public utility office; public utility substation; residential hotel; restaurant, drive-in; restaurant, not drive-in; sale of alcoholic beverages in retail establishments; seafood processing, handling, storage, and sales facility; public or commercial swimming pool; public or commercial tennis courts; vending machines located outdoors; yacht and boating club.	Auto and boat washing facility; boat building; convenience store; floating structures; for-profit recreational facility; piers, wharves, deepwater berth facilities for cargo, marine, research and commercial fishing vessels; theater, outdoor.
B1, General Business	10,000 s.f.	Refer to all of the above districts' uses, with the addition of: appliances (retail/maintenance); automotive dealers and truck sales; bus and taxi terminal; exterminating services; fabricating shops (wood, metal, etc); farm implement sales and service; miniature golf course; golf or baseball driving range; handcrafing of small articles.	Adult establishments; assembly of prepared parts into finished products; cabinet/woodworking shop; clothing manufacturing; cold storage plants; contractor's plant/storage yard; convalescent home; day care center; floating structures; junkyard; manufactured home park; other communication facilities; public utility office; public utility workshop and storage; recycling of waste matter; signs (manuf. and assembly); public stables; vehicle terminal activities.
LIW, Light Industrial Wholesale	1 acre (43,560 s.f.)	Accessory building; agricultural uses; aquacultural uses; armories for meeting and military training; assembly hall; auto parking deck; boat building; bus repair and storage; cabinet and woodworking shop; clothing manufacturing; contractor's office; dock or pier, private; dry cleaning/laundry; exterminating services; fairground; fiberglass manufacturing; furniture manufacturing plants; government offices; handcrafting of small articles; kennels; laboratory: medical, dental, optical; leather products; marine research facility; mini-warehouse; motor vehicle repair garage; newspaper office; offices; plastic manufacturing; printing and publishing; public utilities; rubber products; seafood processing; shooting range; sign manufacturing and assembly.	Auto manufacturing; bakeries; boat storage yard; bus and taxi terminal; chemical/mineral manuf.; dairy products processing plant; fish processing; misc. manuf.; overnight camping vehicle storage; pottery, porcelain and vitreous china manufacturing; recycling of waste matter; stone, clay, glass and concrete products; textile manufacturing; tire recapping and retreading; tobacco manufacturing; transportation equipment.
PI, Port Industrial	1 acre (43,560 s.f.)	Accessory building; agricultural uses; aquacultural uses; armories for meeting and military training; assembly hall; auto parking deck; boat building; bus repair and storage; cold storage plants; contractor's office; dock or pier, private; dry cleaning/laundry; export cargo packing and crating facilities; fabricating shops; floating platforms used for cargo and handling; foundries; grain storage; lumber and wood products; government offices; marine research facility; mining and quarrying; paper and allied products; vessels; primary metal; railroad transportation facility; scrap processing; stone, clay, glass and concrete products; tobacco sales warehousing; water transportation facilities.	Bus and taxi terminal; chemical/mineral manuf.; commercial marina; cooperage works and crafting services; drystack boat storage; fiberglass manufacturing; floating structures; outer continental shelf service and supply base; petroleum and related products; plastic manuf.; rubber products; tire recapping; tobacco manuf.; wholesale storage of flammable materials.

Table G-2 Zoning Summary (continued)

Zoning Districts	Density Per Dwelling Unit	Principal Permitted Uses	Special Uses
		Town of Bogue (cont'd)	
IW, Industrial and Wholesale	1 acre (43,560 s.f.)	Refer to PI with the addition of: alcohol manufacturing and related products; air transportation/airport; bakeries; bottling plants; breweries; cannery; chicken hatchery; clothing manuf.; cold storage plant; contractor's office; dairy products processing plant; fabricating shops (wood, metal); fish processing; floating platforms for cargo; foundries; freight transportation warehousing; furniture manufacturing plants; general warehousing; junkyard; kennels; leather products; marine railway yard; mini-warehouses; offices; outdoor shooting range; outer continental self service and supply base; paper and allied products; marine research and commercial fishing vessels; plastic manufacturing; pottery, porcelain and vitreous china manuf.; rubber products; scrap processing, slaughter house; textile manuf.; tobacco manuf.; tobacco sales warehousing; transportation equipment.	Billboards/off-premise signs; bus and taxi terminal; bus repair and storage; drystack boat storage; floating structures; landfill; manufactured home park; wholesale storage of flammable materials.
		Town of Cape Carteret	
B10, Business and Professional Offices	10,000 s.f.	See Town of Bogue OP, Office and Professional.	See Town of Bogue OP, Office and Professional.
B10CU, Business and Professional Offices, Conditional Use	10,000 s.f.	See Town of Bogue OP, Office and Professional.	See Town of Bogue OP, Office and Professional.
B20, Retail Sales and Shopping Centers	20,000 s.f.	See Town of Bogue B1, General Business.	See Town of Bogue B1, General Business.
B30, Light Industrial	30,000 s.f.	See Town of Bogue LIW, Light Industrial Warehousing.	See Town of Bogue LIW, Light Industrial Warehousing.
		Carteret County	
OP, Office and Professional	30,000 s.f.	Accessory building; agricultural uses; aquacultural uses; armories for meeting and military training; assembly hall; auto parking deck; banks and other financial institutions; civic center; colleges and related facilities; convalescent home; day care center; dock or pier, private; funeral home, mortuary, crematorium; government offices; hospital, health, sanitarium care; laboratory: medical, dental, optical; laboratory, research; libraries, museums, art galleries; motel, hotel, motor court; non-profit recreational facility; offices; public or private school; public utility office; public utility substation; residential hotel; restaurant, not drive-in; TV, radio broadcasting studio; TV, radio transmitting tower; vending machines located outdoors.	Group care facility; floating structure.
B3, Planned Business	30,000 s.f.	ABC store; accessory building; agricultural uses; aquacultural uses; armories for meeting and military training; assembly hall; auto parking deck; banks and other financial institutions; barber shop; billiard or pool hall; building materials; church; civic center; contractor's office; dock or pier, private; dry cleaning/laundry; fruit or vegetable stand; general merchandise store; government offices; hospital, health, sanitarium care; mail order house; marine equipment store; misc retail; offices; motor vehicle service station; public or private school; public utility office; public utility substation; residential hotel; restaurant, drive-in; restaurant, not drive-in; sale of alcoholic beverages in retail establishments; theater, indoor; vending machines located outdoors.	Ambulance service; animal hospital/veterinary clinic; auction sales; circus, carnival, fair; entertainment facilities (bars, discos); floating structures; for-profit recreational facility; kennels; printing and publishing; theater, outdoor; TV, radio broadcasting studio; TV, radio transmitting tower.

Table G-2 Zoning Summary (continued)

Zoning Districts	Density Per Dwelling Unit	Principal Permitted Uses	Special Uses
Carteret County (cont'd)			
B2, Marine Business	10,000 s.f.	Accessory building; agricultural uses; aquacultural uses; auto parking deck; boat launching ramp; boat sales, service, repair; boat storage yard; business residence; cemetery; club or lodge; dock or pier, private; drystack boat storage; electrical repair shop; entertainment facilities (bar, disco); fishing pier; fishing ranch; government offices; laboratory research; libraries, museums, art galleries; marine equipment store; marine railway yard; marine research facility; motel, hotel, motor court; offices; public or private school; public utility office; public utility substation; residential hotel; restaurant, drive-in; restaurant, not drive-in; sale of alcoholic beverages in retail establishments; seafood processing, handling, storage, and sales facility; public or commercial swimming pool; public or commercial tennis courts; vending machines located outdoors; yacht and boating club.	Auto and boat washing facility; boat building; convenience store; floating structures; for-profit recreational facility; piers, wharves, deepwater berth facilities for cargo, marine, research and commercial fishing vessels; theater, outdoor.
B1, General Business	10,000 s.f.	Refer to all of the above districts' uses, with the addition of: appliances (retail/maintenance); automotive dealers and truck sales; bus and taxi terminal; exterminating services; fabricating shops (wood, metal, etc); farm implement sales and service; miniature golf course; golf or baseball driving range; handcrafing of small articles.	Adult establishments; assembly of prepared parts into finished products; cabinet/woodworking shop; clothing manufacturing; cold storage plants; contractor's plant/storage yard; convalescent home; day care center; floating structures; junkyard; manufactured home park; other communication facilities; public utility office; public utility workshop and storage; recycling of waste matter; signs (manuf. and assembly); public stables; vehicle terminal activities.
LIW, Light Industrial Wholesale	1 acre (43,560 s.f.)	Accessory building; agricultural uses; aquacultural uses; armories for meeting and military training; assembly hall; auto parking deck; boat building; bus repair and storage; cabinet and woodworking shop; clothing manufacturing; contractor's office; dock or pier, private; dry cleaning/laundry; exterminating services; fairground; fiberglass manufacturing; furniture manufacturing plants; government offices; handcrafting of small articles; kennels; laboratory: medical, dental, optical; leather products; marine research facility; mini-warehouse; motor vehicle repair garage; newspaper office; offices; plastic manufacturing; printing and publishing; public utilities; rubber products; seafood processing; shooting range; sign manufacturing and assembly.	Auto manufacturing; bakeries; boat storage yard; bus and taxi terminal; chemical/mineral manuf.; dairy products processing plant; fish processing; misc. manuf.; overnight camping vehicle storage; pottery, porcelain and vitreous china manufacturing; recycling of waste matter; stone, clay, glass and concrete products; textile manufacturing; tire recapping and retreading; tobacco manufacturing; transportation equipment.
PI, Port Industrial	1 acre (43,560 s.f.)	Accessory building; agricultural uses; aquacultural uses; armories for meeting and military training; assembly hall; auto parking deck; boat building; bus repair and storage; cold storage plants; contractor's office; dock or pier, private; dry cleaning/laundry; export cargo packing and crating facilities; fabricating shops; floating platforms used for cargo and handling; foundries; grain storage; lumber and wood products; government offices; marine research facility; mining and quarrying; paper and allied products; vessels; primary metal; railroad transportation facility; scrap processing; stone, clay, glass and concrete products; tobacco sales warehousing; water transportation facilities.	Bus and taxi terminal; chemical/mineral manuf.; commercial marina; cooperage works and crafting services; drystack boat storage; fiberglass manufacturing; floating structures; outer continental shelf service and supply base; petroleum and related products; plastic manuf.; rubber products; tire recapping; tobacco manuf.; wholesale storage of flammable materials.

Table G-2 Zoning Summary (continued)

Zoning Districts	Density Per Dwelling Unit	Principal Permitted Uses	Special Uses
Carteret County (cont'd)			
IW, Industrial and Wholesale	1 acre (43,560 s.f.)	Refer to PI with the addition of: alcohol manufacturing and related products; air transportation/airport; bakeries; bottling plants; breweries; cannery; chicken hatchery; clothing manuf.; cold storage plant; contractor's office; dairy products processing plant; fabricating shops (wood, metal); fish processing; floating platforms for cargo; foundries; freight transportation warehousing; furniture manufacturing plants; general warehousing; junkyard; kennels; leather products; marine railway yard; mini-warehouses; offices; outdoor shooting range; outer continental self service and supply base; paper and allied products; marine research and commercial fishing vessels; plastic manufacturing; pottery, porcelain and vitreous china manuf.; rubber products; scrap processing, slaughter house; textile manuf.; tobacco manuf.; tobacco sales warehousing; transportation equipment.	Billboards/off-premise signs; bus and taxi terminal; bus repair and storage; drystack boat storage; floating structures; landfill; manufactured home park; wholesale storage of flammable materials.

5. Existing Regional Land Use

Large areas of land within the coastal plain that are ecologically unsuited for development influence regional land uses. Development constraints include extensive areas of wetlands, federal and state lands, water bodies, floodplains, and soil limitations (i.e. wetness, slow permeability and low strength). Craven County consists of approximately 500,000 acres that is largely undeveloped. The primary land covers are forest (55.5%), farms (14.4%), parks (12.7%), water (8.4%), developed areas (7.4%), and rights-of-way (1.5%). Croatan National Forest occupies the vast majority of the land impacted by noise and APZs east of MCAS Cherry Point. The Neuse River and its tributaries bound the areas to the north of the Station.

The City of Havelock has experienced substantial growth over the years, primarily due to the annexation of MCAS Cherry Point by the City in 1979. From 1979 to 1980 the population of Havelock jumped 488.2 % (from 3,012 to 17,718 residents). Between 1980 and 1998 the City saw an increase of 5,055 new residents. A limited amount of urban development primarily associated with the City of Havelock, exists to the south and west of the Station. Commercial land uses are concentrated west of the Station along U.S. 70; the bulk of the commercial development occurs between NC 101 (the southern boundary of MCAS Cherry Point) and Slocum Road off U.S. 70. The area south of NC 101 is the core area of the City of Havelock. Excluding the Air Station (which is 63.9% of the City's incorporated acreage), the predominate land use within the City is residential comprising 14.9 % of the City's land area. Commercial and service uses make up 2.2%, industrial activities occupy 0.1%, with the remaining areas made up of government/institutional, cultural/recreation, vacant, and infrastructure uses.

The North Carolina Coastal Area Management Act (CAMA) requires the development of land use plans for coastal areas. The development of CAMA is North Carolina's response to the Federal Requirements of the *Coastal Zone Management Act of 1972*. The City of Havelock, and the Counties of Craven and Carteret are required to develop land use plans under CAMA.

Carteret County consists of roughly 240,000 acres. While much of the County is undeveloped, much of the development is concentrated in the coastal areas. Since much of the AICUZ footprint is over water areas, the land uses near Bogue field, within and near the AICUZ footprint, are largely developed or zoned for residential and resort uses, with strip commercial development along Route 24. Figures G-5 and G-6 outlines existing land uses in the area of MCAS Cherry Point and MCALF Bogue environs.

6. Future Land Use

There are development pressures particularly along existing roads and along the water front areas. There has also been increased attention paid to avoiding the problems associated with development in flood plains, as well as, the desirability of preservation of farmlands and woodlands. The proposed Havelock by-pass and widening of Route 24 adjacent to Bogue Field will encourage development along those corridors. Future Land Uses are shown on Figure G-7 and G-8 for the MCAS Cherry Point and MCALF Bogue field environs. The future uses reflect current land uses and those allowed in zoning regulations. The result in some cases will be an increase in land uses that are incompatible with AICUZ recommendations.

