Flint Hills Joint Land Use Study

June 2005

This study was prepared under contract with the communities of the Flint Hills region with financial support from the Office of Economic Adjustment, Department of Defense. The content reflects the views of the communities of the Flint Hills and does not necessarily reflect the views of the Office of Economic Adjustment.

The Policy Committee has agreed to receive the study recognizing that there was not total agreement among the communities on all matters. By receiving this study, local jurisdictions and Fort Riley are not bound to take any action and the study may be used by each jurisdiction as it sees fit.

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Table of Contents

Executive Summary

1. Study Purpose 7

2. Organization 12

3. Background Information 18

4. Technical Information 35

5. Compatibility Options 63

6. Implementation Plan 86

Appendix 1. Sample Real Estate Disclosure Form

Appendix 2. Sample Noise Easement Form

Appendix 3 Sample Memorandum of Understanding

Appendix 4. Sample Noise Reduction Standards for Residential Construction

Appendix 5. Land Use Compatibility Standards

Appendix 6. Fort Riley Environmental Documents

List of Tables

Table 1. Flint Hills JLUS Committee Structure 14
Table 2. JLUS Committee Meeting Dates 14
Table 3. Total Economic Impact, Fort Riley, FY 2003 17
Table 4. Total Personnel & Family Statistics, Fort Riley, FY 2003 17
Table 5. Fort Riley Training Assets 19
Table 6. Population Growth and Projections by County 29
Table 7. Population Growth and Projections by City 29
Table 8. Land Use Compatibility Guidelines, A-Weighting 46
Table 9. Existing Local Government Compatibility Tools 59
Table 10. Meteorological Conditions and Effects on Noise 74
Table 11. Development Constraint Criteria 77
Table 12. Land Use Compatibility Categories and Tools 82

List of Figures

Figure 1	Location Map	9
Figure 2	Regional Context	13
Figure 3	On-Post Activity	24
Figure 4	Air Safety Zones	27
Figure 5	Transportation Systems	28
Figure 6	Community Development Activity	30
Figure 7	Areas of Conservation Interest	32
Figure 8	Environmental Resources	34
Figure 9	Common Sounds and Noise Levels	36
Figure 10	2004 Small Arms Noise Contours	39
Figure 11	2004 Large Arms Noise Contours	41
Figure 12	Proposed AMPTR Noise Contours	42
Figure 13	Existing Land Use and Proposed AMPTR Contours	48
Figure 14	Existing Land Use and AMPTR Contours, City of Riley	49
Figure 15	Existing Land Use and AMPTR Contours, Keats	50
Figure 16	Existing Land Use and AMPTR Contours, City of Ogden	51
Figure 17	Future Land Use and Proposed AMPTR Contours	53
Figure 18	Future Land Use and AMPTR Contours, City of Ogden	54
Figure 19	Zoning	56
Figure 20	Growth and Constraints Analysis Map	79
Figure 21	Land Use Compatibility Map	81

List of Acronyms

AMPTR	Automated Multi-purpose Training Range
APZ	Accident Potential Zone
BFV	Bradley Fighting Vehicle
CZ	Clear Zone
dB	Decibels
dBA	A-weighted decibels
dBC	C-weighted decibels
DNL	Day-night sound level
DoD	Department of Defense
DU	Dwelling Unit
FAA	Federal Aviation Administration
FICUN	Federal Interagency Committee on Urban Noise
ICUZ	Installation Compatible Use Zone
JLUS	Joint Land Use Study
LUPZ	Land Use Planning Zone
MAAF	Marshall Army Airfield
MOA	Military Operations Area
MPRC	Multi-purpose Range Complex
MUA	Manhattan Urban Area
NZ	Noise Zone
OEA	Office of Economic Adjustment
TMDL	Total Maximum Daily Loads
UA	Unit of Action
USAB	Urban Service Area Boundary (Manhattan)

1.1 Introduction

The Flint Hills is a narrow stretch of rolling tall grass prairie that runs across the eastern portion of Kansas into Oklahoma. The region derives its name from the flinty rock that lies beneath the grasslands of the area.

This Joint Land Use Study focuses on the area including the counties of Clay, Geary and Riley, and the cities of Grandview Plaza, Riley, Milford, Ogden, Wakefield, Manhattan and Junction City, which sit within the broader Flint Hills region, approximately 65 miles west of Topeka (see Figure 1 – Location Map). The area is noted for its scenic prairie landscape, recreation opportunities, ranching, agriculture, and education and research associated with Kansas State University.

The military has also been a long-standing presence in the Flint Hills. The Army established Fort Riley as a 24,000-acre cavalry outpost in 1853 to protect westward travelers on the Oregon-California and Santa Fe trails. Over a century and a half of operations, the post's mission, equipment, and weaponry have continually evolved. Factors such as the realignment of tanks, aircraft and weapons systems at fewer installations, the use of more powerful weapons systems, and the increased importance of night training all affect Fort Riley's interactions with its physical surroundings.

The Flint Hills landscape

Similarly, the cities and counties around Fort Riley have grown over the years, reinforcing the close relationship between the military and the nearby community. This interdependence, however, raises the challenge that is central to the Joint Land Use Study effort.

As military installations grow, they bring new people and economic activity to an area. The communities then build houses, schools and infrastructure, and create new jobs to support soldiers, installation workers, and their families. More people begin to live and work in proximity to the noise and accident risks generated by military installations. The presence of such civilian uses can, in turn, place pressure on installations to modify their operations, possibly compromising the overall military mission.

The Department of Defense (DoD) has two major programs designed to address potential conflicts between military and civilian land uses. In 1983, the Army established the Installation Compatible Use Zone (ICUZ) program to identify noise-affected areas around installations and to develop cooperative approaches for reducing adverse impacts. The ICUZ program has since become the Army's Installation Operational Noise Management Plan.

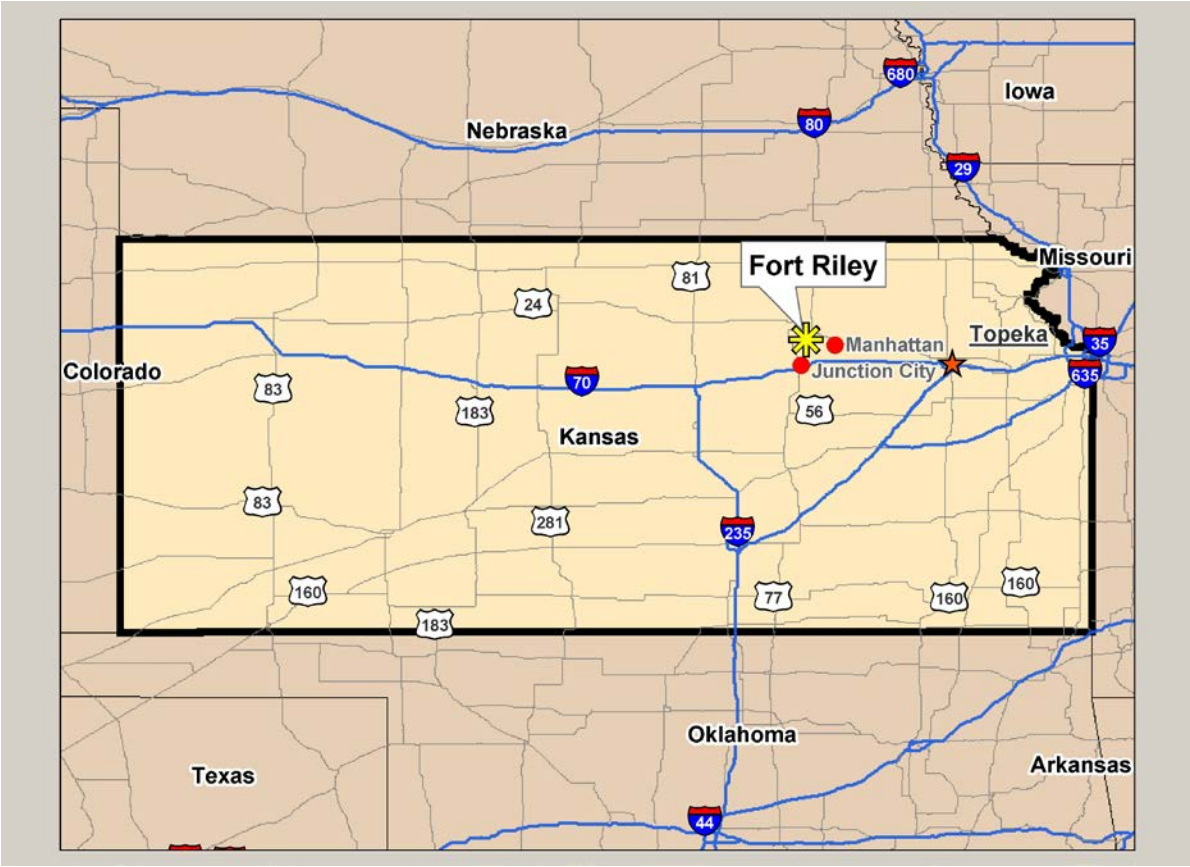
In 1985, the DoD initiated the Joint Land Use Study (JLUS) program to create a participatory, community-based framework for land use planning around military installations. The objectives of the JLUS are two-fold:

1. to encourage cooperative land use planning between military installations and the surrounding community

2. to seek ways to reduce the operational impacts of military installations on adjacent land

The JLUS process encourages residents, local decision-makers, and installation representatives to study issues of compatibility in an open forum, balancing both military and civilian interests. Civilian and military stakeholders joined in initiating this effort for the Flint Hills region as part of DoD's nationwide JLUS program. The Office of Economic Adjustment (OEA) within DoD funded three-quarters of the study, which was further supplemented by the resources and efforts of participating local governments.

Figure 1 Location Map



1.2 Study Goals

The Flint Hills JLUS is the outcome of the public, private and military sectors acting together to achieve the following overall goals:

- Maintain an open, transparent decision-making process that involves the community.
- Sustain the mutual economic growth of both the post and the surrounding communities.
- Understand land use activities on both sides of the fence and find mutually agreeable solutions to reduce impacts and conflicts.
- Protect the mission and existence of Fort Riley.
- Protect the property rights of adjacent landowners.
- Increase community satisfaction with Fort Riley as a good neighbor.

Joint land use planning involves a range of competing and complementary interests. The intent of the JLUS process is to strike a reasonable balance in promoting the diverse goals listed below.

Environment/Natural Resources:

- Manage wildlife habitat.
- Mitigate noise and vibration impacts.

Economic Development/Community Growth:

- Maintain the viability of Fort Riley as a training center that contributes to the regional economy.
- Manage urban growth to limit encroachment associated with Fort Riley's mission, while not hindering local economic development.
- Promote complementary economic goals.

Transportation/Civilian Air Operations/Infrastructure:

- Explore opportunities to create a "win-win" collaboration with improved air service at the Manhattan Regional Airport.
- Evaluate enlargement of designated controlled airspace around the post and any increased use of high performance fixed-wing aircraft for joint training exercises with the Air Force.
- Understand the effects of possible K-18 re-alignment and airport expansion on surrounding areas, especially Ogden.

Military Operations/Mission:

- Maintain the flexibility and adaptability of Fort Riley to meet current and future missions.
- Evaluate plans for increased operations levels on the post.
- Mitigate the operational impacts of the post, particularly noise, on surrounding communities.

Community Outreach/Education:

- Maintain honest, open communication and full public involvement.
- Educate the public about the mutual economic interests of the post and surrounding communities and the impacts of encroachment on Fort Riley.
- Work with the media to publicize public involvement opportunities throughout the JLUS process and into the implementation phase.

Stakeholders gave the following issues the highest priority:

- Minimize any conflict between Fort Riley interests and the interests of adjacent residents/land owners.
- Educate the public and maintain open communication.
- Understand the mutual benefits of an area-wide approach to development and land use decisions.

2.1 Planning Area

The Flint Hill JLUS focuses primarily on Fort Riley, a 100,656-acre installation, and the cities and counties of the Flint Hills region. The post is surrounded by the city of Manhattan and the city of Ogden to the east; unincorporated Riley County and the city of Riley to the north; the city of Milford, Milford Lake, the city of Wakefield, and unincorporated Geary County to the west; and to the south the city of Junction City and the city of Grandview Plaza (see Figure 2 – Regional Context).

The JLUS boundary includes a broad area around the post to ensure that the study team collected sufficient data for the analysis of compatibility issues on all lands that could either affect or be affected by installation activities. The JLUS also examined air safety and access issues related to two civilian airports operating within the region:

- Freeman Field in Junction City, south of the post; and
- Manhattan Regional Airport, three miles west of Manhattan on Highway K-18.

2.2 Participating Stakeholders

One of the most critical goals of the JLUS process is to create a community-based plan that builds consensus from varied interests, including residents and property owners, local elected officials, business interests, and military representatives. The following organizational committees participated throughout plan development to ensure that the JLUS document incorporated a cross-section of opinions and reflected feasible, practical solutions.

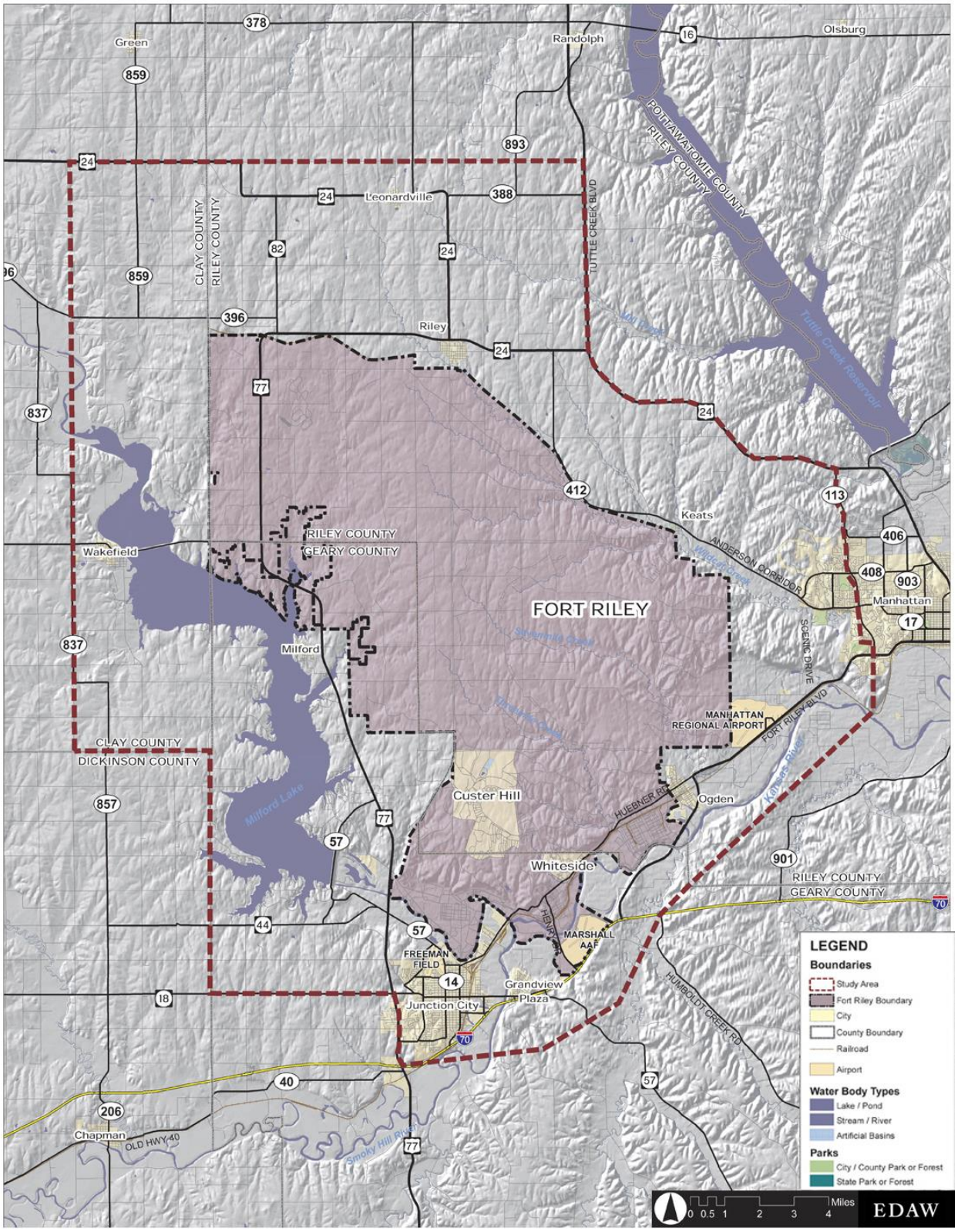
The Policy Committee

This committee consisted of local elected officials from participating cities and counties, military leaders, and an at-large resident representative. The committee gave overall direction to the process and assumed responsibility for receiving the report.