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Existing Land Use
Cherry Point Environs

— MCAS Cherry Point —

Legend

- Commercial
- Industrial
- Low Density Housing
- Medium Density Housing
- High Density Housing
- Institutional
- Open Space / Agricultural
- AICUZ Footprint, 2001
- Base Boundary
- Airfield

Sources:
1. Havelock zoning map
2. Craven County zoning map

N 0 6000

Scale: 1" = 6000'

Figure
G-5

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Existing Land Use
Bogue Environs

— MCALF Bogue —

Legend

- Commercial
- Industrial
- Low Density Housing
- Medium Density Housing
- High Density Housing
- Planned Unit Development
- Open Space / Agricultural
- AICUZ Footprint, 2001
- Base Boundary
- Airfield

Sources:
1. Emerald Isle zoning map
2. Carteret County zoning map

N 0 6000

Scale: 1" = 6000'

Figure
G-6

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Future Land Use
Cherry Point Environs

— MCAS Cherry Point —

Legend

- Commercial
- Industrial
- Low Density Housing
- Medium Density Housing
- High Density Housing
- Institutional
- Open Space / Agricultural
- AICUZ Footprint, 2001
- Base Boundary
- Airfield

Sources:
1. Havelock zoning map
2. Craven County zoning map

N 0 6000

Scale: 1" = 6000'

Figure
G-7

Marine Corps Air Station
Cherry Point, NC

AICUZ Update

Future Land Use
Bogue Environs

— MCALF Bogue —

Legend

- Commercial
- Industrial
- Low Density Housing
- Medium Density Housing
- High Density Housing
- Institutional
- Planned Unit Development
- Open Space / Agricultural
- AICUZ Footprint, 2001
- Base Boundary
- Airfield

Sources:
1. Emerald Isle zoning map
2. Carteret County zoning map

N 0 6000

Scale: 1" = 6000'

Figure
G-8

H. AICUZ Implementation

1. General Implementation Strategies

A wide variety of land use strategies oriented toward the Marine Corps, federal, state and local levels are available for encouraging compatible land use within the MCAS Cherry Point and MCALF Bogue AICUZ areas.

Following is a summary of the programs and techniques generally applicable to AICUZ-compatible land use planning, including an analysis of their applicability to MCAS Cherry Point and MCALF Bogue:

A. Federal Strategies

- *National Environmental Policy Act of 1969, Environmental Impact Review*
- *E.O. 12372, Intergovernmental Review of Federal Programs*
- *HUD Noise Regulation 24 CFR Part 51A/B and Federal Housing Administration (FHA) and Veterans Administration loans*

B. Marine Corps Strategies

- Noise Abatement Program
- Easement Acquisition
- Leaseholds
- Fee Simple Title Acquisition

C. State and Local Strategies

- County Planning
- County Airport Zoning
- Subdivision Regulations
- City Planning and Zoning
- Annexation
- Fair Disclosure Statements
- Public Relations and Education Programs

D. Private Sector Strategies

- Acquisition, development and construction loans to private contractors
- Real estate industry cooperation

E. MCAS Cherry Point Strategies

- Activity Responsibilities
- AICUZ Implementation Strategies

2. Federal Level Strategies

A. National Environmental Policy Act of 1969 (NEPA) – *NEPA* mandates full disclosure of the environmental effects resulting from proposed federal actions. An *Environmental Impact Statement (EIS*) disclosure provides an open forum for negotiating changes to other federal agencies actions that would be incompatible with AICUZ objectives.

In situations where another federal agency is preparing a more limited *Environmental Assessment (EA*), which does not require a formal public review, upon becoming aware of the proposed action which is seen as incompatible with AICUZ, objections can be raised with that agency, and resolution of the differences sought with the other agency through this process.

B. Executive Order E.O. 12372, Intergovernmental Review of Federal Programs)- As a result of the *Intergovernmental Cooperation Act of 1968*, the Office of Management and Budget (OMB) requires that all Federal-Aid Development Projects must be coordinated with, and reinforce, state, regional and local planning. If land use compatibility requirements as set forth in the AICUZ for MCAS Cherry Point are adopted by local agencies, then this process can be used by the local jurisdictions to divert federal money away from support of incompatible development in the AICUZ.

C. HUD Noise Regulation, 24 CFR Part 51 A/B- Approvals of mortgage loans from the Federal Housing Administration (FHA) and the Veterans Administration (VA) are subject to this HUD circular. The circular sets forth a discretionary policy to withhold funds for housing projects when noise exposure is in excess of proscribed levels. Residential construction may be permitted within 65 Ldn contour, provided sound attenuation is accomplished. The added construction expense of sound attenuation, however, may make siting in these noise exposure areas financially less attractive. Because the HUD policy is discretionary, variances may also be permitted, depending on regional interpretation and local conditions. HUD also has a policy (*24 CFR 51D),* which prohibits funding for projects in Clear Zones and Accident Potential Zones unless the project is compatible with the AICUZ.

3. Marine Corps Level Strategies

A. Noise Abatement Program.-MCAS Cherry Point and MCALF Bogue Field have implemented a number of noise abatement procedures. To limit the noise exposure, certain noise producing events (including maintenance turn on engines, touch-and-go, practice GCA, and low approaches) are normally restricted during noise abatement hours.

B. Property and Property Rights Acquisition Strategies – Acquisition of real estate may involve disruption of existing communities and can result in high monetary cost and substantial litigation. Acquisition of real estate is normally regarded as appropriate when there is reasonable question regarding the ability of the community to institute adequate controls over key parcels in the face of strong market forces for incompatible uses, and when the community lacks the statutory authority to protect against encroachment. For these reasons, such strategies are generally applied selectively and in those instances in which other means of achieving the AICUZ objectives are not effective and where the potential costs involved can be justified.

Acquisition can take one of three forms:

- Fee Simple Purchase: This strategy consists of an outright purchase of title to a parcel of land. As such, a fee simple purchase involves substantial monetary outlays. They do, however, completely assure land uses compatible with AICUZ objectives.

- Easements: Easements involve the purchase of certain rights to the use of real property without the purchase of the actual property. Easements can be purchased for any such property rights including the right to prohibit human habitation and various land uses, the right to prohibit construction of structures without certain insulation standards, the right to release various substances into the air, the right to restrict electrical or light emissions, and numerous other rights. Thus, easements can result in compatible land use development without requiring full purchase of the land.

  The costs of easements will vary with theoretically higher costs for those easements that place higher restrictions on the property's development potential. Some easements, such as the right to prohibit construction of any structures, which significantly removes land development potential, can be costly as a fee simple purchase.

- Land Exchange: A third type of acquisition strategy consists of a real estate exchange program. Instead of purchasing incompatibly-used property, this strategy would exchange property outside of the AICUZ area for the incompatible property located within the AICUZ. A major limitation of this strategy is, of course, the amount of land owned and available for trade that represents an acceptable exchange to the private parties involved.

AICUZ acquisition was pursued in the late 1980s and early 1990s at Cherry Point. At that time approximately 1,300 acres in AICUZ easements and 291 acres in fee were acquired to prevent encroachment in APZs and high noise areas off the end of Runway 32 between NC 101

and NC 306. There are no projects currently programmed for AICUZ encroachment protection land acquisition at either Cherry Point or Bogue Field.

C. Emphasis on Public Awareness - Marine Corps authorities can increase opportunities to create greater awareness of noise conflicts and accident potential in the vicinity of the installation through a public information program.

A forthright and carefully designed program of public relations and education will make owners and residents in the area more aware of the importance of the installation to the local communities and the Marine Corps's desire to be a good neighbor. The Community Plans and Liaison Office at MCAS Cherry Point is active in this area addressing public awareness in both the Cherry Point and Bogue Field environs.

4. State and Local Strategies

The following land use controls and regulations have been identified as potential mechanisms to implement land uses in the AICUZ areas. Many of these controls were discussed in the original AICUZ study and updates of these are described as appropriate. Generally, these means of controlling land use are still applicable and are reassessed in relation to the current conditions. Because control of land use and development is essentially a function of local government, those strategies which impact local land use regulations are the most likely to result in achieving the AICUZ land use objectives. This does not mean that other potential strategies should not be pursued if appropriate, but that the primary strategies should be those most directly related to control of future development.

A. Zoning - Compatible Zoning within the airport imaginary surfaces areas in all of the jurisdictions should be undertaken to provide airfield height protection for areas and the avoidance of creation of airport hazards. Strengthening of zoning regulations can provide additional protection.

B. Subdivision Regulations - The political jurisdictions in the MCAS Cherry Point and MCALF Bogue Field environs all have adopted subdivision regulations. As a general policy, all subdivision reviews should include an analysis of the potential effect the AICUZ will have on the proposed development. Modifications could then be instituted in the development plan to minimize the potentially adverse effects. The local government jurisdictions have not specifically included AICUZ impact analysis requirements in current subdivision regulations with the exception of Carteret County's requirement for noise disclosure on subdivision plats.

C. Building Codes - Building codes govern the construction and physical modification of structures, which can provide a means to control noise. Presently, the local municipalities enforce the use of building codes. Although the building code contains requirements more specifically keyed to local construction needs, these codes also include provisions concerning administration and enforcement.

Building codes could serve as an implementation mechanism strategy not only for their application to areas within the defined AICUZ area, but also for surrounding areas, which are impacted by the noise levels to a lesser degree. Minimum amounts of noise suppression materials in new structures could be related to the location of the structure in relation to air operations. Existing compatible and incompatible structures, however, will generally not be

impacted by new code modifications of existing structures, the need for which will depend upon the level of noise and types of land uses affected.

On the federal level, incentives have been implemented to encourage home thermal insulation and the installation of solar heating units. Similar incentives could be used to encourage the installation of noise suppression materials. To some extent, thermal building insulation measures will also assist in noise suppression.

Additional modification of the building code could require that the physical orientation of a newly constructed building be related to aircraft noise. For example, the amount of window openings could be oriented away from the major sources of noise. Efforts to this end may be accomplished during the review of a subdivision plat.

D. Capital Improvements Programs - In large undeveloped areas, which are not currently served by public facilities such as sewer, water, or surfaced roads, expansion of such public facilities could be limited so that land within the AICUZ currently not served would remain unserved.

E. Comprehensive Planning Programs - A Comprehensive Plan is a plan for the future development or redevelopment of a community. The Plan, a policy guide for physical development and land management practices within a local jurisdiction, consists of a variety of Subplans relating to the various elements of a community (e.g., Land Use Plan, Transportation Plan, Public Utilities Plan, Housing Plan, etc.).

An updated Comprehensive Plan coordinated with the AICUZ land use objectives will reinforce the overall vision and objectives of the municipality helping potential developers to stay in tune with the long-range goals for the township and help promote compatible uses in the areas impacted by MCAS Cherry Point operations.

F. HUD Restrictions - The United States Department of Housing and Urban Development (HUD) has instituted a policy "*to foster the creation of controls and standards for community noise abatement and control by general purpose agencies of state and local governments....*"

Included among the various policies are: (1) a requirement that noise exposures and sources of noise be given adequate consideration as an integral part of urban environment in connection with all HUD programs, which provide financial support to planning; (2) a withholding of HUD assistance for the construction of new dwelling units on sites (which have or are projected to have unacceptable noise exposures), or are in Clear Zones or incompatible uses in APZs; (3) encouragement of modernization efforts for existing buildings in noise environments; and (4) grants and allowances to state and local governments to provide acoustical privacy in multi-family dwellings through building design and acoustical treatment. Generally, external noise exposure within Noise Zone 3 is considered unacceptable and within Noise Zone 2 is normally unacceptable with respect to new construction. HUD funds may also be available to encourage noise abatement planning and acoustical treatment for proposed and existing incompatible land uses within the AICUZ.

G. Public Purchase of Open Space - A primary means to assure that land is compatible with the AICUZ objectives is for the land to be under public ownership. This has

been pursued in some jurisdictions in the past. The purchase of undeveloped lands in the AICUZ could also be considered where appropriate.

H. Fair Disclosure Statements - Fair disclosure can be approached as a voluntary or regulatory practice. Regulations currently provide various approaches to fair disclosure in various jurisdictions. Conceptually these provisions require that developers or landowners who own property falling within the AICUZ area must notify any prospective purchaser of such property of the existence of the noise and safety exposure. This concept could be strengthened by having each buyer or renter execute a "*Disclosure Statement*," which contains the language that acknowledges that the buyer or renter has been advised that this property is adjacent to a military airport and installation and is within an "airport noise or safety area." While the concept of disclosure has been applied in varying degrees in the past, the application should be revisited where not found to be effective.

5. Private Sector Strategies

A. Acquisition, Development and Construction Loans to Private Contractors - This strategy encourages review of noise and accident potential as part of the lender's investigation of potential loans to private interests for real estate acquisition and development. Diligent lending practices will promote the compatible development of Craven and Carteret Counties adjacent to MCAS Cherry Point and MCALF Bogue Field, and protect lenders and developers alike. Local banking and financial institutions should be encouraged to incorporate a "*Due Diligence Review*" of all loan applications, including a determination of possible noise or APZ impacts on the mortgaged property. The Marine Corps can play a role in this strategy by providing AICUZ information to lenders throughout the region.

B. Real Estate Industry Cooperation – Recent events in the real estate industry have brought into focus the Realtor/Broker responsibility for accurate and full disclosure of facts related to real estate transactions. Both licensed real estate professionals and private individuals have recently been found to have liability for economic damages incurred by a purchaser for conditions which may affect the use or enjoyment of property, where those conditions were not disclosed to the purchaser prior to the time of sale. The moral issue of full disclosure is an important element in the future success of AICUZ. Voluntary actions could preclude the need for regulatory action in this area.

The voluntary incorporation of a notice that a property is in an airport noise or accident zone in standard disclosure statements signed by prospective purchasers and renters (similar in concept to those acknowledging the presence of lead paint in a house; siting in a floodplain or wetland area, etc.) would ensure a buyer or renter was aware of the environment the property is exposed. These provisions reinforce the real estate industry moral responsibility to notify potential future residents and businesses of possible AICUZ impacts prior to sale or rental.