Steering Committee

The Steering Committee consisted of community residents and local property owners, who assisted with developing public outreach strategies and worked in tandem with Technical Committee members to evaluate possible compatibility options.

Figure 2 Regional Context



Technical Committee

The Technical Committee consisted of city and county staff, as well as military planners and information specialists. This committee reviewed technical issues, gave feedback on report development, and evaluated implementation options for the Policy Committee.

Table 1 outlines the general roles and responsibilities of the committees throughout the planning process, as recommended by the DoD Program Guidance Manual.

Table 1. Flint Hills JLUS Committee Structure

Committee	Members	Responsibilities
Policy Committee	City Officials County Officials Post Leadership	Policy Direction Study Oversight Budget Approval Monitoring Receive Report
Steering Committee	Local Residents Property Owners	Public Involvement Tool Evaluation Report Development
Technical Committee	Post Planners City Staff County Staff	Technical Issues Tool Evaluation Report Development

Table 2 shows the dates on which the Policy, Steering, and Technical Committee members met during the JLUS planning study.

Table 2. JLUS Committee Meeting Dates

Policy Committee	Steering Committee	Technical Committee
June 9	June 9	June 9
August 25	July 21	July 21
September 29	August 25	August 25
October 27	September 29	September 29
November 18	October 27	October 27
January 27	November 17	November 17
March 1	January 27	

2.3 Public Participation Opportunities

In addition to the Policy, Steering and Technical Committee meetings, the JLUS process conducted a series of public involvement events in jurisdictions around the post. These meetings gave residents an opportunity to understand the existing issues, review draft tools, and provide input on implementation strategies.

Public workshops were held on:

June 8, 2004 – city of Riley - An overview of the JLUS purpose and goals and a brief summary of existing conditions.

June 9 – city of Ogden - An overview of the JLUS purpose and goals and a brief summary of existing conditions.

August 25 – city of Wakefield – An overview of current compatibility issues.

August 26 – city of Manhattan – An overview of current compatibility issues.

September 29 – Junction City – An overview of community growth trends, foreseeable military operations, and future compatibility issues.

September 30 – city of Ogden – An overview of community growth trends, foreseeable military operations, and future compatibility issues.

December 8 – city of Riley – Open House to review maps and draft compatibility tools.

December 9 – city of Manhattan – Open House to review maps and draft compatibility tools.

January 27, 2005 – city of Junction City – Presentation of draft findings and public comment.

March 1, 2005 – city of Junction City – delivery of the Pre-Final Draft Report.

2005 – Policy Committee accepts report.

In addition to public forums, the JLUS team met with residents and property owners from the Keats community on July 22, and conducted stakeholder interviews with garrison staff, planning staff, and local business and development interests. The team also established a project web site (www.flinthillsjlus.com) which featured draft materials and maps for public review, links to participating entities, technical background on the issues being studied, and an electronic comment form.

3.1 Chronology of Events

This JLUS document is one step in an ongoing effort by the Flint Hills local governments and Fort Riley to address compatibility around the post. The following timeline of actions represents a desire on the part of local and military officials to be proactive in dealing with land use and noise issues and to protect the health and well-being of both the military and civilian communities.

1986	Fort Riley first publishes noise contours as part of the Installation Compatible Use Zone program
Jul 1993	Fort Riley updates the Installation Compatible Use Zone Study
Jun 2001	Fort Riley completes an Installation Environmental Noise Management Plan
Sep 2002	DoD accepts Fort Riley JLUS nomination
Dec 2002	Organizing committee holds kick-off meeting
2003	Organizing committee develops a Request for Proposal for consultants to perform work
Mar 2004	Army updates noise contours with BNOISE2 (Blast Noise Impact Assessment) software
Apr 2004	JLUS contract awarded
Jun 2004	Kick-off meeting for JLUS committees
Jun-Nov 04	Committees study impacts/develop compatibility tools/hold public sessions
Dec 8/9 04	Open House
Jan 27 05	Final Draft JLUS Report

3.2 Economic Impacts of the Installation

Over the years, Fort Riley has become a major economic force in the Flint Hills region. The military and civilian payroll, coupled with spending in goods and services, infuse the regional economy with almost a billion dollars each year. Table 3 demonstrates the economic significance of post operations on the surrounding communities.

Table 3. Total Economic Impact, Fort Riley, FY 2003

Charitable Contributions	$20,850
Construction	$70,228,486
Education	$12,219,181
Health Care	$20,069,531
Payroll	$707,227,138
Supplies/Services/Contracts	$56,937,562
TOTAL Economic Impact	**$866,702,748**

Source: Fort Riley Annual Economic Impact Summary for Fiscal Year 2003

The post has over 11,000 assigned military personnel, almost 5,000 civilian employees, and processed approximately 26,500 annual and weekend reserve component trainees during Fiscal Year 2003. The State of Kansas is also home to approximately 19,000 military retirees dependent on Fort Riley services.

Table 4. Total Personnel and Family Statistics, Fort Riley, FY 2003

Civilians	4,813
Family Members	12,151
Military	11,616
Reserve Trainees	26,539

Source: Fort Riley Annual Economic Impact Summary for Fiscal Year 2003

3.3 Military Mission and History

Fort Riley is steeped in the history of the military and the settlement of the American west. The post contains three historic districts with approximately 287 historic buildings, monuments, and structures.

The installation began in 1853 as a cavalry outpost to secure the largely unsettled western territory. Following the Civil War, Fort Riley was home to the 7th Cavalry Regiment and its commander, General George A. Custer. The famed "Buffalo Soldiers" of the 9th and 10th Cavalry Regiments were also stationed at the fort several times during their history.

The statue of the cavalry soldier "Old Bill," by western artist Frederic Remington

As many frontier forts closed following the end of the campaign against the Native Americans, Fort Riley continued as a site for state militia units to encamp and train.

In the 20th Century, Fort Riley grew to support American participation in major international conflicts. During World War II, some 125,000 soldiers trained at the fort's facilities. It was also during this era that the Army purchased 31,720 acres to expand the post.

In 1955, the 1st Infantry Division, Big Red One, arrived at Fort Riley, signaling the post's transition from a training and educational center to home base for a major infantry division. In 1966, the Army acquired an additional 50,000 acres to accommodate its expanding training needs.

In the spring of 1995, the Army transferred the Headquarters of the 1st Infantry Division from Fort Riley to Germany. But in June of 1999, Fort Riley once again became a Division Headquarters with the reactivation of the 24th Infantry Division (Mech).

Nicknamed the "Victory Division," the 24th ID currently consists of an active component headquarters at Fort Riley and three separate brigades: 30th Heavy Separate Brigade at Clinton, North Carolina, 218th Heavy Separate Brigade at Columbia, South Carolina, and the 48th Separate Infantry Brigade in Macon, Georgia. Active duty units currently stationed at Fort Riley include the 1st Brigade Combat Team, the 1st Infantry Division, the 3rd Brigade Combat Team, the 1st Armor Division, and the 937th Engineer Group.

As America's Warfighting Center, Fort Riley's primary mission is to:

- provide mission ready, deployable forces to Combatant Commanders;
- provide readiness and training oversight to three National Guard Separate Brigades;
- support soldiers and their families with well-being services; and
- provide infrastructure and services to accomplish the mission, while being good stewards of the environment and fiscal resources

3.4 Current and Future Military Operations

Fort Riley facilities provide year-round support for live-fire exercises, maneuver training for mechanized/armored vehicles, attack helicopter gunnery, small arms firing, mortar, artillery and tank firing exercises, and maneuver training for almost all weapons systems in the Army. The installation uses its 100,656 acres of land intensively to accommodate the wide range of mission related activities. Maneuver areas take up 70,000 acres and, when combined with other training areas, equal more than 90 percent of post land. Table 5 shows the military assets currently assigned to Fort Riley.

Table 5. Fort Riley Training Assets

Tracked Vehicles	
Tanks	180
Bradley Fighting Vehicles	110
Other	640
Wheeled Vehicles	3,985
Rotary Wing Aircraft	15

Bradley Fighting Vehicle

Major facilities on Fort Riley include the Douthit Multi-purpose Range Complex (MPRC), a 6,900-acre site in the northwest portion of the post where tanks and Bradley Fighting Vehicles (BFV) travel on existing roads and fire at moving, pop up targets to simulate battle conditions. Primary weapons fired in the MPRC are the 120mm gun on the M1 Tank and the 25mm gun on the BFV.

Douthit Multi-purpose Range Complex

Units also fire the attack helicopter, TOW (Tube-launched, Optically-tracked, Wire command-link guided) missiles, and small arms at the MPRC. All munitions fired in this area of the post are inert (non-explosive).

The Artillery and Mortar Impact Area consists of 16,200 acres in the center of Fort Riley. Soldiers fire both live and inert (non-explosive) rockets/missiles (LAW, AT4, TOW, Dragon, Stinger and 2.75 inch rocket) into the Impact Area. This is the only area of the post where explosive munitions are used. Mortar firing points, rifle ranges, and artillery observation points surrounding the site also accommodate the firing of small arms (shotgun and M16 rifle), machine guns, and TOW missiles. The Impact Area also includes Range 18 in the southern section of the site, which serves as the installation's second gunnery range for tanks and BFV. With the exception of the MPRC and the Impact Area, units use range lands to conduct coordinated maneuvers of troops and vehicles, which may or may not involve the firing of weapons.

The Milford Amphibious Training Area is a 3,000-acre site on Milford Lake north of the city of Milford that supports the deployment of ribbon bridges and water crossings of the BFV. At Range 52 near the Impact Area, soldiers conduct engineering training, such as demolitions, claymore mines, and Mine Clearing Line Practice Charges.

Marshall Army Airfield (MAAF), Fort Riley's on-post airfield, consists of a 4,400-foot long runway (140 feet wide), 40-foot wide taxiways, and 48,000 square yards of parking aprons. The MAAF serves 15 UH-1 helicopters for medical evacuation flight training. The helicopters based at MAAF do not fly set schedules.

The post also has three drop zones: the Milford Drop Zone, the Riley Drop Zone, and the Timber Creek Drop Zone. Air Force C-130 aircraft use the Timber Creek Drop Zone about 25 times a year to drop objects or equipment.

The current military environment is extremely fluid and dynamic. The post has been operating at a high tempo since initiation of hostilities in Afghanistan and Iraq. Fort Riley's foreseeable military mission will continue to evolve as a result of both planned growth on the post and broader Army policy (see Figure 3 – On-Post Activity)

The Army conducted an environmental assessment for a proposed Automated Multi-purpose Training Range (AMPTR) and the upgrading of capabilities at the MPRC. The analysis identified as the preferred alternative the construction of the new automated facility adjacent to the existing MPRC in the northwest portion of the post. The purpose of the AMPTR is to:

- increase training capacity;
- increase training realism;
- conduct coordinated training exercises; and
- allow for digital communications, targeting and scoring equipment.

As discussed more fully in Section 4, operations at the enhanced MPRC and the new AMPTR would affect the post's noise environment. Munitions fired at the facilities would not generate more noise, but additional range capacity would allow for a higher throughput of training units, therefore increasing the intensity and frequency of range use.

The Army also assessed the environmental effects of a proposed Air Assault Landing Zone to support joint operations with the Air Force. The Army's preferred alternative is to construct a new Air Assault Landing Zone near the existing Timber Creek Drop Zone. The purpose of the landing zone is to:

- integrate transport aircraft with ground units; and
- practice the loading, transporting, and off-loading of troops or equipment during assault landings.

The C-130 Hercules and C-17 Globemaster aircraft would conduct exercises at the airstrip about four times each year. Expected aircraft operations would affect the noise environment surrounding the post, particularly for areas west of the installation, such as Wakefield.

Several factors, however, would limit expected increases in aircraft noise, including the use of the airstrip only during short intervals, the integration of new flights into existing air-drop operations, and the flying of low level operations over post land. Noise associated with ground training would not increase in conjunction with planned airstrip exercises.

The Federal Aviation Administration (FAA) designates a significant portion of the airspace around Fort Riley as Class E Controlled Airspace, extending from 1,200 feet Above Ground Level (AGL) to 17,999 feet above MSL. The designation as Class E airspace allows the FAA to manage air traffic in the local area and to protect aircraft during instrument approaches.

The Army is seeking designation of airspace north of the installation as a military operations area (MOA). The area would allow for close air support aircraft, such as Air Force F-16s and A-10s, to fly safer approaches toward the post during joint training operations with ground forces. The MOA eliminates the risk of military and civilian aircraft conflicts by restricting commercial and general aviation aircraft from flying in an area between 7,000 and 18,000 feet above ground level. The FAA would activate this imaginary safe "box" only when military aircraft are flying in the area.

An existing MOA—the Ada Military Operations Area—is in place west of the installation over Clay County. The proposed Riley MOA would link to the Ada MOA and then extend north of the post for approximately 20 miles. Joint military training is becoming more common at installations around the country and the presence of an approved MOA at Fort Riley would enhance the ability of the post to host such exercises.

The Army has also assessed the environmental consequences of proposed urban terrain facilities on post. The preferred alternative is to construct the facilities at five sites on the range area north of Custer Hill and the Impact Area. The proposed facilities simulate urban warfare conditions and would likely increase noise levels primarily on-post due to more small arms firing, vehicle movement, and demolition activities.

In addition to growth planned by Fort Riley, the Army disclosed plans to assign a new infantry brigade to the installation in October 2005. The brigade, which will add, at least temporarily, about 3,400 new soldiers to the post will be organized as a Unit of Action.

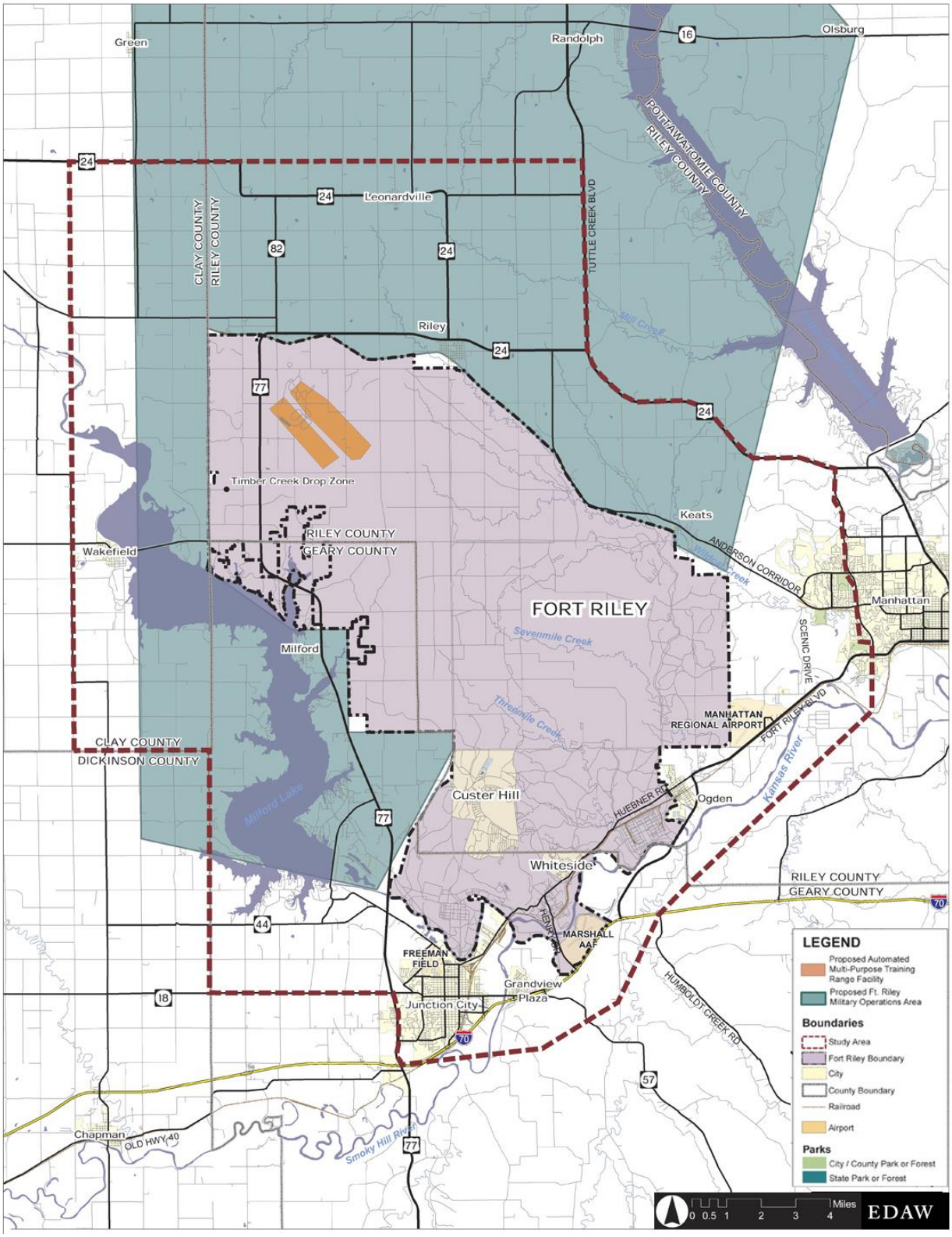
To better meet today's global security threats, the Army is promoting the concept of modularity, which seeks to convert large units attached to Divisions into smaller stand-alone units that can deploy rapidly to areas of conflict anywhere in the world. These stand-alone, or modular, units are called Units of Action (UAs).