6. MCAS Cherry Point Strategies

A. OPNAVINST 11010.36A outlines activity responsibilities as follows:

(1) Familiarize themselves with the AICUZ Program.

(2) Implement an AICUZ Program for the air installation following the concepts set forth here.

(3) Actively work with state and local planning officials to implement its objectives.

(4) Notify the chain-of-command and the AICUZ Program Office whenever local conditions merit update or review of the AICUZ Plan.

(5) Promote attendance at OPNAV-sponsored AICUZ Seminars by Commanding Officers, Executive Officers, Air Operations and Air Traffic Control Officers and other aviation-related staff personnel to increase awareness of current trends and techniques for AICUZ Program development and implementation.

(6) If appropriate, designate a Community Liaison Officer to assist in the execution of the AICUZ Plan by the installation and act as a spokesperson for the Command in AICUZ matters.

(7) Maintain a documentary file on the implementation of the AICUZ Plan at the air installation. Such a file should contain, among other things, a chronological narrative of important events, newspaper articles, data and referenced aerial and ground photographs, and pertinent correspondence.

(8) Provide assistance in developing AICUZ information, including operational data needed to update the AICUZ Plan.

(9) Justify the retention of land or interests in land required for mission performance.

B. AICUZ implementation Strategies should also emphasize the following:

(1) Monitor Development Activity.

Land development activity should be monitored as an early warning system for identifying and minimizing conflicts between land development and air operations. Regular communication with city and county governments, federal mortgage agencies, and local developers and property owners should aid in pinpointing properties that are within the AICUZ footprint that are being considered for development. Appropriate Marine Corps action can then be developed in the early stages of the development process.

(2) Public Information.

MCAS Cherry Point has shown great concern for its surrounding communities in the past. Marine Corps personnel should continue to develop opportunities to interact positively with the public to minimize any negative attitudes or misconceptions, which may precipitate unwarranted complaints. Personnel in charge of receiving and logging noise complaints should respond courteously to callers and ensure proper procedures are followed in the processing of complaints.

The Marine Corps should seek every opportunity to publicize the current conditions in the noise environment and their impact upon development in the area. The AICUZ pamphlet, including a map of the new AICUZ footprint, should be sent to all of the impacted political jurisdictions, civic and public institutions, businesses, property owners within the AICUZ, and to other affected citizens in the vicinity.

The public education program should inform citizens and local governments of the benefits of coordinating land use within the AICUZ land use objectives. This will require coordination with local planning commissions and governmental officials. These civic leaders should be briefed on the AICUZ study and its implications for local land development.

(3). Support Local Regulation and Planning.

The AICUZ areas at MCAS Cherry Point are largely within the City of Havelock and Craven County while the AICUZ areas of MCALF Bogue are largely within Carteret County and the Towns of Bogue and Emerald Isle. Municipalities should be encouraged to enact protection of areas within the imaginary surfaces of the airport to control heights.

The Marine Corps can also exercise an active role in monitoring and supporting land use planning and regulation process. The Counties of Craven and Carteret as well as the City of Havelock through their Zoning Regulations, have recognized the need to protect the public health safety and welfare in areas impacted by aircraft operations primarily through various disclosure strategies. The Marine Corps should continue to strongly support the local jurisdiction's efforts to implement and expand compatible land use control regulations. Specifically, Marine Corps personnel should encourage local planning activities that support implementation of the AICUZ. This will particularly include land use plans and development goals that are compatible with the AICUZ land use objectives.

(4). Acquisition of Property and Property Rights.

While some existing development is incompatible with air operations, the primary focus of AICUZ is normally to prevent future incompatible development. It is not always practicable to turn back the clock on developed areas. There are no AICUZ acquisition projects for MCAS Cherry Point or MCALF Bogue Field in the current Marine Corps future five-year Acquisition Program. Although present conditions within the AICUZ footprint do not appear to warrant acquisition of property or property rights at this time, the Marine Corps should retain this option in case future conditions warrant exercising this option.

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APPENDIX –1

Noise and Its Effect on the Environment

Noise and Its Effect on the Environment

1.0 INTRODUCTION

This appendix contains describes noise, noise effects and provides a list of references on noise and noise effects. This material was assembled from a variety of sources for the AICUZ Seminar and is provided as background information.

2.0 NOISE

A background and description of noise is given in Section 2.1 and noise metrics applicable to this noise study are defined in Section 2.2.

2.1 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 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 impacted by their noise and are typically singled out for special attention and criticism. Consequently, aircraft noise problems often dominate analyses of environmental impacts.

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 which is the number of times per second the air vibrates or oscillates. Low-frequency sounds are characterized as rumbles or roars, while high-frequency sounds are typified by sirens or screeches.

2.1.1 Sound Waves

Sound consists of a series of pressure disturbances or waves moving through air or a similar fluid medium. These pressure waves consist of minute back-and-forth movements of molecules which are caused by the vibration or motion of the sound source.

A simplistic analogy to the motion of sound waves in air is the motion of water waves on the surface of a pond into which a stone is thrown. The outward-moving circles formed by the peaks of the water waves correspond to high-pressure regions in the sound wave moving outward from a sound source; the outward-moving troughs on the water wave correspond to low-pressure regions in the sound wave. The analogy is not quite complete however, since the water waves form expanding circles on the surface of the pond while the sound waves form expanding spherical shells in space.

Figure AP-1 illustrates a schematic representation of the instantaneous cross-section of the sound wave emanating from a tuning fork showing that the wave consists of a series of outwardly moving crests and troughs of sound pressure. Since this particular sound is a pure tone, the spacing between pressure "crests" is constant and equal to the spacing between pressure "troughs". The distance between successive crests or successive troughs is called the *wavelength* of the sound wave and is usually designated by the Greek letter "lambda", λ.

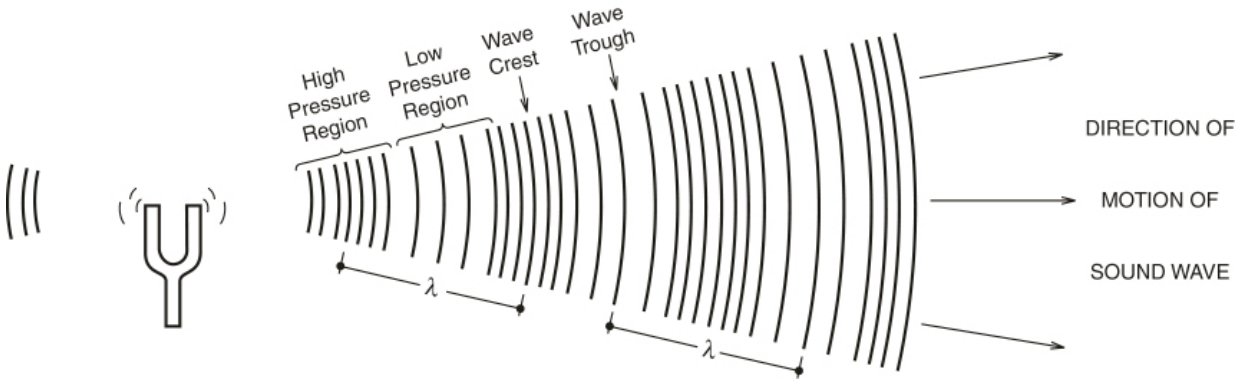

Figure AP-1. Schematic Representation of a Pure-Tone Sound Wave.

This figure represents a cross-section of the wave at one instant of time. As time progresses, each feature of the wave will move outward, away from the source. Thus a particular crest or trough can be thought of as an expanding spherical surface, such as a balloon being inflated. The speed at which any feature of the wave moves outward is called the wave speed or *sound speed*, c. The value of the sound speed is a function of both the type of material through which the wave is propagating and the temperature.

For sound waves traveling through air, the speed is

$$c = 49\sqrt{T_R} \quad \text{ft / sec} \qquad (2\text{-}1)$$

where T_R , the absolute temperature in Rankine (°R), is related to the Fahrenheit temperature, T_F , by the relation

$$T_R = T_F + 460°. \quad (2\text{-}2)$$

Thus, at a temperature of 70°F the speed of sound is

$$c = 49\sqrt{70 + 460} = 1{,}128 \text{ ft / sec}.$$

As the wave travels past a fixed point in space, crests and troughs will continually pass. The time interval between two successive passages of a crest or a trough is called the *period*, T, of the wave. The number of crests, or troughs, that pass the point each second is called the *frequency*, f, of the wave. It is related to the period by the expression $f = 1/T$. The period of a wave is usually measured in seconds. The unit of frequency is cycles per second or *hertz* (abbreviated Hz).

The wavelength, frequency, and speed of a wave are related by the equation

$$\lambda f = c. \quad (2\text{-}3)$$

The range of audible frequencies is nominally 20 Hz to 20,000 Hz (corresponding to periods from 0.05 sec to 0.00005 sec). Since the speed of sound at 70°F is 1,128 ft/sec, the range of audible wavelengths at this temperature is from 56 feet to 0.68 inch.

Sounds with low frequencies and long wavelengths are heard as low-pitched sounds. Those with high frequencies and short wavelengths are heard as high-pitched sounds. Sound below the lowest frequency at which the ear can respond is called infrasound; that above the highest frequency at which the ear responds is called ultrasound.

2.1.2 Sound Pressure and Decibels

While the pitch of a sound is determined by its frequency, the intensity of a sound is determined by the difference between the pressure at the crest of the wave and the pressure of the undisturbed air (normal atmospheric pressure). This pressure difference is called the *amplitude* of the wave, A. Figure AP-2 shows how the pressure at a fixed point in space will vary with time as the crests and troughs of the wave in Figure AP-1 travel past.

A parameter that is often used to characterize the intensity of a sound wave is its root-*mean-square pressure*, p_{rms} . This is defined as the square root of the mean value of the instantaneous pressure-squared, taken over one period of the wave. For a pure-tone wave, the rms pressure is related to the amplitude of the wave by

$$p_{rms} = \frac{A}{\sqrt{2}} = 0.71A \qquad (2\text{-}4)$$

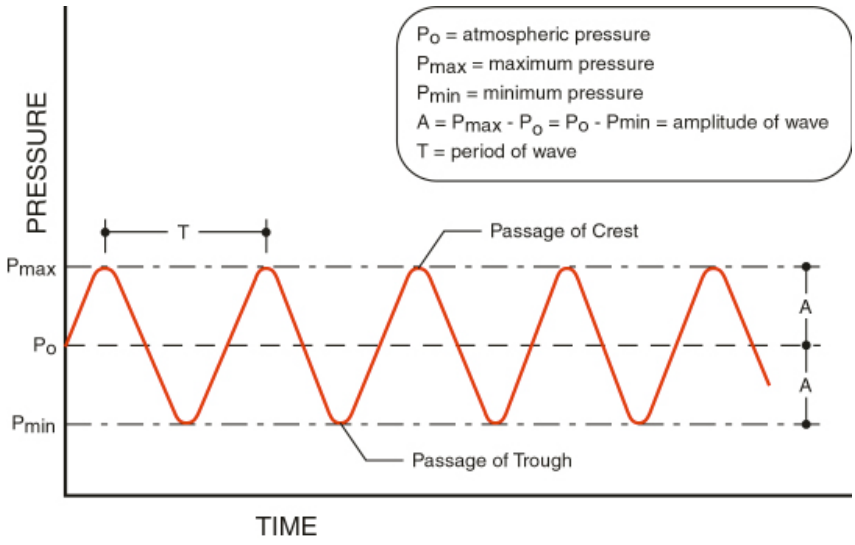

Figure AP-2. Pressure Changes at a Point Due to Passage of a Pure-Tone Sound Wave.

For more complex waves, there is no simple relationship between rms pressure and amplitude. Most modern sound level meters automatically determine the rms pressure by first averaging the squared-pressure of the wave over a pre-defined response time. Two such response times are in common use: *slow* response corresponds to an averaging time of about 1 second; *fast* response corresponds to an averaging time of about 1/8 second. Most

environmental noise studies use slow response measurements, and the adjective "slow response" is usually omitted.

The meter-kilogram-second (mks) unit of pressure is the *pascal* (abbreviated Pa). One pascal is equal to a force of one Newton acting on a surface having an area of one square meter. The minimum discernible sound in quiet laboratory conditions has an rms pressure of about 2 x 10^{-5} Pa or 20 micropascals (abbreviated μPa). The threshold of hearing pain is considered to be approximately 200 Pa. Thus the range of sound pressures likely to be heard extends over seven orders of magnitude (10^7).

To compress this tremendous range into a usable interval and because the brain does not interpret the ear response to changes in sound in a linear fashion, a logarithmic scale is normally used to measure rms sound pressure. The *sound pressure level* of a sound wave having an rms pressure p_{rms} is defined as

$$L = 10 \log_{10} [p^2_{rms} / p^2_{ref}] \qquad (2\text{-}5)$$

where p_{ref} is a reference pressure normally defined as 20μPa (i.e., 20 x 10^{-6} Pa), which is approximately equal to the threshold of hearing in young persons. Although level is really a dimensionless quantity, being the logarithm to the base 10 of the ratio of two squared-pressures, it is normally indicated that the quantity is a level by calling it a decibel. Thus it is said that the sound wave has a sound pressure level of L decibels relative to 20μPa (abbreviated L dB re 20μPa).*

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 about 120 dB begin to be felt inside the human ear as discomfort and eventually pain at still higher levels.

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* The basic definition of a level is the bel, named after Alexander Graham Bell. It is defined as the logarithm of the ratio of two power-like quantities (i.e., functions proportional to the power carried by the wave such as power, power density, or energy)

$$\text{Levels in bels re } W_{ref} = \log_{10} \left[\frac{W}{W_{ref}} \right]$$

where W is the power-like quantity, and W_{ref} is a reference value. In acoustics, the square of the rms pressure is used as the power-like quantity. In addition, since the bel turns out to be too large a unit for convenience, the decibel, which is one-tenth of a bel, is normally used as the unit of sound pressure level.

2.1.3 Decibel Addition and Subtraction

Often more than one source contributes to the sound heard. Because of the logarithmic nature of the decibel unit, sound levels cannot be added or subtracted directly and are somewhat cumbersome to handle mathematically. For example, the sum of two 60 dB levels is *not* 120 dB.

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

To determine the sum of two sound levels, each level must be converted to a squared-pressure; these can then be added.* From Equation (2-5) it can be shown that

$$L_{sum} = 10 \log_{10} [10^{L_1/10} + 10^{L_2/10}] \qquad (2\text{-}6)$$

where L_1 and L_2 are the two sound levels that are to be added.

Example 2-1

The sum of 65 dB and 68 dB is

$$L_{sum} = 10 \log_{10} [10^{65/10} + 10^{68/10}] = 10 \log_{10} [10^{6.5} + 10^{6.8}],$$

$$= 10 \log_{10} [3{,}162{,}277 + 6{,}309{,}573],$$

$$= 10 \log_{10} [9{,}471{,}840] = 70 \text{ dB}.$$

* This assumes that the two sound waves are *incoherent*; i.e., unrelated to each other. This will normally be the case if the waves are generated by different aircraft.

Computations such as these can easily be performed on modern calculators, which have built-in log and 10^x functions.

Subtraction of one sound level from a larger sound level is accomplished in a similar fashion. Both levels are converted to squared-pressures and the resulting quantities subtracted, as follows:

$$L_{dif} = 10 \log_{10} [10^{L_1/10} - 10^{L_2/10}] ; \; L_1 > L_2 . \qquad (2\text{-}7)$$

Example 2-2:

The difference of 70 dB and 68 dB is:

$$L_{dif} = 10 \log_{10} [10^{7.0} - 10^{6.8}]$$

$$= 10 \log_{10} [10{,}000{,}000 - 6{,}309{,}573]$$

$$= 10 \log_{10} [3{,}690{,}427] = 66 \text{ dB}$$

Some simple rules of thumb 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:

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

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

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

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

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

2.1.4 Sound Spectra

So far, only pure-tone sounds have been discussed. Most sounds are much more complicated and cannot be characterized by a single frequency or wavelength. However, no matter how complex the sound wave, it can always be described as a weighted summation of pure tones of various frequencies. The weighting factor for each frequency is a measure of how much sound power of that frequency is contained in the sound wave.

A plot of those weighting factors (Sound Pressure Level, SPL) as a function of frequency is called the *spectrum* of the sound. For a pure tone, the spectrum would be sharply peaked, as shown in Figure AP-3(a). If many frequencies are present, the spectrum will be broadly spread across the audio frequency range as in Figure AP-3(b). Such sounds are called "broadband" sounds. The spectra of two common military aircraft sound sources are shown in Figure AP-3(c), which illustrates the spectrum of an F-16 takeoff, approach, and cruise, and Figure AP-3(d), which illustrates the spectrum of an F-18 under similar conditions.

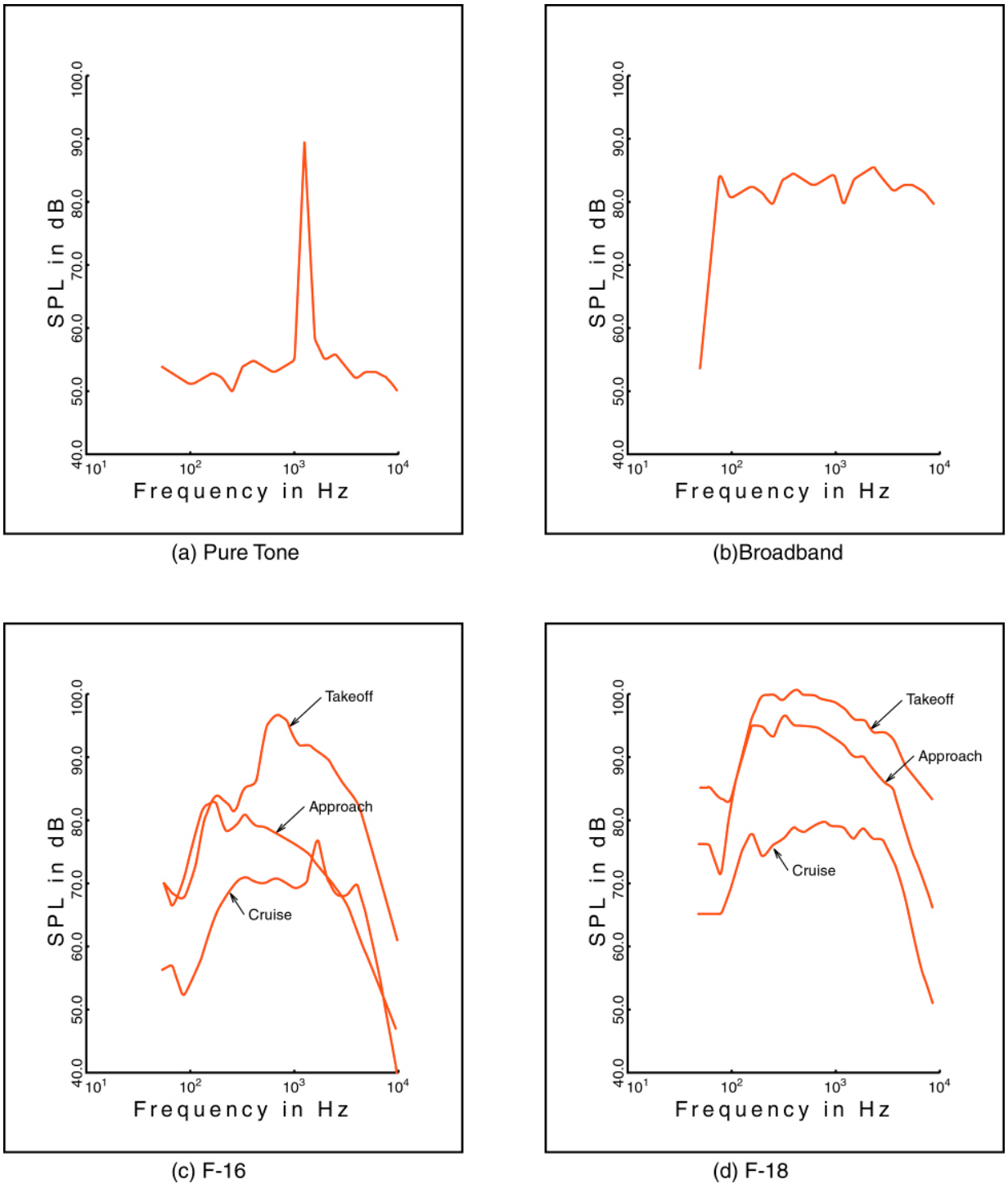


Figure AP-3. Types of Sound Spectra.

Spectra such as these can often be used to determine the precise source of the sound on an aircraft, since any pure-tone components may correspond to engine rotational speeds of components of the engine. Spectra must be used to determine the reduction in level with

distance due to air absorption and ground attenuation as sound propagates through the atmosphere. Finally, the spectrum of a source is necessary to determine the attenuation provided by a barrier or enclosure, such as a hush house.

2.1.5 "CHARACTERISTICS OF AIRCRAFT NOISE"

For an in depth discussion of jet engine noise, propeller aircraft noise, helicopter noise and sonic boom see the accompanying Supplement 1 Characteristics of Aircraft Noise dated 12/98.

2.1.6 HUMAN PERCEPTION

Whether sound is interpreted as pleasant (for example, music) or unpleasant (for example, 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 minimum change in the sound level of individual events which an average human ear can detect is about 3 dB. A change in sound level of about 10 dB is usually perceived by the average person as a doubling (or halving) of the sound's loudness, and this relation holds true for loud sounds and for quieter sounds. A decrease in sound level of 10 dB actually represents a 90 percent decrease in sound *intensity* but only a 50 percent decrease in perceived *loudness* because of the nonlinear response of the human ear (similar to most human senses).

Human response to sound is a complicated function of the physical properties of the sound, the perceptual process within the ear, and the psychological effect that the perceived sound elicits. The first two of these sets of parameters are well defined; the last is less so.

The physical properties of sound waves have been discussed in the previous sections. The loudness of a sound as perceived by the ear is a function of the level and spectrum of the sound. The ear is much less sensitive to low frequencies than it is to high frequencies. Thus, for example, a pure tone at 50 Hz would need to have a sound level about 30 dB higher than that of a tone at 1000 Hz to be perceived as equally loud.

Although the normal human ear can detect sounds which range in frequency from about 20 Hz to about 20,000 Hz, all sounds in this wide range of frequencies, however, are not heard equally well by the human ear, which is most sensitive to frequencies in the 1000 to 4000 Hz range. This frequency dependence is taken into account by adjusting the very high and very low frequencies to approximate the human ear's lower sensitivity to those frequencies. The adjusting is a weighted summation of all of the frequency components in the spectrum of the sound; the weighting function, called "A-weighting", being directly related to the sensitivity of the human ear. "A-weighting" is commonly used in measurements of community environmental noise sources like aircraft.

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, the author will indicate that the 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 **all sound levels** are A-weighted sound levels and the adjective "A-weighted" has been 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.

2.2 Noise Metrics

A "metric" is defined as something "of, involving, or used in measurement." As used in environmental noise analyses, a metric refers to the unit or quantity which 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 or environmental noise abatement has included many different metrics.

Recently, however, various federal agencies involved in environmental noise mitigation have agreed on common metrics for environmental impact analysis documents, and both the Department of Defense and the Federal Aviation Administration have specified those which should be used for federal aviation noise assessments. These metrics are as follows in sections 2.2.1 through 2.2.3.

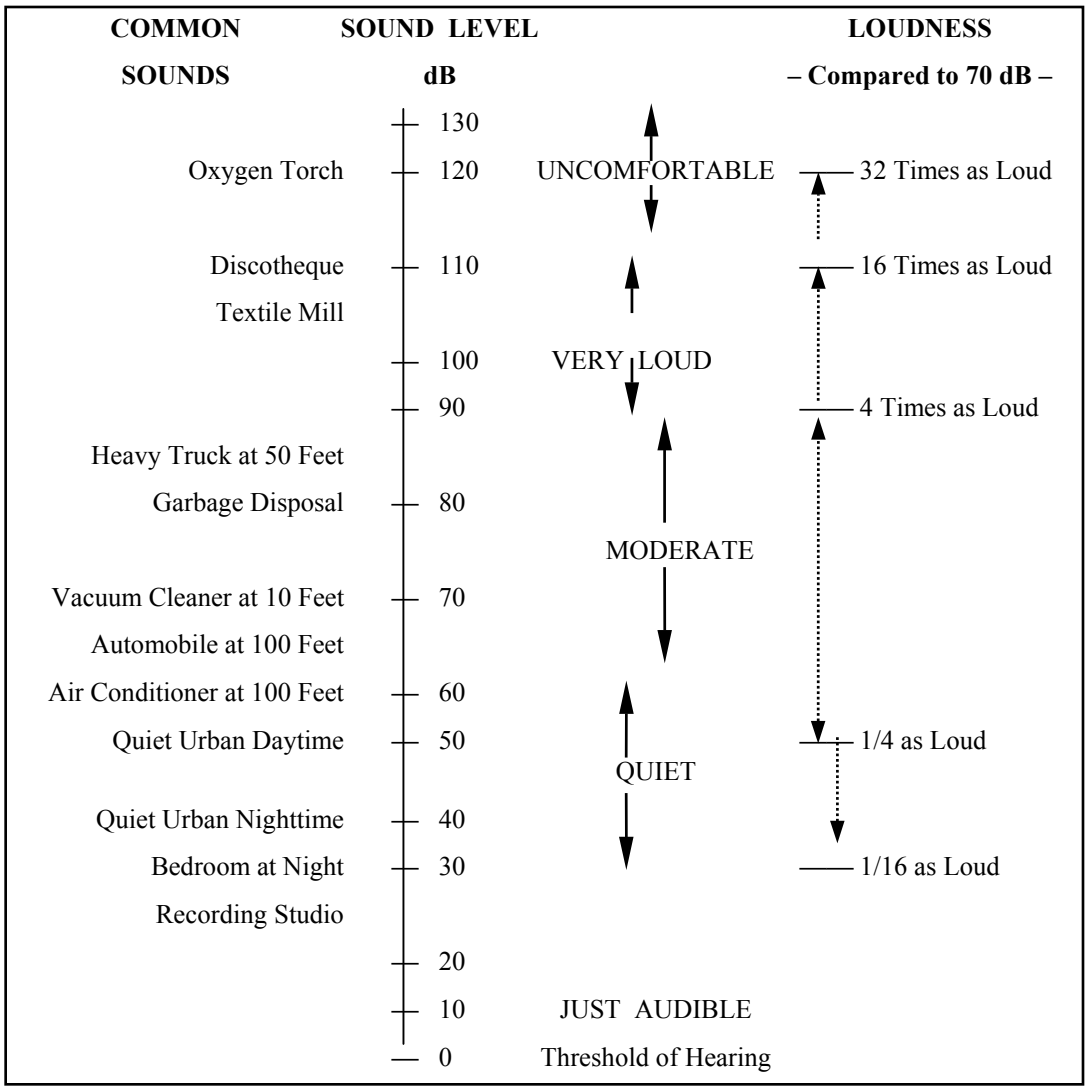
2.2.1 Maximum Sound Level

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 ALM, L_{max} or L_{Amax} .

The maximum sound levels of typical events are shown in Figure AP-4. The maximum sound level is important in judging the interference caused by a noise event with conversation, TV or radio listening, sleep, or other common activities.

2.2.2 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.



Source: *Handbook of Noise Control*, C.M. Harris, Editor, McGraw-Hill Book Co., 1979, and Ref. A5.

Figure AP-4. Typical A-Weighted Sound Levels of Common Sounds.

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 Sound Exposure Level of an overflight is usually greater than the maximum sound level of the overflight.

Note that sound exposure level is a composite metric which represents both the intensity of a 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 has been well established in the scientific community that Sound Exposure Level measures this impact much more reliably than just the maximum sound level.

Because the Sound Exposure Level and the maximum sound level 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.

TIME-AVERAGE SOUND LEVELS

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

2.2.3 Energy-Equivalent Sound Level

The energy-equivalent sound level, L_{eq}, is the level of the continuous constant sound that would contribute to the environment the same amount of A-weighted acoustic energy as did the actual time-varying source. L_{eq} is sometimes referred to as the "average" sound level, although this can be confused with the arithmetic average sound level discussed below. L_{eq} is commonly computed by sampling the time-varying sound level at constant intervals and forming an energy-average of this set of sound levels.