The Army would reorganize by shifting units and personnel from one installation to another, or by restructuring troops on a given installation to meet the modular design, or both. Modular reorganization of forces at Fort Riley could result in more intensive use of installation training lands, the addition of an aviation component to support UA activities, and an increase in the number of soldiers stationed at the post.

Under modularity, more units would train on the installation, producing more noise from small and large arms weapons firing. However, the proposed units would be "lighter" than current units, relying less on heavy armored assets, such as the M1 Abrams tank. Thus, single blast noise events from the 120mm main gun, a major generator of noise affecting off-post lands, would not likely increase as a result of the reorganization. The operation of multiple helicopters to support UA missions, however, could generate additional noise impacts.

With the emphasis on stand-alone units, more soldiers would be assigned to the post. Increased personnel would likely place higher demands on local housing, schools, and infrastructure, but would also lead to offsetting job creation and long-term economic growth in the region.

Figure 3 On-Post Activity



3.5 Other Regional Facilities

Freeman Field

Freeman Field sits on a 205 acre site approximately one mile northwest of Junction City's downtown. Facilities include a primary north-south runway at 3,495 feet in length and two cross-wind runways. A variety of small general aviation aircraft use the airport. As of 2000, the airport accommodated an estimated 26,500 annual general aviation operations and 28 based aircraft, along with an estimated 500 military operations.

Air safety zones around the airport reflect Part 77, Federal Aviation Administration (FAA) Regulations, which are established to protect the airspace and runway approaches from hazards that could interfere with aircraft operations (see Figure 4 – Air Safety Zones). The zones are a series of imaginary surfaces defining the airspace around the airport. As shown in Figure 4, these surfaces include:

- a primary surface immediately surrounding the runway;
- an approach surface that continues from the primary surface but widens and rises upward; and
- the transitional surface (horizontal and conical), which begins at the outside edge of the primary surface.

Transitional zones are subject to height restrictions and any object that penetrates the surface requires FAA review to determine any possible air navigation hazards. The transitional zones for Freeman Field travel southeast and southwest from the runways, covering portions of Junction City.

The Master Plan for Freeman Field calls for runway improvements and construction of hangars and aircraft parking aprons to accommodate the full mix of small aircraft that could use the airport in the future.

Manhattan Regional Airport

Manhattan Regional Airport provides regional airline service between Manhattan and Kansas City for approximately 22,000 passengers each year. General aviation services at the airport include air charter, flight instruction, air photo, major aircraft maintenance, transient aircraft refueling (Jet-A and 100LL), tie-down, and shelter.

The airside infrastructure features two runways, five taxiways, and two parking aprons. This infrastructure normally supports aircraft equivalent in size to a DC-9 or B-737, but can also accommodate the occasional use of commercial aircraft as large as the B-757 or military C-17.

The Manhattan Regional Airport is adjacent to the eastern boundary of the installation. As with Freeman Field, Figure 4 – Air Safety Zones illustrates the Part 77 air safety zones around the airport. The southwestern approach safety zone passes over the cities of Grandview Plaza and Ogden and portions of the post. The northwestern approach safety zone passes over a small portion of the eastern boundary of Fort Riley.

The airport has accommodated C-17 military aircraft on previous medical and military airlift support missions. The city of Manhattan and Fort Riley, however, are pursuing a Memorandum of Understanding/Letters of Agreement to establish the airport as a regular point of transfer for troops and equipment assigned to the post. Under the agreement, the airport would construct and then lease for military use a ramp west of the terminal to accommodate wider body aircraft, such as a C-5, C17 or KC/DC-10. Facilities would also include "hot" ramps for the loading and unloading of munitions. The addition of military operations at the Manhattan Regional Airport is not expected to alter existing noise contours.

Highway K-18

A 6.8-mile section of Highway K-18 from southeast of the city of Ogden to the Seth Child interchange in Manhattan is under study to determine the alignment and right-of-way for future access, site layout and platting along the corridor (see Figure 5 – Transportation Systems).

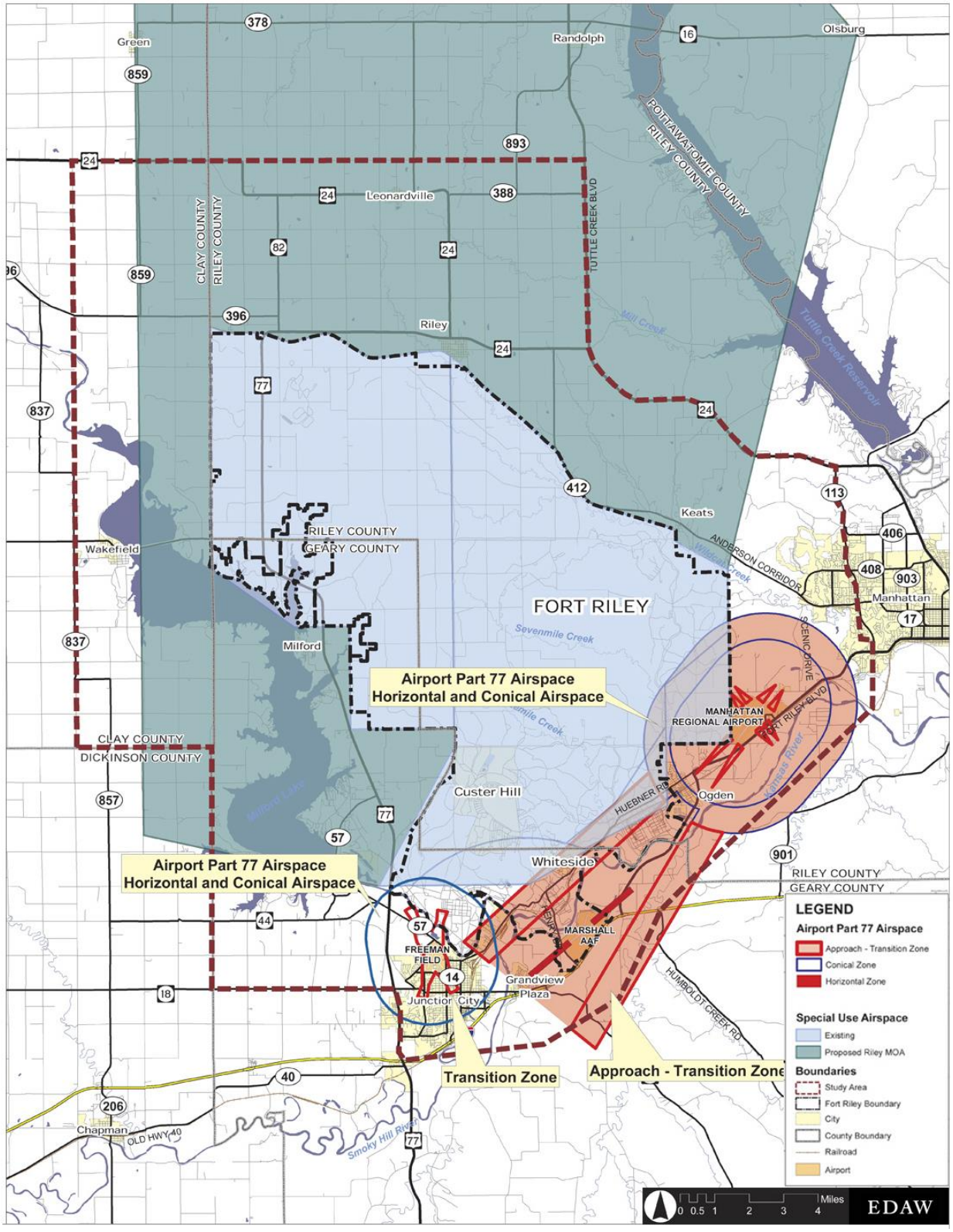
The consultant team and the Kansas Department of Transportation are currently revisiting the original corridor re-alignment concept, which unexpectedly encroached on the site of the proposed joint military-civilian ramp at the Manhattan Regional Airport.

Though a planning and engineering process separate from the JLUS will set the re-alignment of K-18, this report recommends that local stakeholders stress the following land use compatibility and access goals as part of the final corridor design:

- maximize the flexibility for the Manhattan Regional Airport to conduct joint military and civilian operations;
- maximize the flexibility for Fort Riley and city of Ogden to access K-18 safely from both the east and west; and
- ensure continued sufficient access to Fort Riley's Ogden Gate.

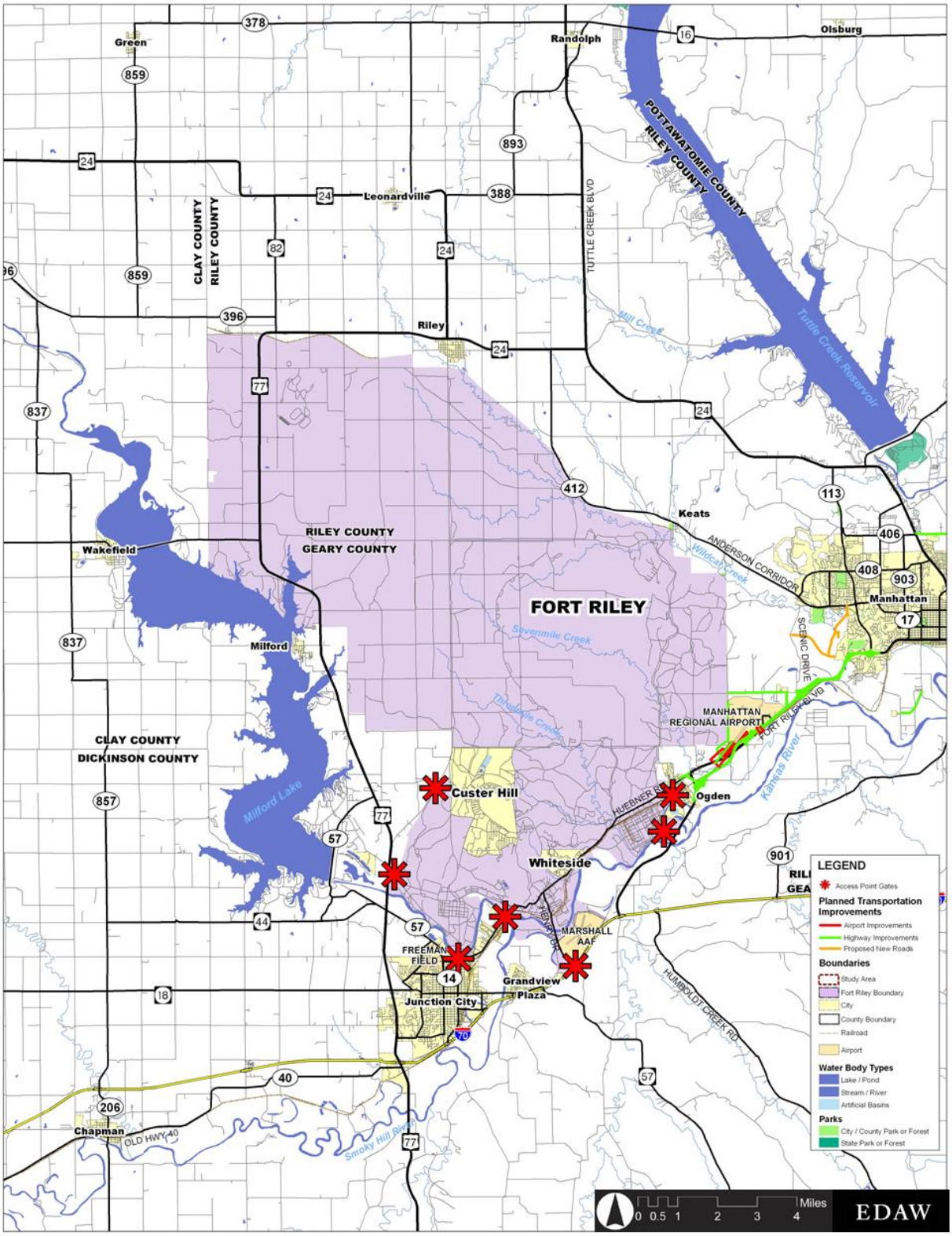
In addition to the K-18 issues, Figure 5 illustrates the seven access gates scattered around the post.

Figure 4 Air Safety Zones



FLINT HILLS JLUS
JOINT LAND USE STUDY

Figure 5 Transportation Systems



3.6 Regional Demographics and Growth Patterns

The Flint Hills region is primarily rural with the exception of two larger population centers at Junction City and Manhattan. The community of Riley is also just north of the post. As shown in Tables 6 and 7, projections indicate relatively modest overall population growth in the region through 2040, though the city of Manhattan is expected to add about 25,000 new residents during that period.

Table 6. Population Growth and Projections by County

Counties	1990	2000	2010	2020	2030	2040
Clay	9,158	9,248	9,333	9,418	9,503	9,588
Geary	30,648	31,440	32,293	33,146	33,999	34,852
Riley	67,139	73,919	80,569	87,219	93,869	100,519
MUA	na	50,144	53,873	57,879	na	na

Source: Kansas Water Office and Manhattan Urban Area Comprehensive Plan

Note: MUA = Manhattan Urban Area

Table 7. Population Growth and Projections by City

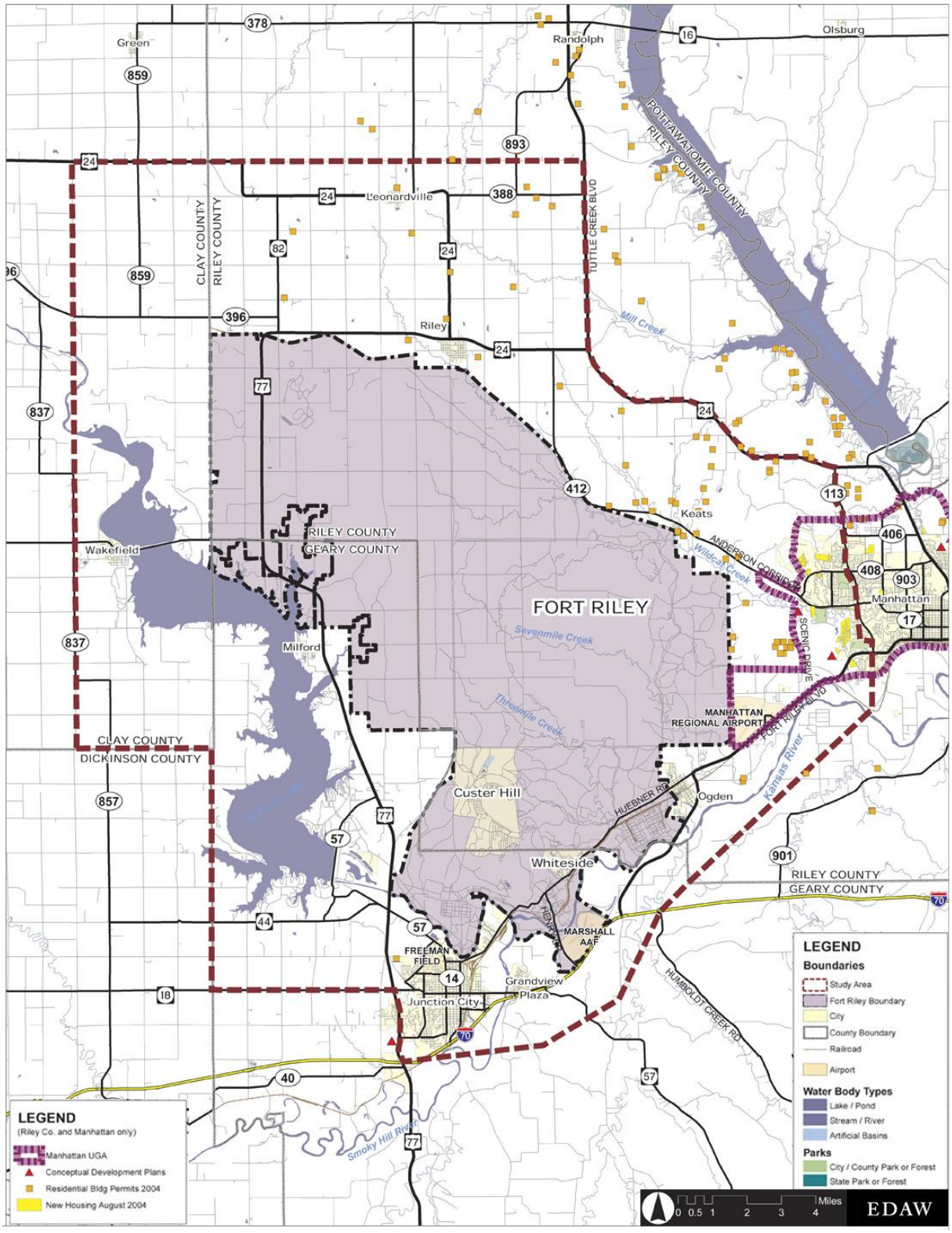
Cities	1990	2000	2010	2020	2030	2040
Grandview Plaza	1,233	1,281	1,323	1,364	1,406	1,447
Junction City	20,642	21,711	22,493	23,276	24,059	24,841
Manhattan	37,569	43,079	49,508	55,937	62,366	68,795
Milford	579	538	523	508	493	478
Ogden	1,494	1,301	1,304	1,307	1,310	1,313
Riley	804	853	910	966	1,022	1,078
Wakefield	900	913	932	950	969	987