The energy-average of a set of sound levels is the level corresponding to the arithmetic average of the intensities of those sound levels. As a result, the energy-average of a set of levels is always greater than the arithmetic average of those levels.

Example 2-3:

Consider the difference between the energy-average of two levels, L_1= 90dB and L_2 = 80dB, and their arithmetic average. The arithmetic average of these two levels is

$$\bar{L} = \frac{L_1 + L_2}{2} = 85 \text{ dB.} \qquad (2\text{-}7)$$

The energy-average is obtained by

$$L_{eq} = 10 \log_{10} \left[\frac{1}{2} \left(10^{L_1/10} + 10^{L_2/10}\right) \right] = 87 \text{ dB.} \qquad (2\text{-}8)$$

If (L_1, L_2, …, L_N) represents a set of N sound levels sampled at equal intervals over the desired period of time, the energy-equivalent sound level is

$$L_{eq} = 10 \log_{10} \left[\frac{1}{N} \left(10^{L_1/10} + 10^{L_2/10} + \ldots + 10^{L_N/10}\right) \right]. \qquad (2\text{-}9)$$

The term in brackets is proportional to the average of the squared rms pressures corresponding to the N sound levels and thus is a measure of the average acoustic energy received during the measurement period.

The duration of the measurement period, in hours, is often indicated in parentheses following the subscript "eq". Thus, for example, $L_{eq}(1)$ indicates a one-hour average, $L_{eq}(2)$ a two-hour average, and $L_{eq}(24)$ a 24-hour average.

Integrating sound level meters are available which measure not only the instantaneous sound level but also the equivalent sound level during a given period of time.

2.2.4 Day-Night Average Sound Level

For the evaluation of community noise effects, and particularly aircraft noise effects, the Day-Night Average Sound Level (abbreviated DNL or L_{dn}) is used. DNL is similar to the energy-equivalent sound level for a 24-hour period, $L_{eq}(24)$, as it averages aircraft sound levels at a location over a complete 24-hour period, but DNL adds 10 dB to those noise events which take place between 10:00 p.m. and 7:00 a.m. (local time) the following morning. This 10-decibel "penalty" represents the added intrusiveness of sounds which 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.

If L_d is the energy-equivalent sound level for the 15 daytime hours (7:00 a.m. to 10:00p.m. or 0700-2200), and L_n is the energy-equivalent sound level for the nighttime hours (10:00 p.m. to 7:00 a.m. or 2200-0700), then the day-night average sound level is defined as

$$L_{dn} = 10 \log_{10} \left[\frac{15}{24} \times 10^{L_d/10} + \frac{9}{24} \times 10^{(L_n+10)/10} \right]. \qquad (2\text{-}10)$$

Community noise analyzers are currently available which will measure and store hourly equivalent sound levels, and after a 24-hour period compute the corresponding day-night average sound level.

Example 2-4:

Suppose that the equivalent sound level at a given site during the daytime has been found to be 75dB and that during the nighttime has been found to be 70dB. The day-night average sound level is thus given by

$$L_{dn} = 10 \log_{10} \left[\frac{15}{24} \times 10^{75/10} + \frac{9}{24} \times 10^{(70+10)/10} \right]$$

$$= 10 \log_{10} \left[\frac{15}{24} \times 10^{7.5} + \frac{9}{24} \times 10^{8.0} \right],$$

$$= 10 \log_{10} [19{,}764{,}233 + 37{,}500{,}000],$$

$$= 10 \log_{10} [57{,}264{,}233] = 78 \text{ dB}.$$

To see the effect of the 10 dB nighttime penalty, consider what the 24-hour energy-equivalent level would have been in this example. This 24-hour energy-equivalent level, as a function of L_d and L_n, is given by:

$$L_{eq}(24) = 10 \log_{10} [\frac{15}{24} \times 10^{L_d/10} + \frac{9}{24} \times 10^{L_n/10}] . \qquad (2\text{-}11)$$

Thus

$$L_{eq}(24) = 10 \log_{10} [\frac{15}{24} \times 10^{7.5} + \frac{9}{24} \times 10^{7.0}] ,$$

$$= 10 \log_{10} [19{,}764{,}233 + 3{,}750{,}000],$$

$$= 10 \log_{10} [23{,}514{,}233] = 74 \text{ dB}.$$

For airfields which operate continuously for 24 hours, the values of L_d and L_n are approximately equal. In such a case the value of L_{dn} is 6.4 dB greater than the value of $L_{eq(24)}$.

An alternate and simplified definition of DNL is

$$DNL = SEL + 10 \log_{10} [N_d + 10 N_n] - 49.4 \qquad (2\text{-}12)$$

where SEL is the (energy-) average SEL over the 24-hour period, N_d is the number of daytime (0700-2200) events and N_n is the number of nighttime (2200-0700) events.

Day-Night Average Sound Level 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 which occur during the day. For example, a Day-Night Average Sound Level of 65 dB could result from a very few noisy events, or a large number of quieter events. As noted earlier for Sound Exposure Level, Day-Night Average Sound Level does not represent the sound level heard at any particular time, but rather represents the total sound exposure.

Scientific studies and social surveys which have been conducted to appraise community annoyance to all types of environmental noise have found the Day-Night Average

Sound Level to be the best measure of that annoyance. Its use is endorsed by the scientific community (References 1 through 5).

There is, in fact, 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 Day-Night Average Sound Level. This is illustrated in Figure 2-5, which summarizes the results of a large number of social surveys relating community responses to various types of noises, measured in Day-Night Average Sound Level.

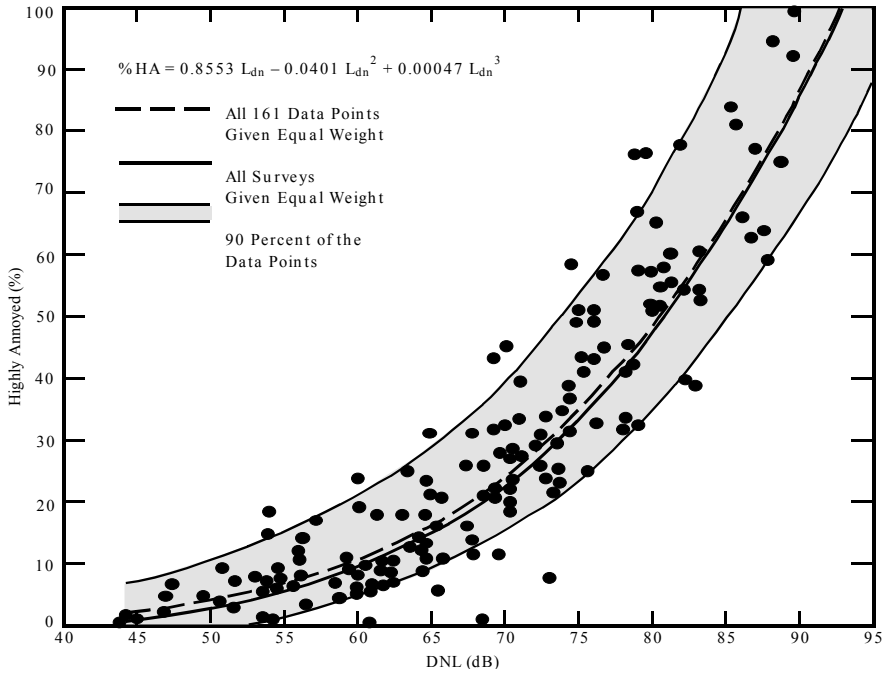


Figure AP-5. Community Surveys of Noise Annoyance.

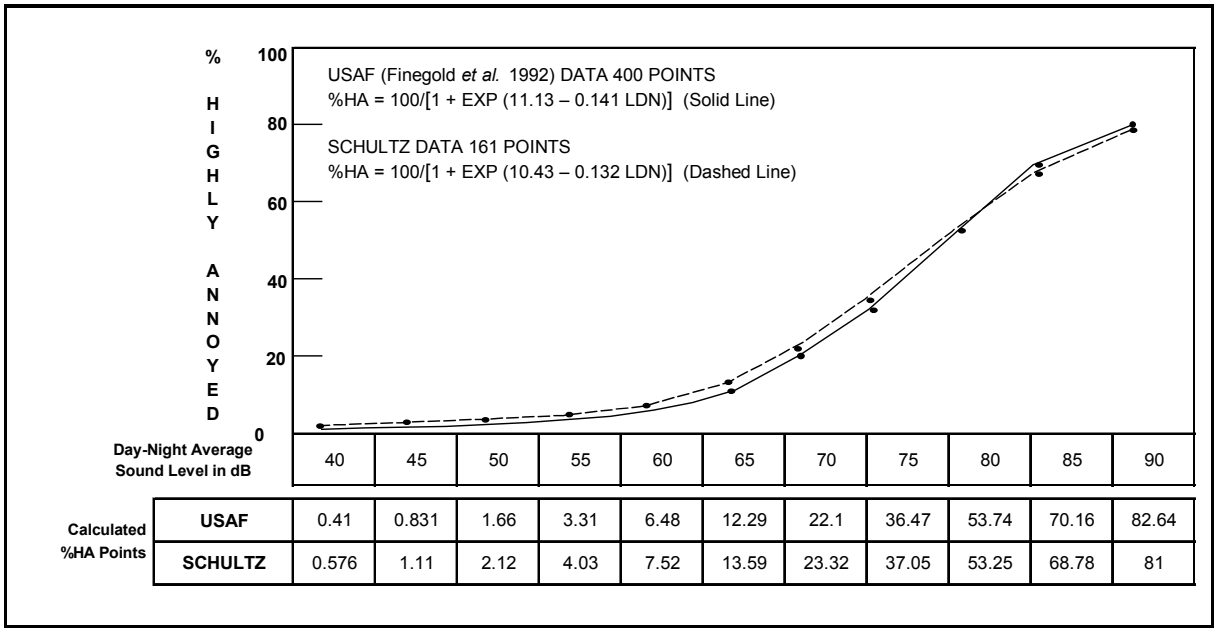
(Reference A6.)

Reference 6, from which Figure AP-5 was taken, was published in 1978. A more recent study has reaffirmed this relationship (Reference 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 which influence the manner in which individuals react to noise. Nevertheless, findings substantiate that community annoyance to aircraft noise is represented quite reliably using Day-Night Average Sound Level.

This relation between community annoyance and time-average sound level has been confirmed, even for infrequent aircraft noise events. Reference 8 reported the reactions of

individuals in a community to daily helicopter overflights, ranging from one to 32 per day. The stated reactions to infrequent helicopter overflights correlated quite well with the daily time-average sound levels over this range of numbers of daily noise events.

In August 1992 the Federal Interagency Committee on Noise published a report entitled *Federal Agency Review of Selected Airport Noise Analysis Issues* (Reference A5) in which the curve of a logistic function was fit to a 400-point data set, which included the data in References 6 and 7. This curve is shown in Figure AP-6. The logistic curve has the advantage that it approaches 0 percent highly annoyed at very low values of L_{dn} and 100 percent at very high values of L_{dn}, which is the behavior that one would expect at these limits.



Day-Night Average Sound Level in dB	40	45	50	55	60	65	70	75	80	85	90
Calculated %HA Points — USAF	0.41	0.831	1.66	3.31	6.48	12.29	22.1	36.47	53.74	70.16	82.64
Calculated %HA Points — SCHULTZ	0.576	1.11	2.12	4.03	7.52	13.59	23.32	37.05	53.25	68.78	81

Figure AP-6. Response of Communities to Noise; Comparison of Original (Schultz 1978) and Current (Finegold *et al.* 1994) Curve Fits

The use of Day-Night Average Sound Level has been criticized recently 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 L_{dn}. One frequent criticism is based on the inherent feeling that people react more to single noise events and not as much to "meaningless" time-average sound levels.

In fact, a time-average noise metric, such as L_{dn}, 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 Day-Night Average Sound Level for this 24-hour period is 65.5 dB. Assume, as a second example, that ten 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 Day-Night Average Sound Level 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 Day-Night Average Sound Level.

2.2.5 Community Noise Equivalent Level

In the State of California, the standard for the evaluation of community noise effects from aircraft is the Community Noise Equivalent Level (abbreviated CNEL). The definition of CNEL is similar to DNL except for the following two components: (1) the daytime period is defined from 7:00 a.m. (0700) to 7:00 p.m. (1900), and (2) an evening period is introduced and defined as from 7:00 p.m. (1900) to 10:00 p.m. (2200), with an approximate five decibel adjustment added to those noise events which occur during that period. The nighttime adjustment of +10 dB is identical to that of DNL.

A simplified definition of CNEL is

$$CNEL = SENEL + 10 \log_{10} [N_d + 3 N_e + 10 N_n] - 49.4$$

where SENEL is the (energy-) average Single Event Noise Equivalent Level over the 24-hour period, N_d is the number of daytime (7:00 a.m. to 7:00 p.m. or 0700-1900) events, N_e is the number of evening (7:00 p.m. to 10:00 p.m. or 1900-2200) events and N_n is the number of nighttime (10:00 p.m. to 7:00 a.m. or 2200-0700) events. SENEL is identical to SEL except that the SENEL is computed only from the top 10 dB of the noise events. In other words, the SENEL only considers the event's sound levels that are within 10 dB of the maximum sound level whereas the SEL considers all of the event's sound levels.

2.2.6 Tone-Corrected Perceived Noise Level

Prior to the advent of DNL and attempts to correlate it (or other *daily* metrics) with community annoyance from aircraft noise, it was common to account for annoyance within the single event noise metric. Developed by Kryter (Reference 9) specifically for fixed-wing jet aircraft flyover noise, Perceived Noise Level (abbreviated PNL) is such a single-event metric. It accounts for annoyance by examining the spectral complexity of the noise.

As mentioned in Section 2.1, the two basic sound characteristics are sound intensity and sound frequency. The relationship between a sound's intensity and frequency is its spectrum – a "frequency profile". To calculate PNL from an aircraft event, the event's spectrum is sampled twice per second. Each sample's frequency profile is split into frequency bands and the sound pressure level of each band is rated on its level of annoyance. The overall annoyance rating is calculated and related back to an overall sound level for the sample – the PNL.