Source: Kansas Water Office

Figure 6 – Community Development Activity illustrates recent growth patterns in communities surrounding Fort Riley. Two trends could raise compatibility issues with post operations in the foreseeable future—the spread of Manhattan's expanding population along the West Anderson corridor toward the post and the emergence of dispersed residential uses within rural areas north of the installation.

The city of Manhattan issued permits for 1,405 dwellings, including both multi-family and single-family units. Figure 6 also identifies additional areas of development interest for which concepts have been prepared. Growth in rural Riley County has been more sporadic. The county issued 136 residential building permits between 2001 and 2004. The city of Riley, adjacent to the post on the north, has also seen new residential growth west of the city along Highway 77 with the Madison Addition (18 lots) and Madison Addition Phase II (15 lots) subdivisions. Junction City also has new housing planned west of Freeman Field and southwest of downtown along Route 77.

Figure 6 Community Development Activity



3.7 Environmental Resources

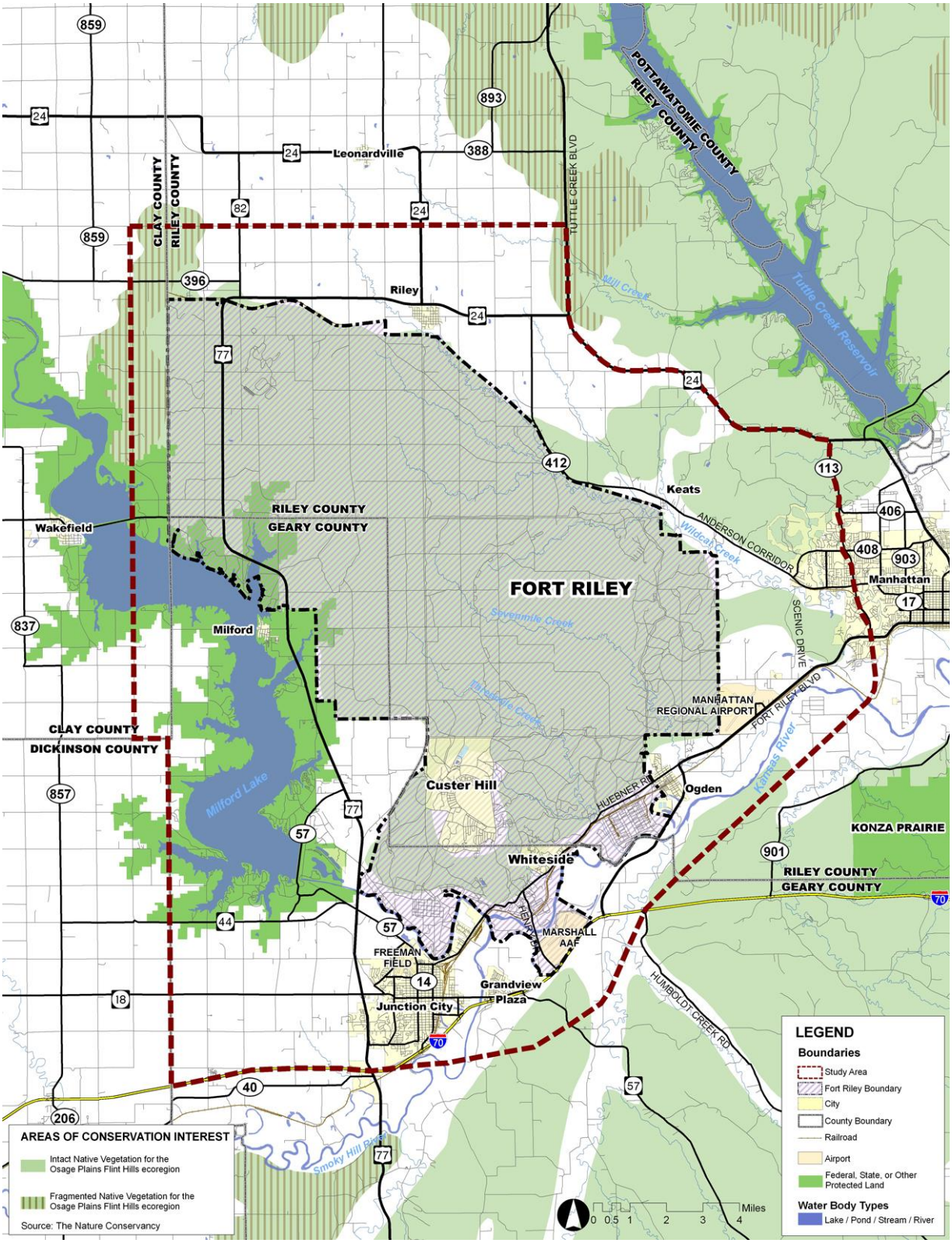
Figure 8 - Environmental Resources shows major natural features in the Flint Hills region, including critical habitat, prime soils, wetlands, slopes, parks and trails, areas of conservation interest, the 100-year floodplain, and locally designated sensitive resources. The region is also part of the very unique tallgrass prairie ecosystem. Only four percent of North America's presettlement tallgrass prairie still exists today and the State of Kansas contains some 80 percent of this scarce landscape.

To preserve dwindling prairie resources, Fort Riley has formed the Fort Riley Tallgrass Prairie Partnership, a cooperative and voluntary program that works with landowners in the area to conserve the landscape. Participating landowners are eligible for an inventory of grassland resources on their property, technical assistance to maintain and enhance habitat, and cost-sharing assistance for habitat improvement projects. Cooperating partners in the program include:

- The US Fish and Wildlife Service
- The U.S. Department of Agriculture
- Kansas State and Extension
- Kansas Farm Bureau
- Kansas Livestock Association
- The U.S. Department of Army
- Kansas Department of Wildlife and Parks

Non-profit conservation organizations such as The Nature Conservancy are also targeting the remaining contiguous areas of prairie for preservation. The Nature Conservancy has identified areas of intact and fragmented native vegetation near the post. Figure 7 – Areas of Conservation Interest shows land with possible conservation value surrounding Fort Riley.

Figure 7 Areas of Conservation Interest, The Nature Conservancy



Fort Riley and the surrounding grasslands of the Flint Hills communities form a core habitat area for many species of plants and animals. Inventories at Fort Riley have documented the presence of four Federally-listed and eight State-listed species, and 23 rare species. Though not documented, studies also indicate that an additional nine listed or rare species could exist on post.

There is no federal threatened and endangered species critical habitat on Fort Riley. However, the state has designated critical habitat on post for four species: bald eagle, piping plover, least tern and Topeka shiner.

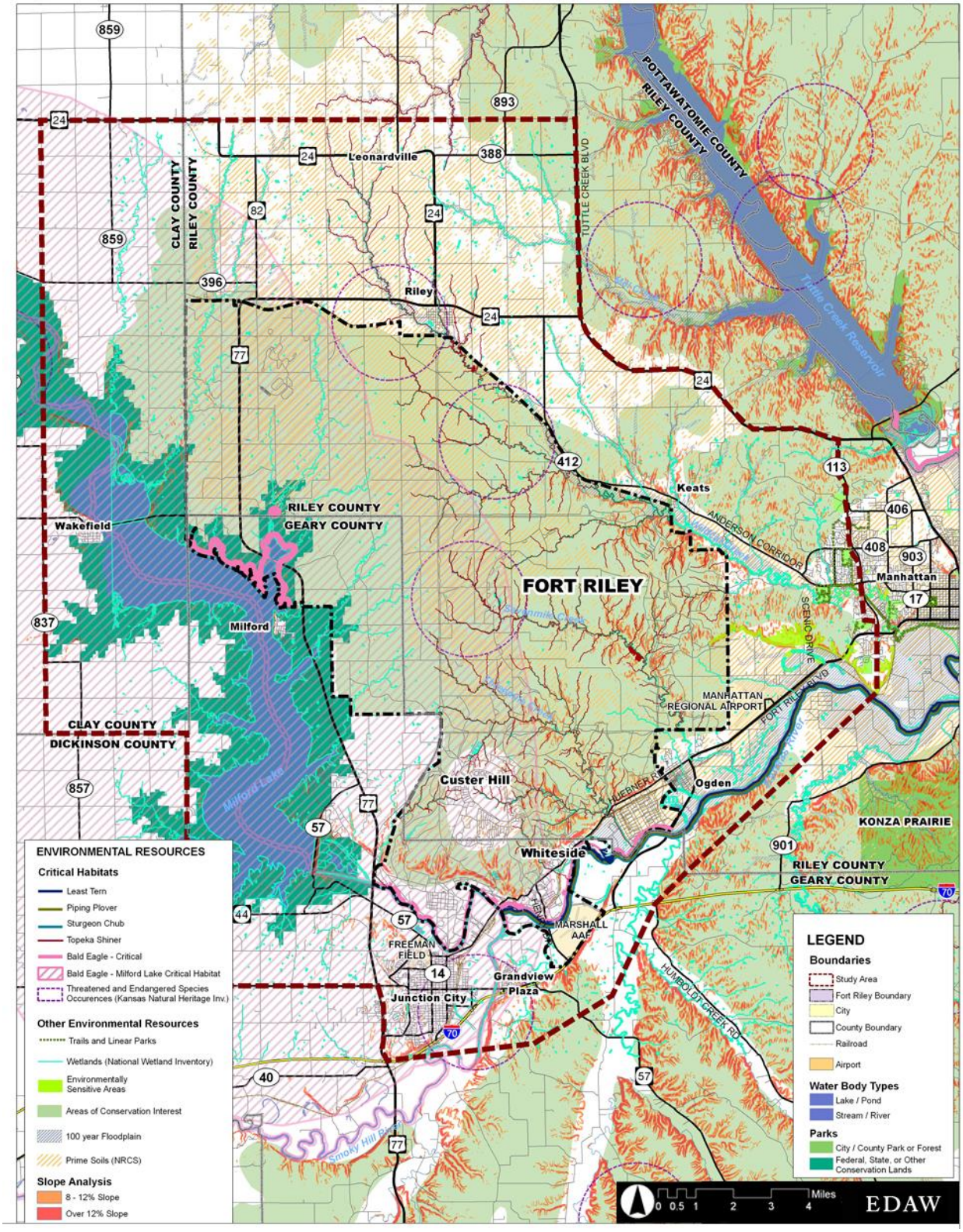
The prairie chicken, a native bird of the Flint Hills region, is in decline

A function of increasing development near the post is the fragmentation and reduction of environmentally sensitive resources, which in turn isolates Fort Riley as an intact, quality habitat. Species drawn to the remaining habitat on the post could trigger federal protections that restrict the use of installation lands for training purposes.

Along with the protection of threatened or endangered species, Fort Riley has cooperated with the Kansas Department of Wildlife and Parks to reintroduce huntable populations of elk and eastern wild turkey on post lands.

Agricultural conservation is also a critical issue in the region. Fort Riley currently has approximately 2,000 acres that may be used for row crop production, restricted to the fire breaks around the post. Agricultural leases are in place for many of these areas. Fort Riley also leases about 40,000 acres for hay production, scattered around post. No lease options exist for grazing on installation lands due to the lack of fencing and water.

Figure 8 Environmental Resources



4.1 Operational Impacts

Fort Riley generates operational impacts that are typical of Army installations around the country with noise being the most common effect as described below. Other issues could include:

- wild fires in training areas;
- accident potential associated with aircraft use on or around the post;
- rare incidents of off-target weapons fire and stray military vehicles affecting private property;
- water quality and water quantity; and
- electronic interference with communications.

4.2 Installation Compatible Use Zone

The Army's Installation Compatible Use Zone (ICUZ) is a program designed to assess the noise and safety effects caused by proximity to an active military installation. Most of the noise associated with Fort Riley results from the following activities:

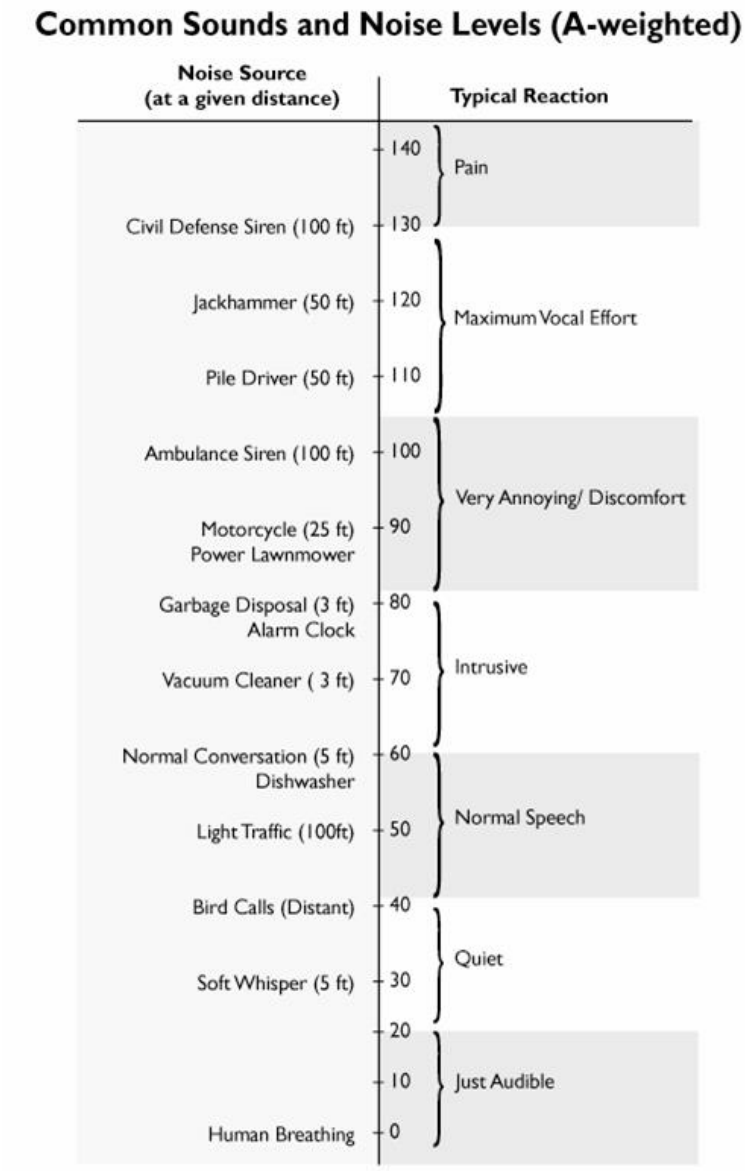
- small arms firing;
- large arms weapons firing; and
- demolitions.

Currently, aircraft are not a major component of the post's noise environment.

The military measures noise in decibels (dB) and assigns a weighting based on the noise frequency and source. A-weighting, expressed as dBA, depicts higher frequency noise caused by small arms firing, aircraft use, and vehicle operations. C-weighting shows the low frequency noise and vibration associated with the firing of larger weapons systems (dBC), the major noise generator at Fort Riley. Though the impulsive noise produced by large arms weaponry can cause vibration and the shaking of nearby buildings, the noise is air-borne. Sound is not transmitted through the ground as a result of mortar or artillery impact on the post, but instead travels through the air.

Noise in excess of 55 dB can become intrusive and continued exposure to noise above the 85 dBA threshold can, over time, cause hearing loss. Figure 9 – Common Sounds and Noise Levels equates decibel levels with the sound of everyday activities.

Figure 9 Common Sounds and Noise Levels, A-Weighted



The contours around the post reflect an annualized noise measure that converts noise varying from peak bursts to relative quiet into a steady measure of acoustic energy over a 24 hour period. The contours essentially take all operations that occur at Fort Riley over the year and divide by 365 days, producing the average day-night sound level (DNL).

The Army depicts noise based on a computer simulation that processes data such as the type of weapons fired from each range or firing point including demolitions, the number and type of rounds fired from each weapon, the location of targets for

each range or firing point and the amount of propellant used to reach the target (see Figures 10, 11 and 12). The DNL is the standard, accepted methodology for modeling the noise impacts of military activity on surrounding lands. The modeling takes into account variables such as:

- maximum loudness;
- how long the sound lasts; and
- the number of annoying sounds.

The measure further "penalizes" or places a higher decibel value on noise that occurs at night because it is more disruptive to the surrounding population.

In addition to operational characteristics, such as the type of weaponry used, a variety of meteorological factors, including wind, air temperature, humidity and cloud cover, can affect the path and the intensity of noise as it travels from its source. For example:

- wind moves the air and thus carries noise farther;
- humid air has more density, thus carrying noise farther from the source; and
- low, dense cloud cover can reflect more noise back to the ground, thus increasing sound intensity.

Experts at the Environmental Noise Program, US Army Center for Health Promotion and Preventive Medicine, created the noise zones shown below. The zones and corresponding land use guidance as identified by the Army are as follows:

Noise Zone III. Noise Zone III (NZ III) consists of the immediate areas around the source of the noise in which the A-weighted DNL (ADNL) is more than 75 decibels, and the C-weighted DNL (CDNL) exceeds 70 decibels. Guidance indicates that noise in this zone is severe enough to cause conflicts with almost all activities, particularly sensitive land uses, such as housing, schools, medical facilities, and places of worship.

Noise Zone II. Noise Zone II (NZ II) consists of an area where the A-weighted DNL is between 65 and 75 decibels and the C-weighted DNL is between 62 and 70 decibels. Guidance deems noise exposure within this area to be significant and recommends limiting use of land to non-sensitive activities such as industry, manufacturing, transportation, and agriculture. However, if the community determines that land in NZ II areas must be used for residential purposes, guidance suggests that the design and construction of the buildings incorporate noise level reduction (NLR) features to minimize the annoyance experienced by residents.

Noise Zone I. Noise Zone I (NZ I) includes areas around a noise source in which the DNL is less than 65 dBA and less than 62 dBC. Since the noise exposure in this zone is low enough that it does not trigger compatibility with sensitive uses, the figures do not show NZ I contours.

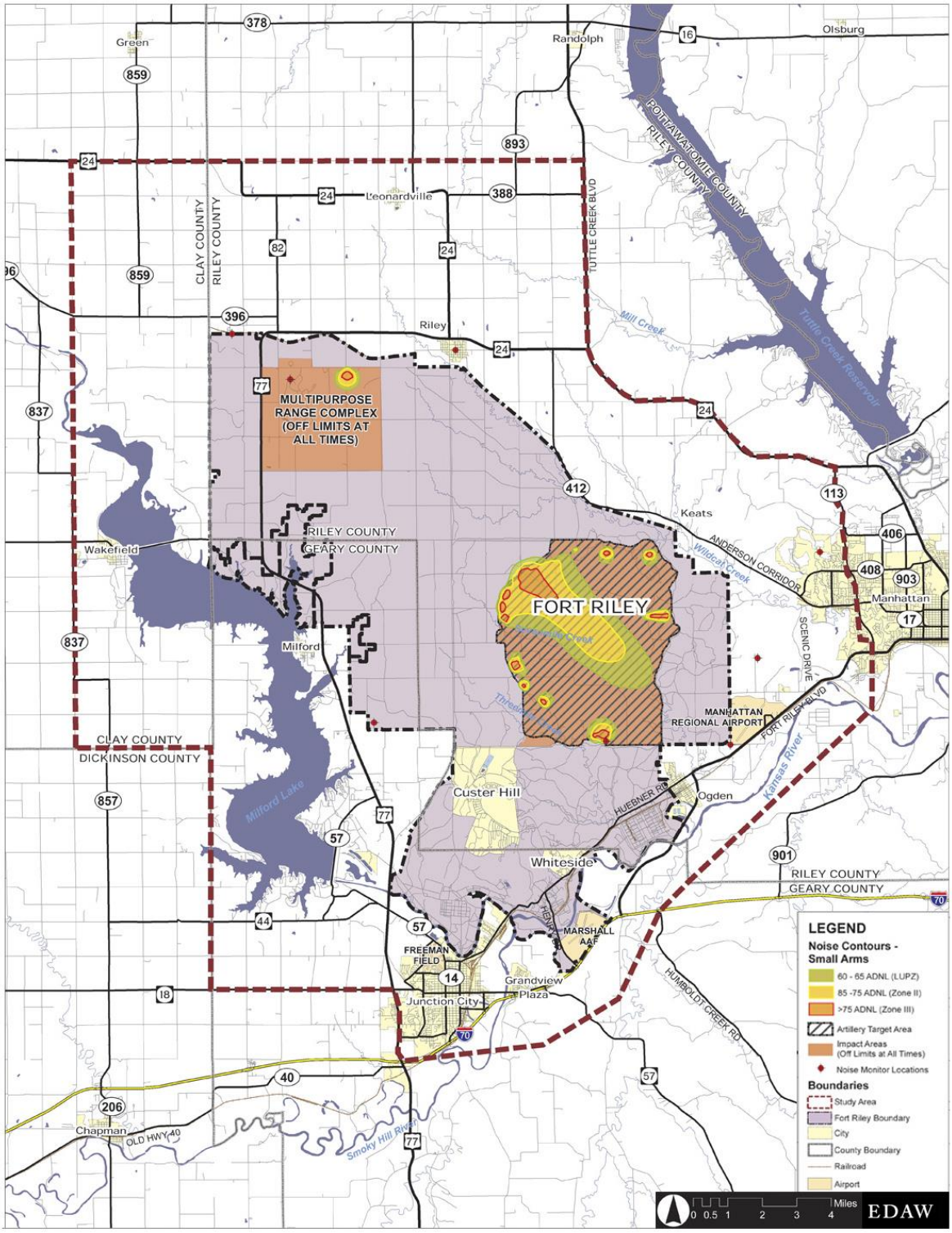
Land Use Planning Zone. The noise contours, 65 ADNL and 62CDNL, represent an annual average that separates the Noise Zone II, which has compatibility issues, from the fully compatible NZ I. Since the noise environment at the installation varies daily and seasonally, the Land Use Planning Zone (LUPZ) contour more broadly encompasses off-post lands, where on particularly active days, noise and the resulting community annoyance can approach levels typically associated with NZ II. The LUPZ, thus, gives the installation more flexibility for performing its mission and better reflects actual noise conditions during a period of heightened activity.

These noise contours should be viewed as a planning tool, not as a series of discrete lines that sharply divide noise-affected land from non-noise affected areas. But, contours are a useful framework for identifying those off-post areas in which noise exposure may be high enough to generate annoyance among a certain percentage of people.

Fort Riley also has on-the-ground sensors that collect data on noise generated at the post. Data from the sensors do not feed into the computer modeling of noise contours, but are used instead for purposes, such as investigating noise complaints.

As shown in Figure 10 – 2004 Small Arms Noise Contours, all noise zones associated with small arms firing are contained on post lands and maneuver areas and, therefore, generally do not pose compatibility issues with surrounding civilian uses.

Figure 10 2004 Small Arms Noise Contours



Noise caused by the firing of heavy weaponry or large arms (large arms weapons 20 mm and greater), such as the main guns off of the BFV and the Abrams Tank, at the MPRC and around the Impact Area, however, affect noise levels experienced on off-post lands as shown in Figure 11 – 2004 Large Arms Noise Contours.

The noise zones shown for large weapons firing reflect the latest noise simulation technology, BNOISE2 (Blast Noise Impact Assessment), which includes variables such as an area's topography and surface water. It should be noted that even though these March 2004 contours are larger than contours previously shown in Fort Riley noise management documents, the zones only reflect a more accurate modeling of the current noise environment surrounding the post. These zones do not indicate an increase in noise produced by post operations.

As shown on Figure 11, the LUPZ from heavy weapons firing covers approximately 36,000 acres off post primarily to the north and east. Land within this zone, particularly during periods of more intense activity, can be subject to noise high enough to trigger annoyance. The more severe NZ II caused from large arms firing covers about 2,400 acres to the north of the post, including portions of the city of Riley. Noise exposure in this zone is sufficient to raise compatibility issues with sensitive uses. The most severe of the zones, NZ III, does not cross post boundaries.

As noted earlier**,** a proposed Automated Multi-purpose Training Range (AMPTR) would affect the noise setting around the post due to increased intensity of range use. Figure 12 shows the noise contours that would result from simultaneous operation of the enhanced existing MPRC and the new AMPTR. NZ II contours would extend farther to the north to encompass the city of Riley, farther to the northeast, and also west over Milford Lake. Since these contours reflect noise in the foreseeable future when the AMPTR begins operation in approximately 2009/2010, analyses of compatibility issues shown later in this section overlay the proposed AMPTR noise contours with land use features.

Figure 11 2004 Large Arms Noise Contours

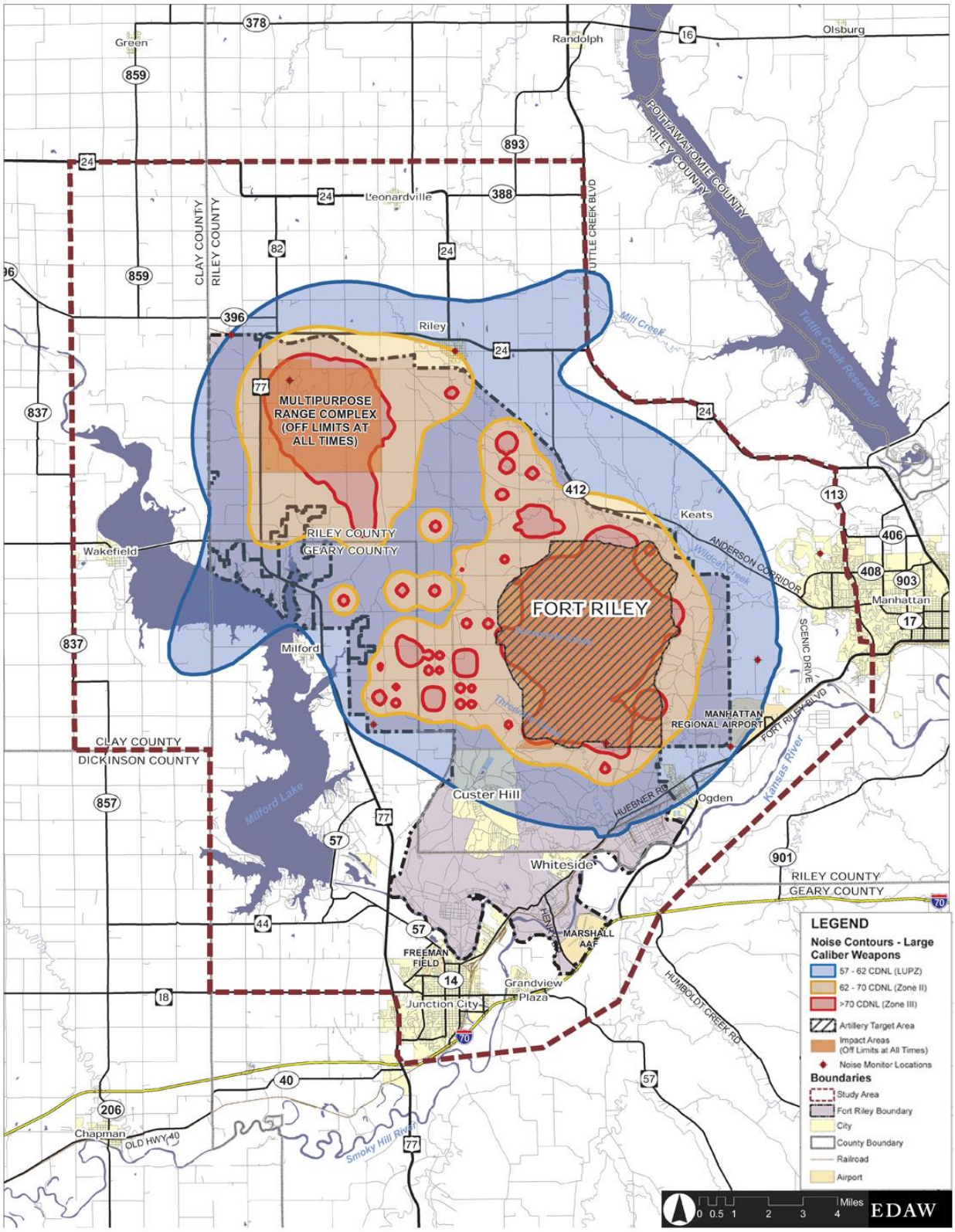
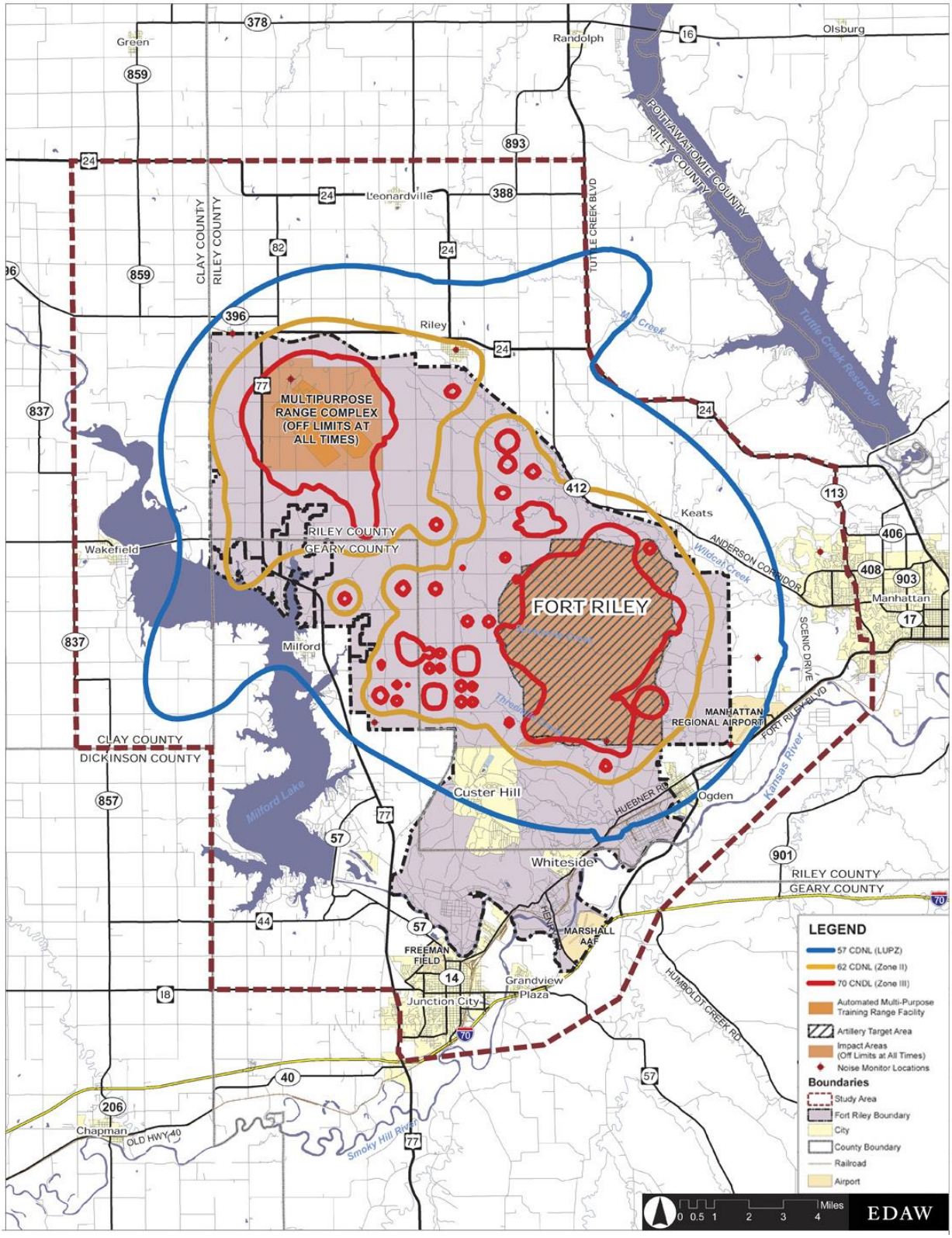


Figure 12 Proposed AMPTR Noise Contours



In addition to assessing the impacts of noise on surrounding land uses, the Army's ICUZ program examines the relationship among nearby land uses, aircraft accident potential, and possible hazards to air navigation. The air safety component of ICUZ identifies areas around the airfield where a mishap would be most likely to occur and also assesses the likely impact of any single accident.