Next, to calculate the Tone-Corrected PNL (abbreviated PNLT or L_{PNT}), each frequency band (of each sample) is examined to detect, via a complex tone-correction procedure (Reference 10), any band whose level exceeds the levels of adjacent bands. The tone-correction can be from 0 dB to 6.7 dB. The resultant PNLT for each sample can then be used to construct a time history of the event.

2.2.7 Effective Perceived Noise Level

The Effective Perceived Noise Level (abbreviated EPNL, L_{PNE}, or L_{EPN}) is the sum of the maximum PNLT and a duration correction. The duration correction is a function of the maximum PNLT and the effective duration of the event. The effective duration is the shortest of the time (a) during which the PNLT remains within 10 PNdB of the maximum PNLT, or (b) during which the PNLT remains greater than 90 PNdB.

2.2.8 Weighted Equivalent Continuous Perceived Noise Level

DNL is not applied world-wide. For the evaluation of community noise effects in the nation of Japan, the Weighted Equivalent Continuous Perceived Noise Level (abbreviated WECPNL) is primarily used. WECPNL characterizes its flyover and run-up noise events with EPNL and PNLT, respectively, whereas DNL is based on A-weighted SEL.

WECPNL is similar to CNEL in that 5 dB is added to those noise events which take place between 7:00 p.m. and 10:00 p.m. (local time) and 10 dB is added to those noise events which take place between 10:00 p.m. and 7:00 a.m. (local time) the following morning.

2.2.9 Onset-Rate Adjusted Day-Night Average Sound Level

Aircraft operations along low-altitude Military Training Routes (MTRs) and in Military Operating Areas (MOAs) and Restricted Areas/Ranges generate a noise environment different from other community noise environments. Overflights can be highly sporadic, ranging from many (e.g., ten per hour) to few (less than one per week). This situation differs from most community noise environments in which noise tends to be continuous or patterned.

Individual military overflight events also differ from typical community noise events, because of the low-altitude and high-airspeed characteristics of military aircraft. These characteristics result in aircraft that exhibit a rate of increase in sound level (onset rate) of up to 30 dB per second. The Day-Night Average Sound Level metric is adjusted to account for the "surprise" effect of the onset rate of aircraft noise on humans with an adjustment ranging up to 11 dB added to the normal Sound Exposure Level (Reference A8.9). Onset rates

between 15 to 150 dB per second require an adjustment of from 0 to 11 dB, while onset rates below 15 dB per second require no adjustment. The adjusted Day-Night Average Sound Level is designated as Onset-Rate Adjusted Day-Night Average Sound Level (abbreviated L_{dnr}). Because of the sporadic occurrences of aircraft overflights along MTRs, in MOAs and Restricted Areas/Ranges, the number of average daily operations is determined from the calendar month with the highest number of operations in each area. This monthly average is denoted L_{dnmr}.

3.0 NOISE EFFECTS

The following noise effect topics are discussed in sections 3.1 through 3.11, respectively: hearing loss, non-auditory health effects, annoyance, land-use compatibility, speech interference, sleep disturbance, domestic animals and wildlife, noise-induced vibration on structures and humans, terrain and historical and archeological sites.

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. Even the most protective criterion (no measurable hearing loss for the most sensitive portion of the population at the ear's most sensitive frequency, 4000 Hz, after a 40-year exposure) suggests a time-average sound level of 70 dB over a 24-hour period. Since it is unlikely that airport neighbors will remain outside their homes 24 hours per day for extended periods of time, there is little possibility of permanent hearing loss below a Day-Night Average Sound Level of 75 dB.

3.2 Nonauditory Health Effects

Nonauditory health effects are those such as hypertension, cardiovascular disease, other nervous disorders, the unborn, mental/social well-being, physiological and stress 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 Institutes 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 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 UCLA researchers apparently found a relation between aircraft noise levels under the approach path to Los Angeles International Airport (LAX) and increased mortality rates among the exposed residents by using an average noise exposure level greater than 75 dB for the "noise-exposed" population (Reference A10). Nevertheless, three other UCLA professors analyzed those same data and found no relation between noise exposure and mortality rates (Reference 11).

As a second example, two other UCLA researchers used this same population near LAX to show a higher rate of birth defects in 1970–1972 when compared with a control group residing away from the airport (Reference 12). Based on this report, a separate group at the U.S. Centers for Disease Control performed a more thorough study of populations near Atlanta's Hartsfield International Airport (ATL) for 1970–1972 and found no relation in their study of 17 identified categories of birth defects to aircraft noise levels above 65 dB (Reference 13).

Other attempts at research of non-auditory effects have resulted in scientific debate over research design. For example, an Air Force Research Laboratory epidemiologic feasibility study concluded that the study of potential health effects of *rural* military overlfights is *not* recommended.

A December 1996 Air Force Research Laboratory review of health effects literature discusses findings that refute adverse effect claims regarding environmental noise.

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

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 as any negative subjective reaction on the part of an individual or group (Reference 3). As noted in the discussion of Day-Night Average Sound Level above, community annoyance is best measured by that metric.

It is often suggested that a lower Day-Night Average Sound Level, 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 Day-Night Average Sound Level of 65 dB:

1. provides a valid basis for comparing and assessing community noise effects,

2. represents a noise exposure level which is normally dominated by aircraft noise and not other community or nearby highway noise sources, and

3. reflects the FAA's threshold for grant-in-aid funding of airport noise mitigation projects.

The U.S. Department of Housing and Urban Development also established a Day-Night Average Sound Level standard of 65 dB for eligibility for federally guaranteed home loans.

For Navy AICUZ noise studies, levels of Day-Night Average Sound Level or Community Noise Equivalent Level equal to and greater than 60 dB are shown.

3.4 Land-Use Compatibility

As noted above, the inherent variability between individuals makes it impossible to predict accurately how any individual will react to a noise event. Nevertheless, when a community is considered as a whole, its overall reaction to noise can be represented with a high degree of confidence. As described above, the best noise exposure metric for this correlation is the Day-Night Average Sound Level or Onset-Rate Adjusted Day-Night Average Sound Level.

In June 1980, an *ad hoc* Federal Interagency Committee on Urban Noise published guidelines (Reference 4) relating Day-Night Average Sound Levels to compatible land uses. This committee was composed of representatives of the United States Departments of Defense; Transportation; Housing and Urban Development; the Environmental Protection Agency, and the Veteran’s Administration. Since issuance of these guidelines, federal agencies have adopted the guidelines for their noise analysis. Following the lead of the committee, the Department of Defense and the Federal Aviation Agency (FAA) adopted the concept of land-use compatibility as the accepted measure of aircraft noise effect. The FAA included the committee’s guidelines in the Federal

Aviation Regulations and they formed the basis for the Navy Suggested Land Use Compatibility in Noise Zones tables outlined in *OPNAVINST 11010.36A*. Although these guidelines and explanatory notes are not mandatory, they provide the best means for determining noise impact in airport communities. In general, residential land uses are normally not compatible with outdoor Day-Night Average Sound Levels above 65 dB, and the land area and population exposed to DNL of 65dB and higher provide a good measure for assessing noise impacts.

In 1990 the Federal Interagency Committee on Noise reviewed how aviation noise effects are assessed and presented. This group reaffirmed the Day-Night Average Sound Level as the best metric for assessing noise impacts on the environment (Reference 5).

3.5 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 aggravation. 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 5).

Indoor speech interference, per Reference 3, can be expressed as a percentage of sentence intelligibility among two people speaking in relaxed conversation approximately 1 meter apart in a typical* living room or bedroom. The percentage of sentence intelligibility is a non-linear function of the (steady) indoor background A-weighted sound level as shown in Figure AP-7. This curve was digitized and curve-fitted for the purposes of this appendix. Such a curve-fit yields 100 percent sentence intelligibility for background levels below 57 dB and yields less than 10 percent intelligibility for background levels above 73 dB. Note that the function is especially sensitive to changes in sound level between 65 dB and 75 dB. As an example of the sensitivity, a 1 dB increase in background sound level from 70 dB to 71 dB yields a 14 percent decrease in sentence intelligibility.

* "Typical" is defined as a room with about 300 sabins of sound absorption which, according to Reference 3, is representative of living rooms and bedrooms.

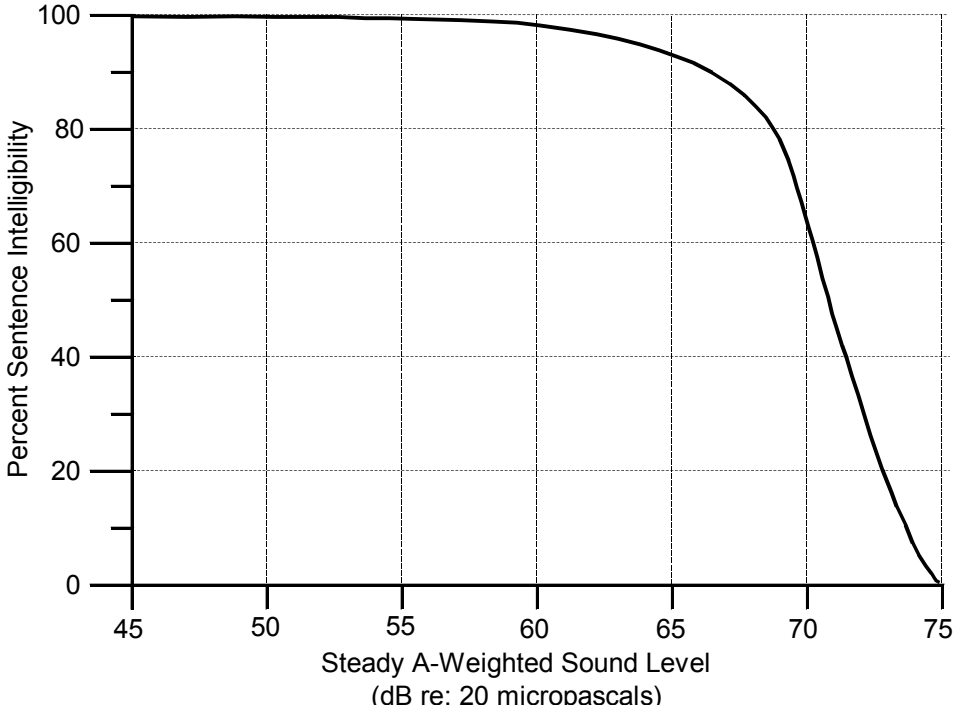


Figure AP-7. Percent Sentence Intelligibility (Reference A3)

3.6 Sleep Disturbance

Sleep disturbance is another source of annoyance associated with aircraft noise. This is especially true because of the intermittent nature and content of aircraft noise, which is more disturbing than continuous noise of equal energy and neutral meaning.

Sleep disturbance can be measured in either of two ways. "Arousal" represents 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 awakening. In general, arousal requires a higher noise level than does a change in sleep stage.

In terms of average daily noise levels, some guidance is available to judge sleep disturbance. The U.S. Environmental Protection Agency identified an indoor DNL of 45 dB as necessary to protect against sleep interference (Reference 3). Assuming a conservative structural noise insulation of 20 dB for typical dwellings, 45 dB corresponds to an outdoor DNL of 65 dB as minimizing sleep interference.

In June 1997, the Federal Interagency Committee on Aviation Noise (FICAN) reviewed the sleep disturbance issue and presented a sleep disturbance dose-response prediction curve (Reference 14), which was based on data from field studies in References 15 through 18, as the recommended tool for analysis of potential sleep disturbance for residential

areas. Figure AP-8 shows this curve which, for an indoor Sound Exposure Level of 60 dB, predicts that a maximum of approximately 5% of the residential population exposed are expected to be behaviorally awakened. FICAN cautions that this curve should only be applied to long-term adult residents.

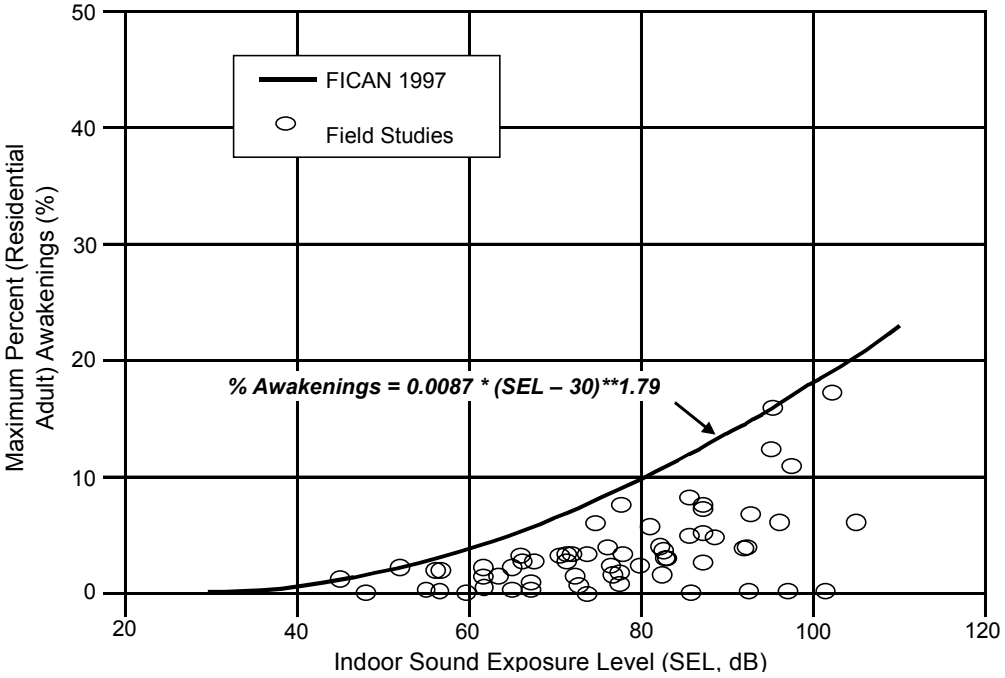


Figure AP-8. Sleep Disturbance Dose-Response Relationship.