Figure 4 - Air Safety Zones (shown in Section 3.0) identifies the following ICUZ air safety zones around Marshall Army Airfield.

- **Clear Zone (CZ).** The Clear Zone is an area 1,000 feet wide by 3,000 feet long at the immediate ends of the runway. The accident potential in this area is sufficient to recommend the prohibition of any structures in this zone.

- **Accident Potential Zone I (APZ I).** APZ I is less critical than the CZ, but still possesses significant potential for accidents. A wide variety of industrial, manufacturing, transportation, open space and agricultural uses can exist safely within this 1,000-foot wide by 2,500-foot long area just beyond the CZ. However, uses that concentrate people in small areas, such as higher density housing pose a conflict with the safety risks of this zone.

- **Accident Potential Zone II (APZ II).** APZ II is the least critical of the three air safety zones, but still carries some risk of an accident. APZ II is also 1,000 feet wide and extends 2,500 feet beyond APZ I. Compatible land uses include those of APZ I, as well as low density single family residential, and lower intensity commercial activities. High density functions such as multi-story buildings and places of assembly (e.g., theaters, schools, churches and restaurants), however, raise compatibility issues.

4.3 Other Possible Operational Impacts

In addition to noise and safety issues, the JLUS examined possible operational impacts to area water quality and quantity and interference with digital communications.

<u>Water Quality and Quantity</u>

Fort Riley and surrounding communities fall within the Kansas-Lower Republican Basin. Major bodies of surface water in the basin include Milford Lake, Tuttle Creek Lake, the Republican River, Smokey Hill River, Kansas River, and Wildcat Creek.

The possible effects of post operations on water quality stem from soil erosion associated with maneuver training activities and explosive ordnance detonation in the Impact Area. Soil erosion at disturbed sites has periodically increased the turbidity (cloudiness of water due to suspended dirt and residue) and sedimentation of some surface waters.

To characterize overall water quality within the basin, the Kansas Department of Health and Environment (KDHE) collects data on Total Maximum Daily Loads (TMDL) for water bodies. A TMDL represents the maximum amount of a pollutant that a water body can receive without violating acceptable water quality standards. Based on the latest available TMDL data, KDHE identifies one water body in the Flint Hills area, Tuttle Creek Lake, as a high priority for action due to eutrophication (excessive algae production), siltation, and pesticides. Milford Lake also shows some lesser water quality impairment due to eutrophication and low levels of dissolved oxygen. These water quality issues are relatively common in reservoirs throughout Kansas and are not related to operations at Fort Riley.

On a more site-specific basis, Kansas State University's Strategic Environmental Research and Development Program began a study in 2003 to identify sources of non-point source pollution resulting from military activities, to assess the water quality effects on surrounding water bodies, and to minimize the impact of training on surface waters. Findings are not yet available.

Hardening the stream crossings over which military vehicles travel is one of the most effective means to protect water quality. A Kansas State University Master's of Science research project collected data on turbidity, total solids, total dissolved solids, total suspended solids, settable solids, pH, total hardness, calcium hardness, and total alkalinity at eight earthen and nine hardened stream crossings prior to and after vehicle movement. The analysis concluded that water quality associated with hardened stream crossings was better than water quality from areas near earthen fords. It should be noted that Fort Riley maintains hardened stream crossings around its maneuver areas to protect water quality.

In terms of water quantity, Fort Riley has two wellfields with a total pumping capacity of 1,400 gpm or 10.8 million gallons per day (mgd). The wells withdraw groundwater from aquifers recharged by the Republican and Kansas Rivers.

Groundwater is the primary source of drinking water for both the installation and the surrounding communities. Groundwater is plentiful within the sand and gravel in the alluvium associated with the major river systems in the area. Smaller quantities of groundwater also exist in the limestone bedrock in the upland areas. The raw water is relatively clean with low turbidity, though hardness levels vary considerably among the wells.

Overall, available data do not indicate major water quality or water quantity issues associated with Fort Riley activities.

Interference with Electronic Communication

With the increasing reliance of the U.S. military on digital communications and information systems, training operations become more vulnerable to electromagnetic interference (EMI). Electromagnetic interference includes any environmental condition, such as weather phenomena, intentional jamming, or

external noise that disrupts the operational capability of military forces, equipment, or systems.

Cordless communication devices, wireless networking, and satellite communication systems use a broad range of the electromagnetic spectrum. As these devices become more numerous, the amount of radiation in the electromagnetic spectrum increases. These emissions can interfere with the normal operation of electronic communication links and systems.

The primary sources of unintentional interference of electronic signals include devices such as broadcast television, VHF transmitters, personal electronic devices, Mobile Satellite Service (MSS) communications systems, and ultra-wideband (UWB) radar systems. Incidental interference is a particular concern for the operation of aircraft electronics.

The Department of Defense's Joint E3 (Electromagnetic Environmental Effects) Program conducts research to develop, design, and operate military systems that minimize electromagnetic environmental effects. Currently, there is no evidence of major electromagnetic interference issues either on the post or in surrounding areas.

4.4 Analysis of Current Land Use

The following analysis assesses the compatibility of existing civilian land uses around the installation. When compatible, land uses can exist next to each other without causing interference or exposing people to undue safety risks or nuisance. In this JLUS context, Army training activities raise compatibility issues when next to the following nearby land uses:

- Noise sensitive uses, such as housing, schools, medical facilities or places of worship;
- Uses that tend to concentrate people (certain higher residential densities, schools, churches, hospitals); and
- Uses that can interfere with safe air navigation, such as tall structures, or activities that throw off excessive lighting, smoke or dust and may impair vision.

For purposes of evaluating compatibility, the JLUS draws guidance from The Federal Interagency Committee on Urban Noise (FICUN) land use guidelines (FICUN 1980). FICUN's land use compatibility guidelines are standards only and do not determine acceptable uses of land within communities. Only local governments have the authority to establish permissible land uses and to define the relationship between specific properties and noise or safety contours.

Table 8 assesses the compatibility of various land uses relative to levels of noise exposure. The guidelines below are based on the A-weighting function, which

evaluates noise from transportation (vehicle and aircraft), small arms, and continuous noise sources. Most of the noise from post operations is impulsive and, therefore, better expressed with a C-weighting that captures the effects of low frequency sound. As noted earlier, the impulsive sound pressure from the firing of large weapons and the detonation of explosive charges can cause structures to vibrate and, therefore, tends to be more annoying than A-weighted noises of the same decibel level. (see Appendix 5 for a full listing of land use compatibility guidelines)

Table 8. Land Use Compatibility Guidelines, A-Weighting

FICUN	NZ I		NZ II		NZ III	
	< 55 DB	55 to 65 DB	65 to 70 DB	70 to 75 DB	75 to 80 DB	80 to 85 DB
Households	Y	Y	Y	Y	N	N
Manufacturing	Y	Y	Y	Y	Y	Y
Retail – General	Y	Y	Y	Y	Y	N
Restaurants	Y	Y	Y	Y	Y	N
Personal Services	Y	Y	Y	Y	Y	N
Hospitals	Y	Y	Y	Y	N	N
Government	Y	Y	Y	Y	Y	N
Education	Y	Y	Y	Y	N	N
Public Assembly	Y	Y	Y	N	N	N
Parks	Y	Y	Y	Y	N	N
Agriculture	Y	Y	Y	Y	Y	Y

Source: FICUN 1980

In general, guidance states that housing is compatible (shown in green) with noise exposure up to DNL 55 dB. Standards indicate that with exposure between DNL 65–75 dB, additional protective measures, such as indoor noise reduction, for residential uses may be warranted (shown in yellow). For conditionally compatible residential land uses, guidelines suggest consideration of the following factors:

- Is there a demonstrated community need for residential use that would not be met if development were prohibited in these zones?

- Where the community determines that residential uses are desired, structures should incorporate noise level reduction measures of at least 25 dB (65-70 ADNL) and 30 dB (70-75 ADNL).

- Noise level reduction 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 particularly from ground level transportation sources. Measures that reduce noise at a site should be used wherever practical in preference to measures that only protect interior spaces.

Guidelines deem noise exposure that exceeds DNL 75 dB to be "incompatible" (shown in red) with all residential uses. Many uses, such as manufacturing, retail, government facilities, and agriculture, however, can be suitable even within a relatively high noise setting.

As shown in Figure 13 – Existing Land Use and Proposed AMPTR Contours, land surrounding the post is predominantly agricultural. While the general character of adjacent communities is rural, a review of existing land use patterns around the post identifies three main areas of possible concern due to noise exposure from current and foreseeable post operations:

- city of Riley
- Keats area
- city of Ogden and areas east of the post

For purposes of compatibility analysis, Figures 14, 15 and 16 focus more closely on these areas to identify existing land use conflicts. The city of Riley is the most noise affected of any of the communities surrounding the post. As shown in Figure 14, foreseeable NZ II impacts generated from post operations raise compatibility issues with housing and other noise sensitive uses, such as schools, in the city of Riley. Similarly, housing in the Keats community of unincorporated Riley County is adjacent to the installation and very close to an off-post NZ II (see Figure 15). The city of Ogden and areas east of the post sit within the LUPZ and are, therefore, subject to nuisance-inducing noise levels during periods of more intense training (see Figure 16).