3.7 Noise Effects on Learning

Research on the impacts of aircraft noise, and aircraft noise in general, on the cognitive abilities of school-age children has received more attention in recent years. Several studies suggest that aircraft noise can impact performance in schools. Chronic exposure to aircraft noise can result in reading deficits and impaired speech perception (i.e., able to hear common, low-frequency {vowel} sounds but not high frequency {consonants} in speech {Clayton 1978}, {Evans and Maxwell 1977}. Specifically, the Avan's study found that chronic exposure to aircraft noise resulted in reading deficits and impaired speech perception for first and second grade children. Similar studies have found that children residing near Los Angeles International Airport had more difficulty solving cognitive problems (Bronzaft 1997), and elementary school children attending schools near New York's two airports demonstrated lower reading scores than children living further away from flight paths(Green 1982). Although many factors could contribute to learning deficits in school age children (e.g. socioeconomic level, home environment, etc.) the growing body of evidence suggests that chronic exposure to high aircraft noise levels can impair learning. Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks (1997), requires

federal agencies to ensure that policies, programs, and activities address environmental health and safety risks to identify any disproportionate risks to children.

3.8 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.

There are available many scientific studies 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. Some of these studies, conducted by the Air Force Research Laboratory and the North Carolina State University, are briefly described in section 3.8.1 through 3.8.9.

In the absence of definitive data on the effect of noise on animals, the Committee on Hearing, Bioacoustics, and Biomechanics of the National Research Council has proposed that protective noise criteria for animals be taken to be the same as for humans 26).

3.8.1 Kit Foxes

A report on the effect of aircraft overflights on hearing-dependent predator and its prey determined aircraft noise effects on the ecological relationship primarily between the Kit Fox and other small mammals. The study also determined the hearing response of the Kit Fox in controlled testing. The report concluded that:

- the noise made no difference in the home range of the foxes,
- the small mammal prey populations in the control and test groups were similar,
- the animals' hearing appeared unaffected by the aircraft noise and
- simulated overflights did not effect the foxes' ability to detect simulated predator noises.

3.8.2 Desert Tortoise

The Desert Tortoise is a threatened species in the California high desert area that has garnered a lot of public attention in recent years. Claims have been made that sonic booms could be life threatening to the tortoise due to loss of body fluid. A 1997 study of the effect of sonic boom on the tortoise established an interim model of the tortoise response to booms and

established the relationship between the tortoise's heart and metabolic rates The report concluded that:

- the tortoises are more sensitive to sounds than initially expected,
- no temporary threshold shift occurred after a 6 psf simulated carpet boom,
- the tortoises exhibited no acoustic startle response, including defecation or urination and
- there was no significant changes in heart rate or activity after simulated sonic booms.

3.8.3 Caribou

The existence of caribou often depends on the caribou's storage and budgeted use of food energy. There has been public concern that the noise from military overflights harass caribou and cause them to use energy reserves which may be needed for the caribou's survival, especially in food-scarce winter months. A 1994 report of this subject involving laboratory and field studies of Alaskan caribou established a preliminary energetics model to predict the effect of such overflights on a population of caribou.

3.8.4 Bighorn Sheep and Desert Mule Deer

A 1993 study was conducted to determine the effects of F-16 overflights on semi-captive Bighorn Sheep. It was determined that the sheep and deer habituate quickly to the aircraft noise. Their heart rate returned to normal within two minutes of the overflight. Although some sheep ran from the noise of the overflight, they ran less than 10 meters before resuming normal activities.

3.8.5 Domestic Dairy Cattle

Court litigation has claimed the noise from aircraft overflights has caused lower milk production. To establish the relationship between aircraft noise and milk yield, a 1992 study was conducted. Exposed to simulated aircraft noise, the dairy cattle did not show signs of startle nor were their milk yield, fat-corrected milk yield, milk component percentages or residual milk significantly affected. Their release of prolactin and cortisol at time of milking did not differ due to the noise exposure.

3.8.6 Pregnant Mares

People in the southeast US have claimed that aircraft noise has caused mares to bear calves of lower-than-average weight. As no scientific data existed to refute these claims, a recent study was performed on eight experimental and eight control mares to measure the effects of aircraft noise on pregnancy outcome, behavior, rate of habituation, cardiac function, serum cortisol and progesterone concentrations. The study concluded that:

- None of the mares, experimental or control, aborted their calves,
- Gestation length in the experimental group did not differ from the control group,
- Jet noise did not alter the experimental group's stall behavior,
- A significant increase in cortisol occurred after the first noise exposure, but not after further exposures and
- There was no significant difference in colostrum (mother's milk) production.

3.8.7 Domestic Turkeys

Turkeys have been observed to crowd each other in response to loud noises and damage claims have resulted from aircraft overflights of domestic turkey farms. To gain scientific data about the phenomena, research on the relationship between aircraft overflight and response of turkeys. This study determined the effect of noise on weight-gain, mortality and carcass quality. The report concluded that:

- Turkeys habituate quickly,
- Sound Exposure Level (SEL) is the most useful predictor,
- Turkeys responded similarly to simulated and actual overflights
- Aircraft noise effected their behavior in terms of picking, downgrading of carcass quality and handling difficulty.

3.8.8 Waterfowl

Twenty-two species of waterfowl were monitored in the vicinity of the Marine Corps Air to Ground Range on Piney Island, NC during the winters of 1990-91 and 1991-92. Wintering ducks used Piney Island for both feeding and resting. No evidence that waterfowl abundance or species diversity (total number of species) were negatively affected by aircraft activity on or around Piney Island. In fact, both in waterfowl numbers and species composition, Piney Island fared better than in other parts of coastal North Carolina and the Atlantic flyway as a whole. Behavior of captive black ducks housed near the bombing targets on Piney Island quickly habituated to the aircraft noise. This behavior supported the observed lack of disruption of daily activity patterns of field populations of waterfowl. However, some concern was expressed for potential age-specific component to behavior. (Reference 27).

3.8.9 Work in Progress

Other animals currently under study by the Air Force Research Laboratory are domestic chicken poults, marine animals, raptors, ratites and free-ranging Bighorn Sheep.

3.9 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. Figure AP-9 illustrates the sound transmission through a wall constructed with a brick exterior, stud framing, interior finish wall, and absorbent material in the cavity. 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 energy lost in the airspace. This surface then radiates sound into the dwelling interior. As the figure shows, vibration 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 pressures 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 hertz for window breakage) may be of more concern than other frequencies, conservatively, only sounds lasting more than one second above a sound level of 130 dB are potentially damaging to structural components (Reference 28).

In terms of average acceleration of wall or ceiling vibration, the thresholds for structural damage (Reference 29) are:

- 0.5 m/s/s – is the threshold of risk of damage to sensitive structures (i.e., ancient monuments, etc.) and
- 1.0 m/s/s – is the threshold of risk of damage to normal dwellings (i.e., houses with plaster ceiling and walls),

where m/s/s is the nomenclature for acceleration in units of meters per second per second or meters per second squared.

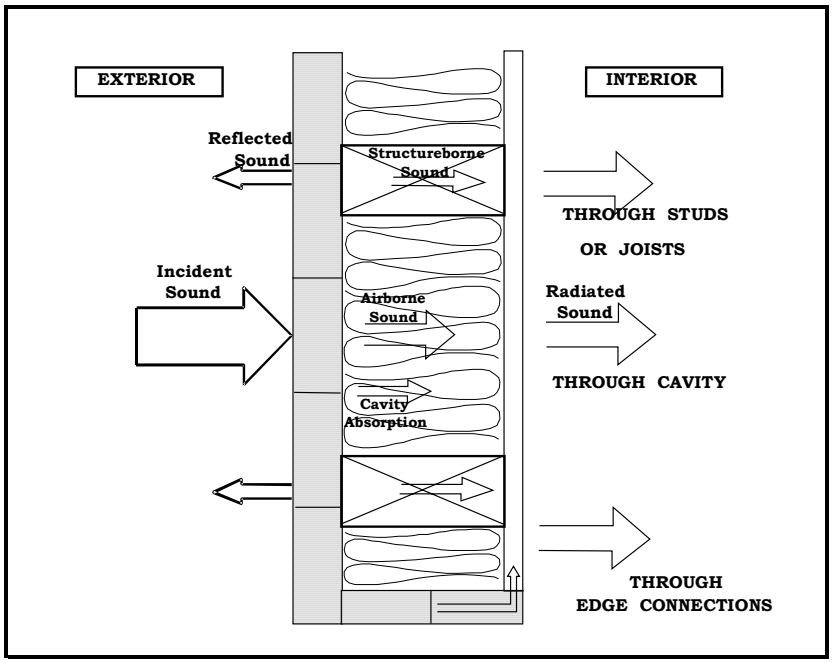


Figure AP-9. Pictorial Representation of Sound Transmission Through Built Construction.

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 airborne 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 vibration on humans, the following factors determine if a person will perceive and possibly react to building vibrations:

1. Type of excitation: steady state, intermittent, or impulsive vibration.

2. Frequency of the excitation. ISO 2631-2 (Reference 29) recommends a frequency range of 1 to 80 Hz for the assessment of vibration on humans.

3. Orientation of the body with respect to the vibration.

4. The use of the occupied space (i.e., residential, workshop, hospital).

5. Time of day.

Table APT-1 lists the whole-body vibration criteria from Reference 28 for one-third octave frequency bands from 1 to 80 Hz.

Table APT-1

Vibration Criteria for the Evaluation of Human Exposure

to Whole-Body Vibration

Frequency (Hz)	RMS Acceleration (m/s/s)		
	Combined Criteria Base Curve	Residential Night	Residential Day
1	0.0036	0.0050	0.0072
1.25	0.0036	0.0050	0.0072
1.6	0.0036	0.0050	0.0072
2	0.0036	0.0050	0.0072
2.5	0.0037	0.0052	0.0074
3.15	0.0039	0.0054	0.0077
4	0.0041	0.0057	0.0081
5	0.0043	0.0060	0.0086
6.3	0.0046	0.0064	0.0092
8	0.0050	0.0070	0.0100
10	0.0063	0.0088	0.0126
12.5	0.0078	0.0109	0.0156
16	0.0100	0.0140	0.0200
20	0.0125	0.0175	0.0250
25	0.0156	0.0218	0.0312
31.5	0.0197	0.0276	0.0394
40	0.0250	0.0350	0.0500
50	0.0313	0.0438	0.0626
63	0.0394	0.0552	0.0788
80	0.0500	0.0700	0.1000

Source: Reference 29.

3.10 Noise Effects on Terrain

It has been suggested that noise levels associated with low-flying aircraft may impact 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.

3.11 Noise Effects on Historical and Archaeological Sites

Because of the potential for increased fragility of structural components of historical buildings and other historical sites, aircraft noise may impact 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 (IAD). These measurements were made in connection with the proposed scheduled operation of the supersonic Concorde airplane at Dulles (Reference 30). There was special concern for the building's windows, since roughly half of the 324 panes were original. No instances of structural damage were found. Interestingly, despite the high levels of noise during Concorde takeoffs, the induced structural vibration levels were actually less than those induced by touring groups and vacuum cleaning.

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

REFERENCES

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

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

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 1974.

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

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

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

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

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

9 “Kryter, K.D., “Scaling Human Reactions to the Sound from Aircraft”, J. Acoust. Soc. Am.,31,1959, 1415-1429.

10 Edge, P.M., Jr., and Cawthorn, J.M., “Selected Methods for Quantification of Community Exposure to Aircraft Noise”, NASA TN D-7977, February 1976.

11 Stusnick, E., and Bradley, K.A., “The Effect of Onset Rate on Aircraft Noise Annoyance. Volume 2: Rented Home Experiment”, AL/OE- TR-1993-0170, October 1992.

12. 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.

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

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

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

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

17. "Federal Interagency Committee on Aviation Noise (FICAN) Effects of Aviation Noise on Awakenings From Sleep", June 1997.

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

19. Ollerhead, J.B., Jones, C.J., Cadous, R.E., Woodley, A., Atkinson, B.J., Horne, J.A., Pankhurst, F., Reyner, L., Hume, K.I., Van, F., Watson, A., Diamond, I.D., Egger, P., Holmes, D., and McKean, J., *Report of a Field Study of Aircraft Noise and Sleep Disturbance*, London: Department of Safety, Environment and Engineering, 1992.

20. Fidell, S., Pearsons, K., Howe, R., Tabachnick, B., Silvati, L., and Barber, D.S., "Noise-Induced Sleep Disturbance in Residential Settings", AL/OE-TR-1994-0131, Wright Patterson AFB, OH, Armstrong Laboratory, Occupational & Environmental Health Division, 1994.

21. Fidell, S., Howe, R., Tabachnick, B., Pearsons, K., and Sneddon, M., "Noise-Induced Sleep Disturbance in Residences Near Two Civil Airports", Langley Research Center, 1995.

22 Clayton, G.D., and F.E. Clayton, editors, 1978, Patty's Industrial Hygiene and Toxicology, Third Revised Edition Vol. 1 General Principles, John Wiley and Sons,NY

23 Evens, Gary W., and Lorraine Maxwell, 1997, "Chronic Noise Exposure and Reading Deficits: The Mediating Effects of Language Acquisition," Cornell University, Ithaca, New York.

24 Bronzaft, Arline L., 1997, "Beware: Noise is Hazardous to our Children's Development", Hearing Rehabilitation Quarterly.

25 Green, Kendall B., 1982, "Effects of Aviation Noise on Reading Ability of School-Age Children," Archives of Environmental Health.

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

27. Fleming, J.W., Dubovsky, J.A., Collazo, J.A., "An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina", North Carolina Cooprative Fish and Wildlife Research Unit North Carolina State University, August 1996.

28. von Gierke, H.E., and Ward, W.D., "Criteria for Noise and Vibration Exposure", *Handbook of Acoustical Measurements and Noise Control*, Third Edition, 1991.

29. "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, Standard 2631-2, February 1989.

30. Wesler, J.E., "Concorde Operations At Dulles International Airport"; Chicago, IL, March 1977," NOISEXPO 1977.

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CHARACTERISTICS OF AIRCRAFT NOISE

At the core of the problem of community response to aircraft noise is the actual sound itself; only through a careful analysis of this unique noise source can these response patterns be understood. Audible aircraft sounds -- those with potential effects on humans -- are of four types: jet engine noise, reciprocating engine noise, sonic boom and helicopter noise. Of the four, noise from the engines of jet aircraft is the most pervasive in the military environment at this time, and is, therefore, of greatest concern to those of -us involved with the AICUZ Program.

Modern military aircraft produce roughly three million times the sound energy of the human voice. For people living or working near military airfield, this noise level can be deafening. The effects are compounded when the noise events are repetitive, occur at night, or are made up of strong, pure tone components.

Unique aspects of each of the four primary noise sources are discussed below.

JET ENGINE NOISE

Jet engine noise comes from two primary sources: turbulent mixing and rotational noise. Turbulent mixing of the exhaust gases from the engine exhaust with the relatively still air outside of the engine occurs in a region extending far beyond the nozzle. Escaping gasses at the nozzle, in fact, have very little turbulence. It is not until about 4½ nozzle diameters from the exhaust opening that the smooth flow core ends and turbulence increases to the point of noise formation. The turbulent area extends many diameters behind the nozzle, and sound is produced at differing frequencies, with their location dependent on the number of nozzle diameters distance from the exhaust opening. Higher frequency sounds are produced closer to the nozzle, and the lower frequencies farther away.

For normal exposure distances, the single discrete point at which the sound is generated becomes insignificant, and jet exhaust noise can reasonably be considered as originating from a single point.

The exhaust noise from typical commercial aircraft is broadband in nature, with the predominance of acoustic energy concentrated in frequencies below 2,000 Hz.

Exhaust noise from jet aircraft is concentrated in two lobes which extend at approximately 45-degree angles to the rear of the aircraft. Thus, the listener experiences sound of maximum intensity after the aircraft has passed his position at a distance equal to the distance to the aircraft's flight path.

A second source of jet aircraft noise is that produced by the rotating parts of the engine. In discussing rotational noise, the type of engine must be considered. Both the turbojet and the turbo-fan engines produce internal machinery noises, which are of a broadband nature. However, pure tones are more predominant in rotational noise than in exhaust noise.

The turbojet engine produces such high levels of exhaust noise that the rotational whine of the compressor mechanism is rarely heard. Engine whine is usually heard only when the engine is operating at low thrust while taxiing or in an approach configuration.

In the turbo-fan engine, such as is used in the S-3, air entering the engine and passing through the fan is exhausted before entering the combustion chamber. This bypassing of air results in an engine with much quieter exhaust noise, but increased whine from the compressor fan. This whine is made up of pure tone frequencies in the 2,000 Hz to 4,000 Hz range, which radiate from turbo-fan engines.

A new generation of turbo-fan engines used in the wide-bodied civil aircraft includes internal modifications and higher ratios of bypass air to combustion air. This higher bypass ratio reduces the exhaust noise; including lowering the frequencies of fan noise to ranges which are less annoying to humans. This has been moderately successful in civilian aircraft. However, the civilian aircraft noise reductions do not translate directly into military aircraft. As evidenced by the transition from the F-14 to the F/A–18, which brought with it a major increase in aircraft, noise for the navy.

PROPELLER AIRCRAFT NOISE

In recent years, noise has directed a great deal of attention at jet aircraft, but we would do well not to forget the propeller aircraft just yet. Jet powered aircraft dominate both the military and the air carrier fleet, but almost 80 per cent of all aircraft in service are powered by reciprocating engines. Such engines dominate the general aviation fleet. While 90 per cent of all air carrier aircraft are jet powered, only 1½ per cent of the general aviation fleet is.

As vertical and short take off and landing (V/STOL) aircraft assume increasing importance - as they are expected to do - reciprocating engines may return to more widespread use. Because this type of aircraft is best suited to short haul, close-in service, its potential noise impact on urban populations should be carefully watched.

Noise from reciprocating engine, propeller aircraft comes from two primary sources within the engine/propeller assembly. These two sources are both associated with the propeller; exhaust noise is relatively insignificant in modern aircraft. Each of the two types of noise has a counterpart in the noise of a jet engine.

Rotational noise is the propeller counterpart of the turbo-machinery noise of the jet engine. It is produced as the blades of the propeller rotate, producing an oscillating pressure field whose frequency is dependent on the rotational frequency of the propeller and the number of blades. Rotational noise has higher pure tone components than the more broadband vortex noise.

Vortex noise is the turbulence noise produced by the vortices shed by the propeller tips. At its extreme, vortex noise can be a popping sound, not unlike rotor blade slap, discussed in a subsequent section. As previously mentioned, it is of a more broadband nature than the rotational noise. Vortex noise is the counterpart of jet engine exhaust noise. The exact mechanics of vortex noise is discussed below in the section on helicopter noise.

In general, commercial propeller driven aircraft produce noise that is from 25 to 30 EPNdB below jet powered aircraft. The difficulty lies in the fact that the environment in which propeller aircraft operate may be much closer to centers of population in the future. The importance of propeller aircraft noise is dependent on future trends in general aviation and V/STOL aircraft for commercial use.

HELICOPTER NOISE

While helicopter noise is of relatively minor importance in the civil aviation environment today, its importance may increase dramatically in the coming years. Helicopter noise contains all of the components of propeller noise found in fixed wing aircraft, but with one important addition -- rotor or blade slap. Rotor or blade slap is a characteristic and very distinctive sound, common only to helicopters. It is best described as a popping or “whup-whup” sound.

With the recent increased use of turbine engines in helicopters, the roar of piston engines has been eliminated, and the blade slap is, therefore, more obtrusive. Whine from the turbine engines is, however, noticeable.

There are three prevalent theories as to what causes blade slap. The most common theory is that, the characteristic sound is caused when a following blade passes through or near the tip vortex of a leading blade. Other theories postulate that the sound is caused by periodic stalling and unstalling of blades or by the formation of a shock wave by localized super-sonic flow near the blade tip.

Blade slap-sound energy falls within the 20 Hz to 1,000 Hz range, with the maximum intensity around 200 Hz. This blade slap may result from more than one of the three possible mechanisms mentioned above, depending on the forward velocity of the helicopter.

There are currently no significant passenger carrying helicopter operations in this country. There are, however, approximately 30,000 military helicopters in the world. The growth in helicopter technology has lead to increased commercial use of helicopters.

Blade slap and other helicopter noise sources and their effects on humans are especially worthy of further study. This need is reinforced because the helicopter is expected to play a strong role in inner city and short haul transportation in the future. One has only to look around to find that the future is almost upon us.

SONIC BOOM

The fourth -- and least significant type of aircraft sound in this country -- is sonic boom. Sonic boom is the pressure wave that radiates behind an aircraft while in supersonic flight. When this wave reaches the surface of the earth, an overpressure or characteristic "boom" occurs. Sonic boom has a wide variety of effects within the "boom carpet" that is laid down behind and below the aircraft. The area of effect can extend up to eight miles on either side of the flight path. Aircraft fly at supersonic speeds only on long distance flights, and reach supersonic speeds only after a long climb out.

It appears that for the foreseeable future, this country will be exposed to sonic boom only from military aircraft. Generally, these military aircraft fly at supersonic speeds only at extremely high altitudes and over sparsely populated areas. Consequently, large concentrations of people are seldom exposed to sonic boom. There is a Federal Aviation Administration prohibition against civil aircraft flying at supersonic speeds over the landmass of the United States.

The Secretary of Transportation agreed to permit the Anglo-French Concorde to land at Dulles and John F. Kennedy International Airports. Flights into the United States operate only at subsonic speeds over the land. The controversy over allowing the Concorde to land in this country centered on sideline noise levels, and did not concern sonic boom.

There is no threat at present that supersonic civil aircraft will be allowed to produce sonic booms in the airspace above the United States.

Sonic boom can be destructive to structures beneath the aircraft. Such destruction -- real or potential -- can aggravate and compound the residents' attitude toward the aircraft or the military authority responsible for the supersonic flight.

In describing the potential effect of sonic boom on a house, Dr. Harvey H. Hubbard of NASA says that the house, "…is forced laterally as a result of the initial positive loading on the front surface. Then it would be forced inward from all directions, then forced outward and finally forced laterally again because of the negative pressures acting on the back surface." In view of the high pressures often involved in sonic boom, these forces can bring about significant structural damage.

APPENDIX –2

LIST of ACRONYMS

ACRONYMS

AESO	Aircraft Environmental Support Office
AGL	Above Ground Level
AICUZ	Air Installations Compatible Use Zone
APZ	Accident Potential Zone
ATC	Air Traffic Control
BASH	Bird Aircraft Strike Hazard
BRAC	Base Realignment and Closure
CCA	Carrier-Controlled Approaches
CDSA	Class Delta Surface Area
CNO	Chief of Naval Operations
COMCABEAST	Commander Marine Corps Air Bases East
CP&L	Community Plans & Liaison
C/L	Center Line
CZ	Clear Zone
DNL	Day-Night Average Sound Level
dBa	A weighted decibel
DOD	Department of Defense
DON	Department of Navy
EA	Environmental Assessment
EIS	Environmental Impact Statement
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FCLP	Field Carrier Landing Practice
FL	Flight Level
FRS	Fleet Replenishment Squadron
GCA	Ground Controlled Approach
HUD	Department of Housing and Urban Development
IFR	Instrument Flight Rules
ILS	Instrument Landing System
LOA	Letter of Agreement
Ldn	Symbol for DNL

LH	Left Hand
MAG	Marine Air Group
MAW	Marine Air Wing
MCALF	Marine Corps Auxiliary Landing Field
MCAS	Marine Corps Air Station
MCOLF	Marine Corps Outlying Field
MSL	Mean Sea Level
MTR	Military Training Route
MAEWR	Mid-Atlantic Electronic Warfare Range
MOA	Military Operating Area
MTR	Military Training Route
NASMOD	Naval Aviation Simulation Model
NADEP	Naval Aviation Depot
NAVFAC	Naval Facilities Engineering Command
NAVAIRSYSCOM	Naval Air Systems Command
NM	Nautical Miles
NOISEMAP	DOD Noise Model
NOTAM	Notice to Airmen
OPNAV	Office of the Chief of Naval Operations
PAR	Precision Approach Radar
RATCF	Radar Air Traffic Control Facility
RCNM	Rotor Craft Noise Model
RH	Right Hand
R/W	Runway
SEL	Sound Exposure Level
T&G	Touch & Go
TACAN	Tactical Air Navigation
UAV	Unmanned Air Vehicles
USMC	United States Marine Corps
VFR	Visual Flight Rules
V/STOL	Vertical/Short Take-off and Landing

REFERENCES

References

1. AIR BASES ORDER 11011.1 Encroachment Control Program of 27 Feb. 1990.

2. Air Installations Compatible Use Zones (AICUZ) Program, OPNAV INSTRUCTION 11010.36A of 11 April 1988.

3. Airfield and Airspace Operational Study for the 1995 BRAC Realignment of Navy F/A-18 Aircraft, ATAC Corporation, February 18,1998.

4. Air Operations Manual MCAS Cherry Point, Air Station Order P3710.5F of 5 Sept.1995.

5. Air Operations Manual MCALF Bogue, Wing Order P3710.30C of 25 May 2000.

6. AIR STATION ORDER 3000.2A, Bird Airstrike Hazard (BASH) and Procedures 10 July 95.

7. Air Traffic Activity Reports, MCAS Cherry Point, 1987 through 1998.

8. Air Activity Report for MCALF Bogue Field, NC (1989-1999), MACS 2 February 28, 2000.

9. AICUZ Study for MCALF Bogue, NC, Approved 6 February 1976.

10. AICUZ Study MCAS Cherry Point, NC, Approved 6 February 1976.

11. Airfield and Airspace Operational Study for the 1995 BRAC Realignment of Navy F/A-18 Aircraft, ATAC Corporation, February 18, 1998.

12. City of Havelock Zoning Ordinance, July 29,1975, as Amended.

13. Carteret County Zoning Ordinance, Adopted June 15,1990.

14. Cherry Point Complex Master Plan, Circa 1980/1981.

15. Cherry Point MCAS Master Plan, 1988.

16. Environmental assessment (DRAFT) for the Introduction of the KC-130J to the 2nd MAW, MCAS Cherry Point, NC, Department of Navy, USMC, June 2000.

17. Environmental Impact Statement (DRAFT) for the Revised Land and Resource Management Plan Croatan National Forest, USDA Forest Service Southern Region, November 1999.

18. Federal Aviation Administration (FAA), Objects Affecting Navigable Airspace (14 CFR Part 77), Washington, DC, (as amended) 28 December 1995.

19. Federal Interagency Committee on Urban Noise, Guidelines For Considering Noise in Land Use Planning and Control, Washington, DC, June 1980.

20. Final Environmental Impact Statement, Realignment of the F/A-18 Aircraft and Operational Functions from NAS Cecil Field, FL, to Other East Coast Locations, March 1998.

21. Final Environmental Impact Statement for Introduction of the V-22 into the 2nd MAW, April 1999.

22. Harris, Miller, Miller & Hanson, Inc, Aircraft Noise Survey for MCAS Cherry Point, NC (HMMH Report No.270137) of November 1988

23. Harris, Miller, Miller & Hanson, Inc. Aircraft Noise Surveys: MCAS Cherry Point, North Carolina and MCALF Bogue, North Carolina, (HMMH Report No, 290530.27B) of 28 February 1993.

24. MCAS New River V-22 Introduction Airfield and Airspace Study, ATAC Corporation, March 1999.

25. U.S. Department of Agriculture, Forest Service, Southern Region, CROATAN NATIONAL FOREST LAND AND RESOURCE MANAGEMENT PLAN (Revision 1), November 1999.

26. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Charlotte Sectional Aeronautical Chart-, August 13, 1998.

27. U.S. Department of Housing & Urban Development (HUD), HUD Environmental Criteria & Standards (Noise Abatement & Control), 24 CFR Part 51, Washington, DC, August 13, 1979.

28. Wyle Research Report WR 97-10 Aircraft Noise Study for 1995 BRAC Realignment of Navy F/A-18 Aircraft. February 1998.

29. Wyle Research Report WR-99-02, Aircraft Noise Study for the Introduction of the V-22 to the 2nd MAW, April 1999.

30. Wyle Letter Report J/N 46209 Adjustments to Noise Levels for AV-8B aircraft to reflect F402-RR-406 / RR-408 Engines and Vectored Thrust in Operations at MCAS Cherry Point, NC and MCALF Bogue, 28 September 2001

31. Zoning, Flood, Group Housing, Mobile Home/Park, and Subdivision Ordinances, Town of Bogue, Adopted July 20, 1999