Figure 13 Existing Land Use and Proposed AMPTR Noise Contours

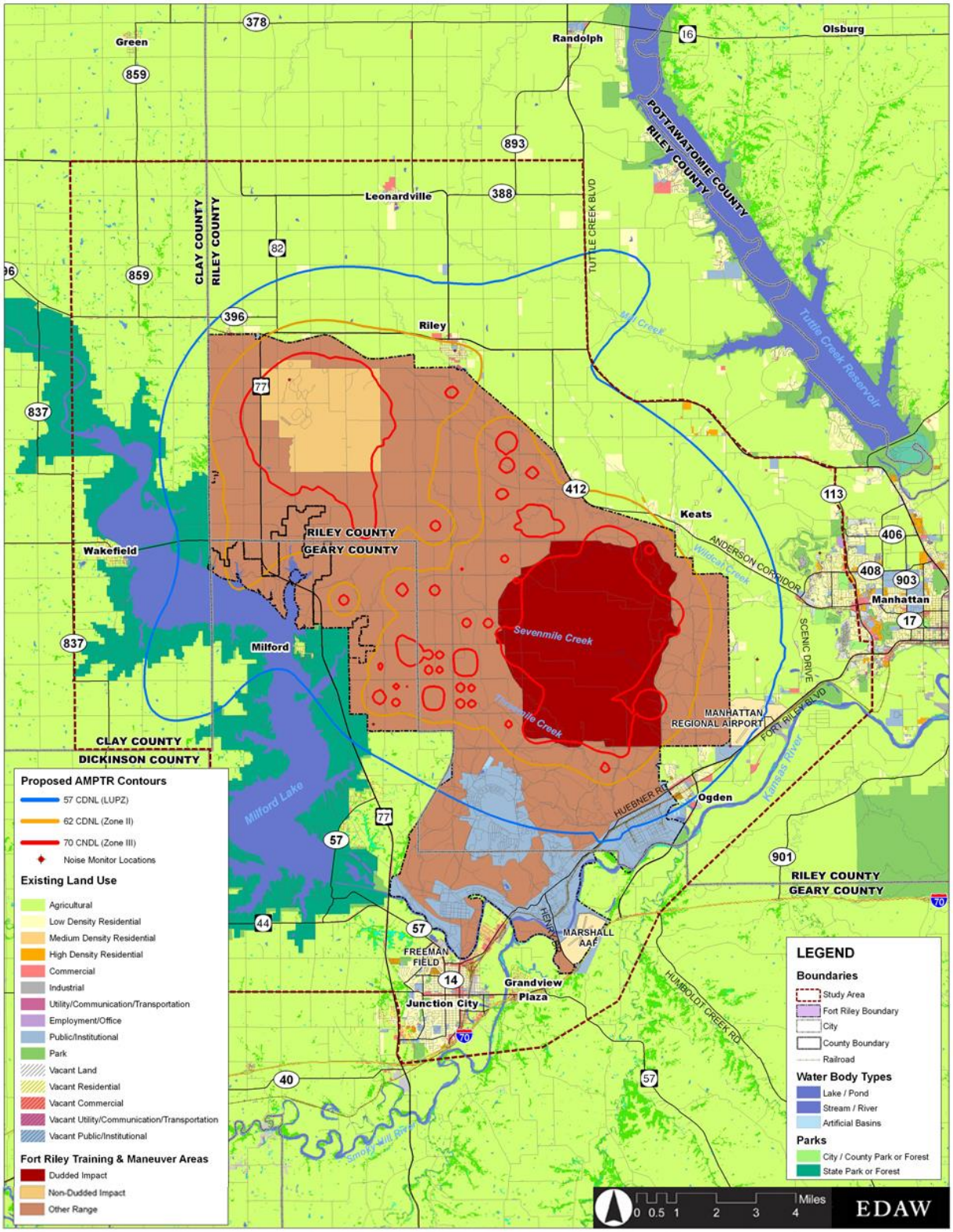


Figure 14 Existing Land Use and Proposed AMPTR Contours, City of Riley

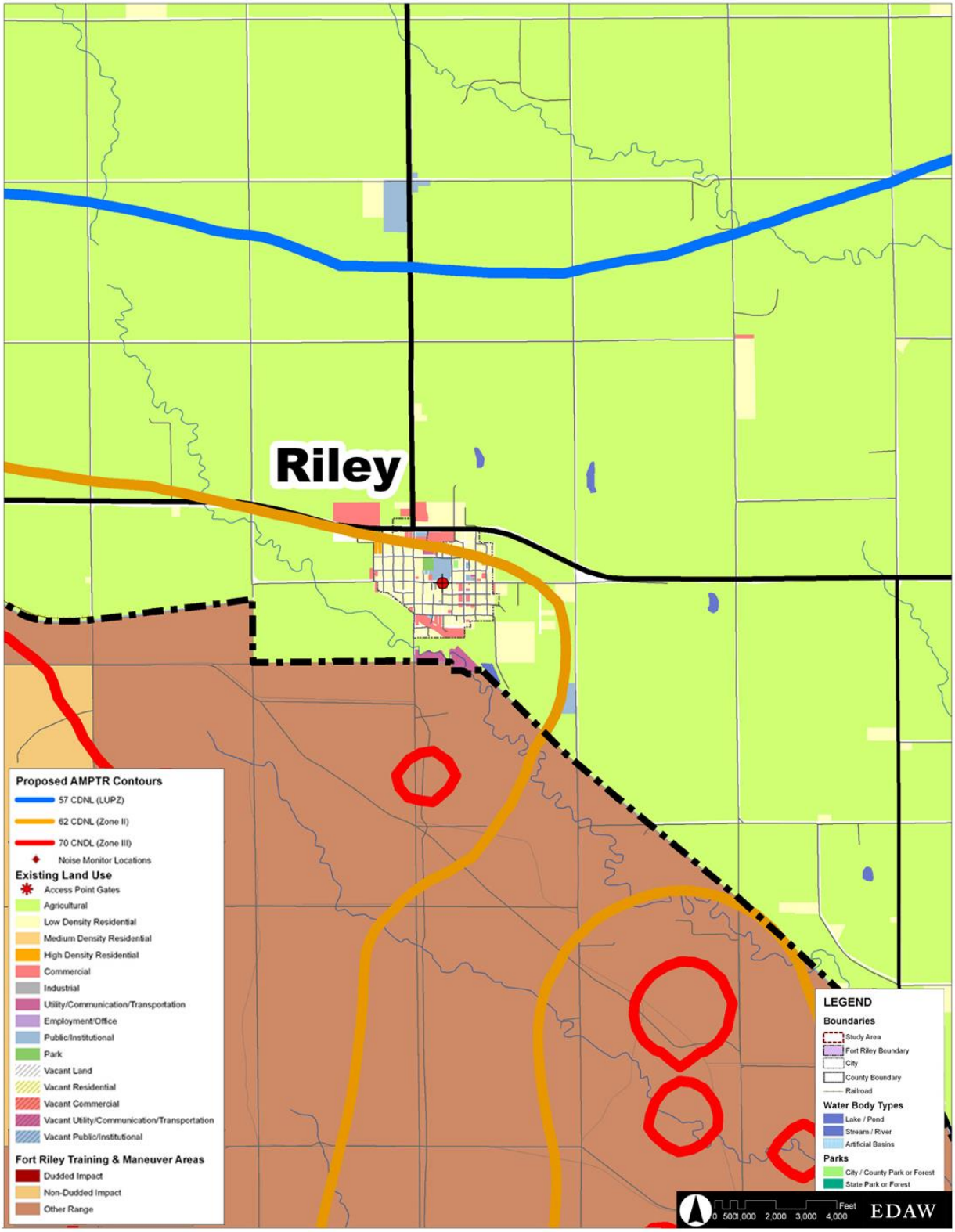


Figure 15 Existing Land Use and Proposed AMPTR Noise Contours, Keats

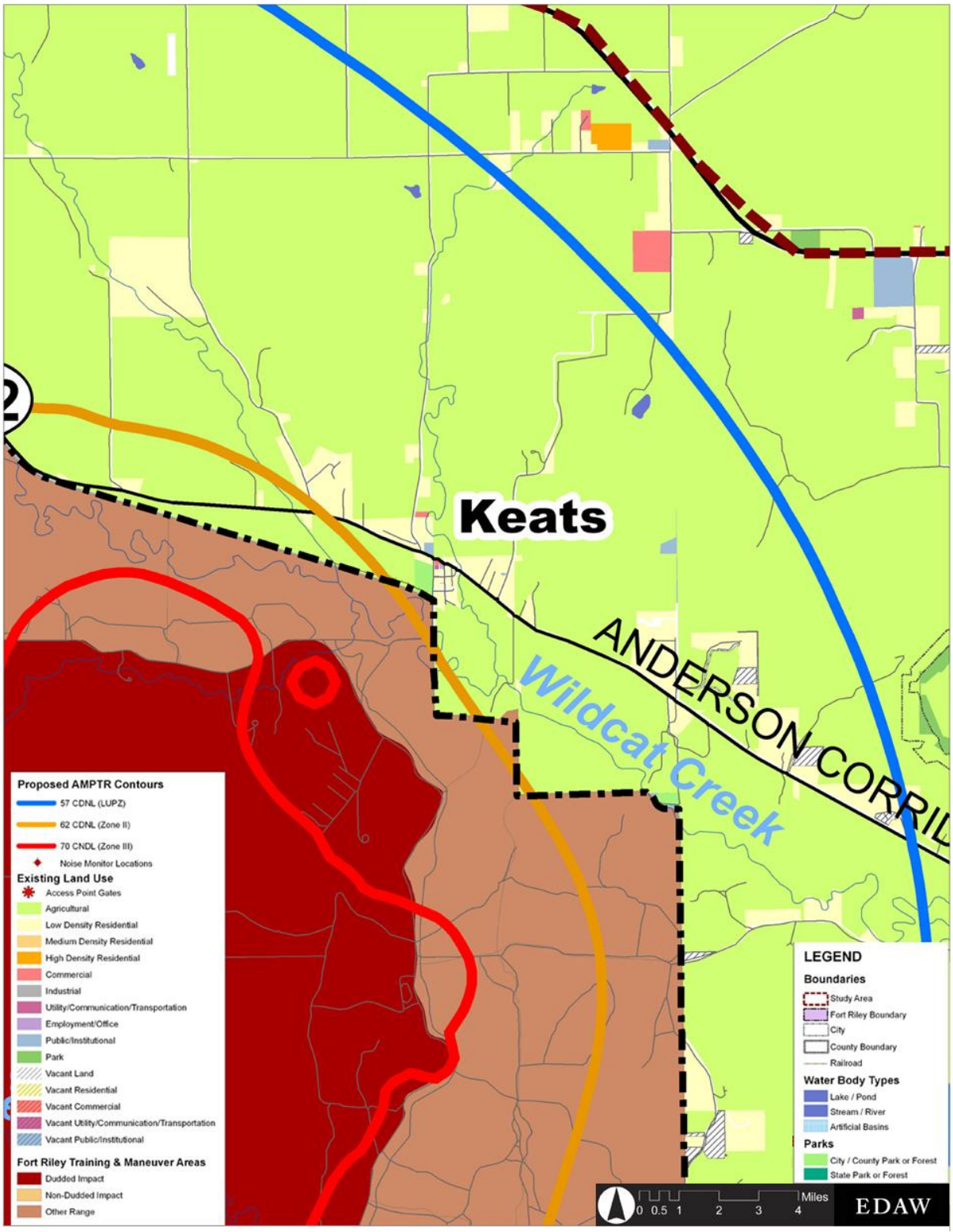
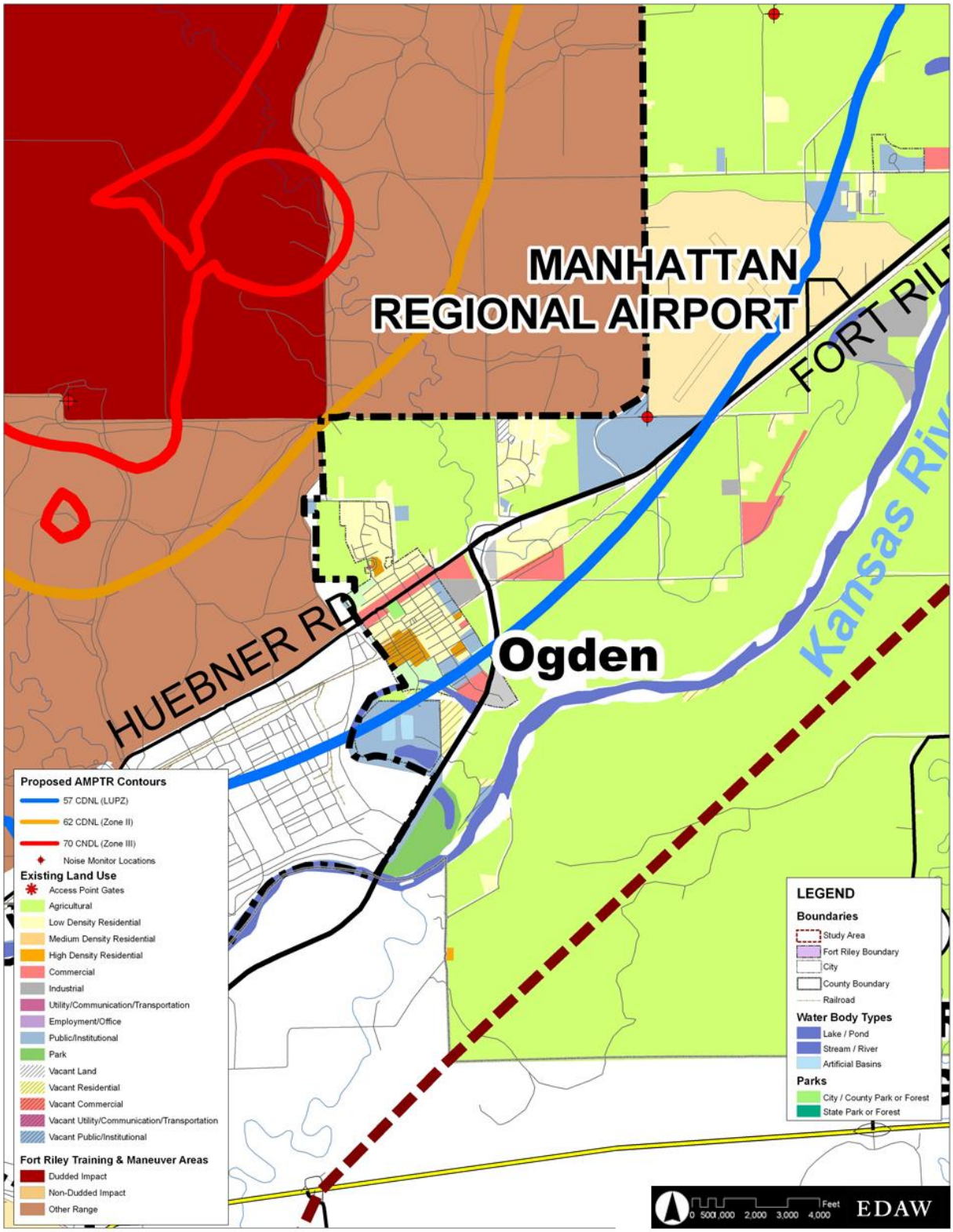


Figure 16 Existing Land Use and Large Arms Noise Contours, Ogden



4.5 Future Land Use

Most of the land surrounding the post remains designated for rural/agricultural purposes in the future (see Figure 17 – Future Land Use and Proposed AMPTR Noise Contours). As noted earlier, two trends could raise compatibility issues with post operations in the foreseeable future—the spread of Manhattan's expanding population west along the West Anderson corridor toward the post and the emergence of dispersed residential uses within rural areas north of the installation.

The Manhattan Urban Area (MUA) Comprehensive Plan identifies areas outside of its Urban Service Area Boundary (USAB) for rural residential use with tracts typically between 2 and 20 acres in size. The MUA Comprehensive Plan identifies the West Anderson Corridor, which runs along the northern side of Wildcat Creek westward to within one mile of the northeastern boundary of the post, as an area for future potential urban growth. The Plan states that the area will remain primarily rural in the near-term with transition to a more developed character dependent upon the timing and availability of infrastructure. The western end of this corridor extends into the LUPZ.

A second special planning area in the MUA that could affect compatibility with the post is the West of Scenic Drive Area, just east of the installation, in which the Plan urges rural development that is sensitive to the scenic qualities of the landscape and promotes clustered site design. At the northern edge of the West of Scenic Drive Area, the MUA Comprehensive Plan identifies an urban high-density residential growth corridor just south of Wildcat Creek along both sides of Scenic Drive. However, this identified urban growth corridor is outside of the LUPZ.

The MUA plan also designates areas around the city of Ogden both to the south and the east of the post for low density residential growth (see Figure 18). The Junction City Future Land Use plan sets aside land to the southwest of the installation near Junction City and Milford Lake for future low density housing. The city of Riley, north of the post, does not have a Future Land Use Plan at this time.

Rural and agricultural lands surrounding the post

Figure 17 Future Land Use and Proposed AMPTR Noise Contours

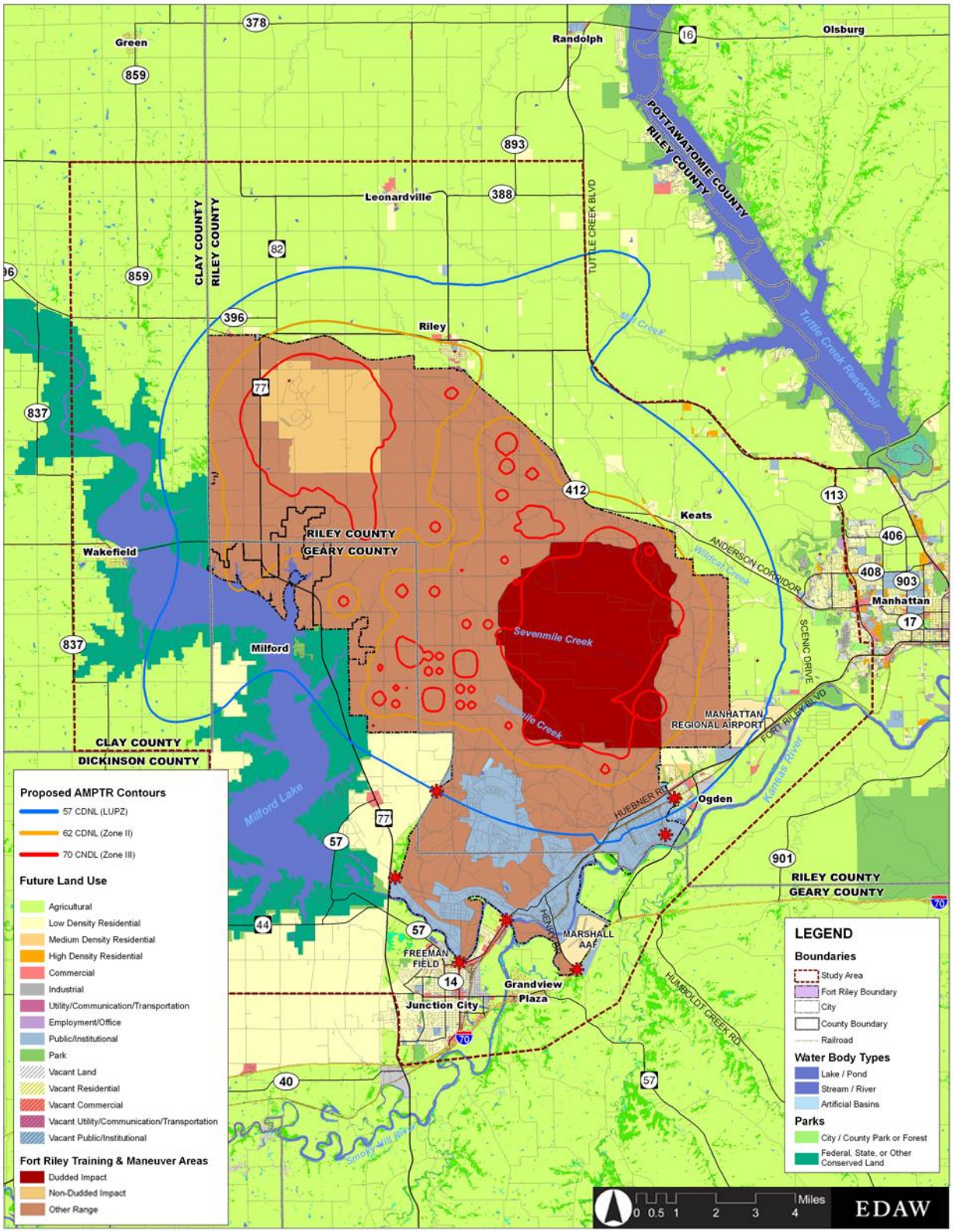
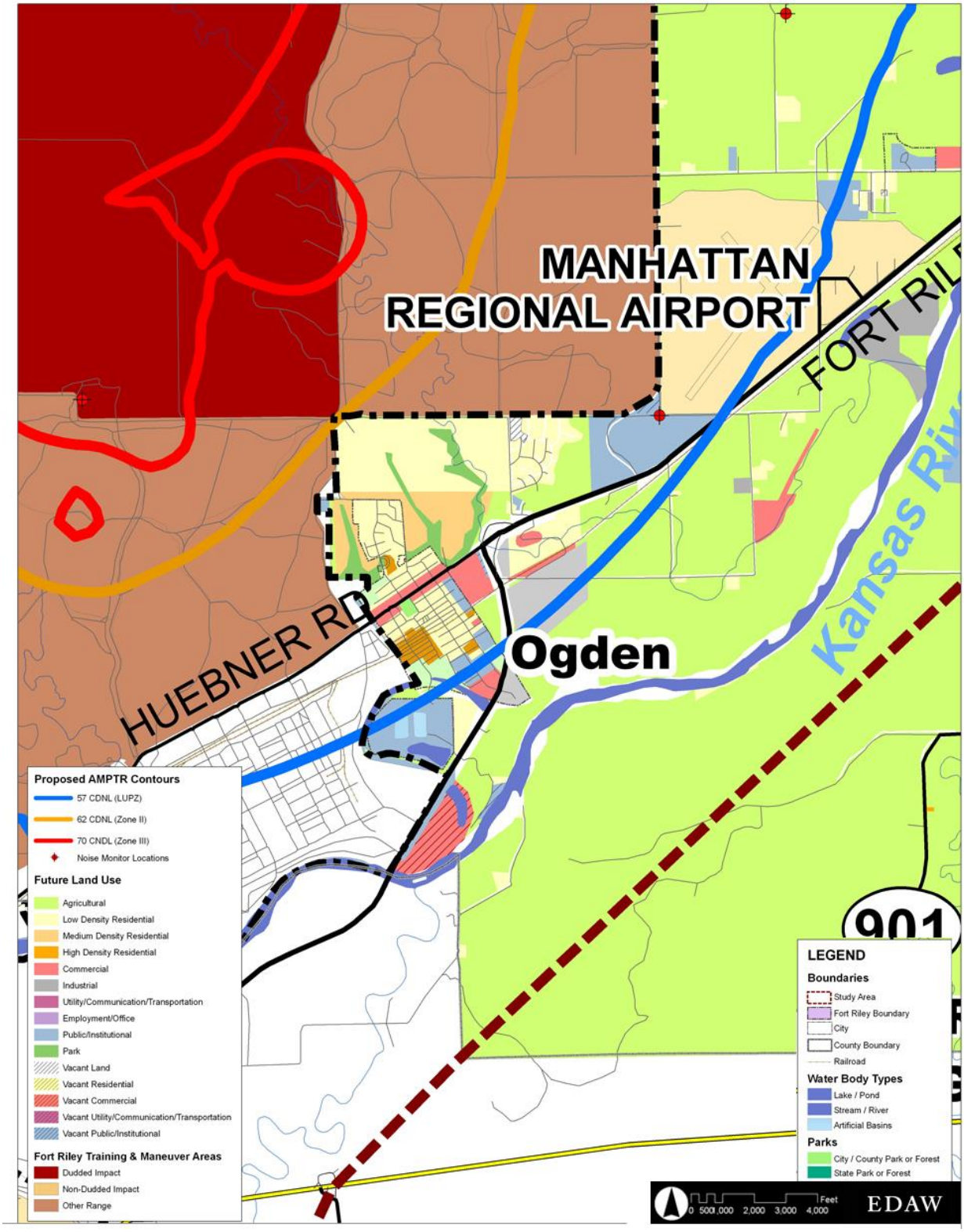


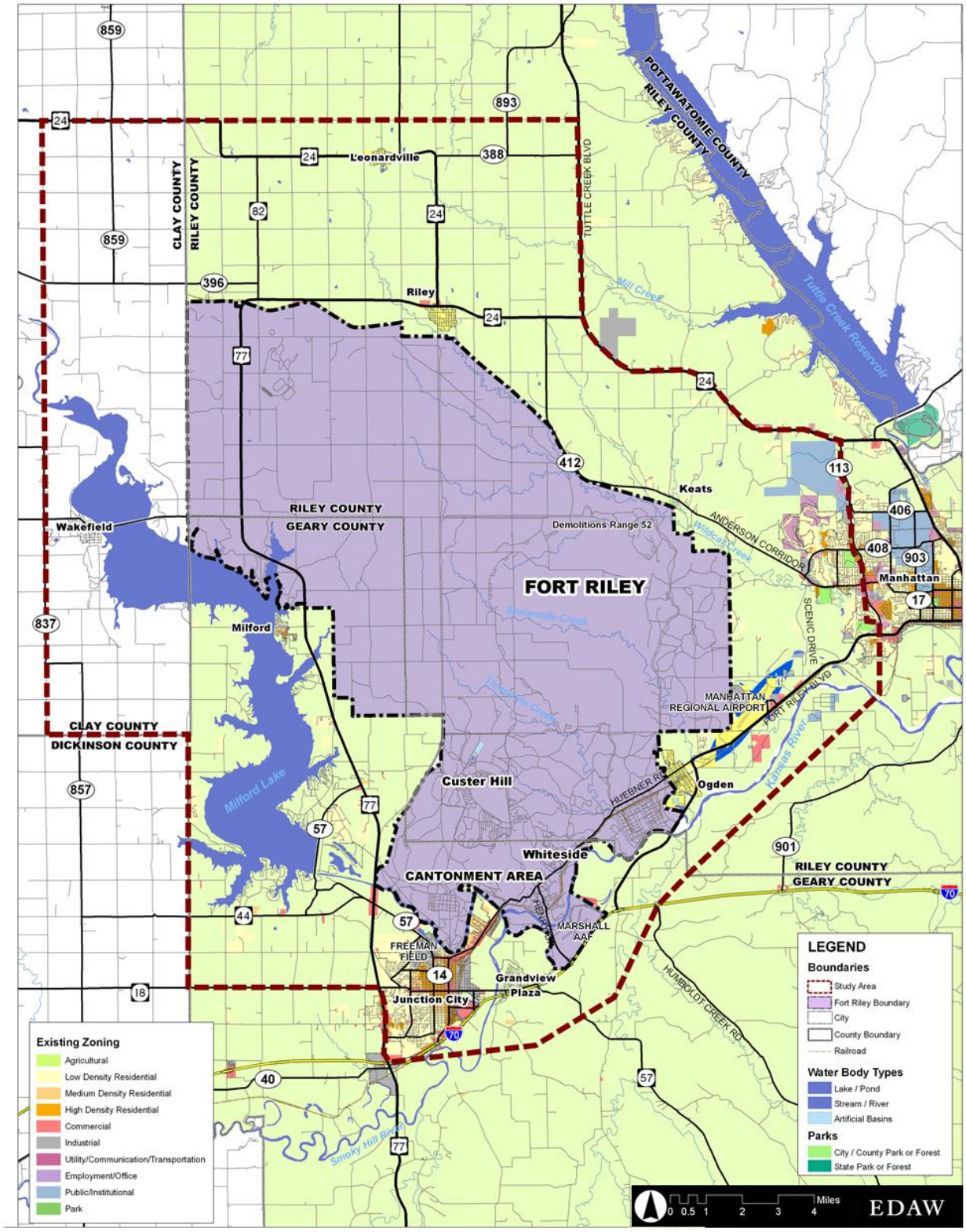
Figure 18 Future Land Use and Proposed AMPTR Noise Contours, Ogden



4.6 Analysis of Zoning

As shown in Figure 19 – Zoning, unincorporated Clay County, west of the post, zones land mainly for agricultural purposes, requiring a minimum tract size of 5 acres for each residence. The city of Milford is zoned for single family uses, along with duplex and multi family housing, and commercial/industrial activities. The predominant zoning of unincorporated Riley County north and east of the post is agricultural with a minimum lot size of 20 acres for a single family dwelling unit. The zoning pattern of Ogden east of the post is mainly single family residential. The city of Riley is zoned primarily for low to medium single family residential uses with commercial activity near the intersection of Highways 24 and 77. Geary County to the south is zoned primarily for agricultural uses, while Junction City contains a mix of commercial, industrial and medium to high density residential zoning.

Figure 19 Zoning



4.7 Current Army Compatibility Tools

The Army has a variety of tools in place to address operational impacts, such as noise, on off-post lands. The primary tool for mitigating noise is the Installation Operational Noise Management Plan, which includes identification of the Installation Compatible Use Zone (ICUZ) noise contours discussed earlier, education and outreach components, noise complaint management procedures, and noise/vibration mitigation. Fort Riley has taken the following specific actions to limit noise exposure on nearby communities:

Firing Restrictions. Fort Riley prohibits active Army units from conducting live fire training between the hours of Midnight and Noon on Sundays. Though the restriction is not applicable to the Reserve Component and National Guard, the installation discourages firing by those units between these hours.

Fly Neighborly Program. Fort Riley has adopted a "Fly Neighborly Program," which trains Army helicopter pilots on ways to reduce noise impacts when flying in developed areas. Significant aspects of the Fort Riley program include:

- Investigation of Noise Complaints.
- Designation of Noise-sensitive Areas.
- Requiring military aviators to avoid residences, buildings, and farm-related facilities by at least 500 feet slant range while maintaining appropriate altitude; to avoid towns and cities except when operating in approved corridors; to avoid livestock and recreational areas; and to use established traffic patterns, corridors, and routes at designated altitudes.

Airspace Corridor/Route System. Fort Riley has developed a system of corridors and visual flight rule (VFR) routes to promote the safe and efficient flow of air traffic and to minimize the effect of aircraft noise.

Aircraft Control Procedures. Control procedures designed to mitigate noise include: avoidance of residences, buildings, and farm related facilities; avoidance of towns, cities, and villages; and use of designated traffic patterns and altitudes.

Fort Riley also notifies the public in advance of an unusually extensive training event.

As noted earlier, the Army participates in the Fort Riley Tallgrass Prairie Partnership, an initiative to preserve the remaining grasslands surrounding the post. The post also leases options on installation land for agricultural purposes. These efforts support a broader strategy to create land use compatibility through environmental/agricultural conservation on lands adjacent to the post.

4.8 Current Local Compatibility Tools

This section assessed local government policy to determine what tools are currently available to communities seeking more compatible land use patterns around the post. The review looked for the following specific tools among existing plans, ordinances, and regulations:

Plan Coordination. *Does the jurisdiction have a Comprehensive Plan with specific language promoting land use coordination with Fort Riley and identifying areas subject to possible encroachment near the post?*

Growth Management. *Does the jurisdiction have a stated policy to guide growth away from areas in proximity to the post or from areas likely to be affected by post operations?*

Conservation. *Does the jurisdiction have an established set of environmental criteria to preserve rural/undeveloped lands that may be in proximity to the post?*

Flexible Land Use. *Does the jurisdiction permit flexible land use patterns, such as cluster zoning or planned unit developments that can reduce post impacts through innovative site design?*

Civilian Airport Zoning. *Does the jurisdiction have specific zoning that recognizes airspace hazard prevention and other land use compatibility goals around existing airports?*

Noise Reduction. *Does the jurisdiction require indoor noise reduction for new residential construction within high noise areas?*

Disclosure. *Does the jurisdiction require that real estate transactions in noise or safety affected areas include a release of information on possible impacts to prospective buyers or renters?*

As shown in Table 9 below, the local governments surrounding Fort Riley currently have access to relatively few specific tools to promote compatible, flexible land use around the post.

Table 9. Existing Local Government Compatibility Tools

Tool	Purpose/Intent	Application
City of Manhattan – Manhattan Urban Area		
Plan Coordination	To promote coordinated land use planning with Fort Riley.	Contains specific language on land use coordination: *The City and County shall work closely with Fort Riley to coordinate on issues of mutual concern, particularly as it relates to growth and development issues in the western portions of the Planning Area, to minimize land use conflicts and encroachments and insure that development is mutually compatible with the goals and objectives of this Comprehensive Plan and the mission of Fort Riley.*
Growth Management	To promote a pattern of orderly, contiguous growth from the city, to minimize low density dispersed growth and to conserve environmentally sensitive areas.	The Urban Service Area Boundary (USAB) sets the boundary inside which urban scale uses are appropriate, calling for very low density living areas, open space, and agricultural activities outside of the USAB and clustering to preserve cohesive blocks of open space/agriculture.
Conservation	To identify and protect environmentally sensitive resources as part of the development review process.	The Development and Environmental Constraints Map identifies the 65 decibel noise contour around the Manhattan Airport, sensitive habitat, prime agricultural land, and flood prone areas as constraints to be considered in proposals.

Tool	Purpose/Intent	Application
Flexible Zoning and Land Use	To promote the progressive development of land and Construction.	The Planned Unit Development District provides for flexibility in the mixing of compatible uses and the location and type of structures, while setting aside perpetual common use open space and facilities.
Airport Overlay	To promote the use and development of land in a manner that is compatible with the continued operation of the Manhattan Municipal Airport and to protect public health, safety, convenience, and general welfare.	Special zoning within the air safety zones of the Manhattan Regional Airport establishes permitted and conditional uses.
Avigation Easements	To grant the right to fly airplanes over private property.	The Manhattan Urban Area Subdivision Regulations establish avigation easements in the vicinity of flight paths and noise areas of publicly owned or controlled airports to protect navigable airspace.
Noise Reduction	No	No
Real Estate Disclosure	No	No
Riley County		
Plan Coordination	No	No (county plan is being updated)
Growth Management	To encourage a land use pattern that is more compact, to protect natural resources, to minimize infrastructure costs, and to maintain the efficiency of agriculture.	Comprehensive Plan sets policies to reduce the intrusion of scattered urban uses that are incompatible with a rural environment.
Conservation	No	No
Flexible Zoning and Land Use	To promote more flexible and progressive land use patterns.	Planned Unit Development
Airport Overlay	To prevent the obstruction of air navigation.	Airport Noise Hazard District sets height and use restrictions.
Noise Reduction	No	No (county does not currently have building codes)

Tool	Purpose/Intent	Application
Real Estate Disclosure	No	No
City of Riley		
Plan Coordination	No	No
Growth Management	No	No
Conservation	No	No
Flexible Zoning and Land Use	To give flexibility on the size, siting, and types of dwelling units permitted, while setting aside common open space.	Planned Unit Development District
Airport Overlay	No	No
Noise Reduction	No	No
Real Estate Disclosure	No	No
Junction City and Geary County		
Plan Coordination	No	No
Growth Management	To lay out general policies to protect environmental resources and to promote orderly growth.	Comprehensive Plan sets a policy to encourage a land use pattern that protects natural resources, minimizes infrastructure costs, and maintains the efficiency of agricultural uses.
Conservation	No	No
Flexible Zoning and Land Use	To permit modification to the zoning or other applicable regulations contingent upon the site development plan, the amenities incorporated within the project, and the public interest that is met.	Planned Development District
Airport Overlay	To prevent the obstruction of air navigation around Freeman Field.	An Airport Zone regulates the height of structures, requires hazard markings within airport approach zones and transition zones, and prohibits uses that may interfere with pilot vision or the operation of electrical systems.
Noise Reduction	No	No
Real Estate Disclosure	No	No
City of Ogden		
Plan Coordination	No	No
Growth Management	To promote orderly and efficient growth.	Comprehensive Plan sets goals to reinforce the existing city grid with new growth and to cluster uses to preserve open space.

Tool	Purpose/Intent	Application
Conservation	No	No
Flexible Zoning and Land Use	No	No
Airport Overlay	No	No
Noise Reduction	No	No
Real Estate Disclosure	No	No
City of Milford		
Plan Coordination	No	No
Growth Management	No	No
Conservation	No	No
Flexible Zoning and Land Use	No	No
Airport Overlay	No	No
Noise Reduction	No	No
Real Estate Disclosure	No	No
Clay County		
Plan Coordination	No	No
Growth Management	No	No
Conservation	No	No
Flexible Zoning and Land Use	No	No
Airport Overlay	No	No
Noise Reduction	No	No
Real Estate Disclosure	No	No

5.1 General Compatibility Tools

The Technical, Steering, and Policy Committees met on a regular basis throughout the JLUS planning process to evaluate a full range of available compatibility tools. The JLUS team also conducted a series of Public Information sessions and met with community stakeholders to gather feedback on possible compatibility strategies.

Representatives of local jurisdictions, the Army, and the public voiced a wide variety of issues, concerns, and ideas during the study. The resulting set of tools seeks a balance among these diverse interests by stressing:

- the feasibility of implementation;
- the effectiveness of the approach;
- the ability to sustain the economic health of the region and to protect individual property rights;
- the protection of the critical military missions performed by Fort Riley; and
- the protection of the health, safety, welfare, and overall quality of life of those who live and work in the Flint Hills region.

This section organizes tools into five sections:

- an overview of basic approaches to enhancing post/community compatibility;
- tools appropriate for the Flint Hills region;
- tools appropriate for individual jurisdictions;
- tools appropriate for the Army; and
- tools to promote land use compatibility within the JLUS study area boundary.

5.2 Overview of Compatibility Approaches

Coordination/Organizational

One of the most critical outcomes of the JLUS study is the process itself. Stakeholders from the community and military have the opportunity to build collaborative relationships, identify mutual interests, and work toward reasonable solutions that protect both civilian and Army goals. Coordination and organizational tools create the institutional capacity to support on-going implementation.

Communications/Information

These tools establish clear mechanisms for information exchange among residents, local governments, and the military. Communication options raise overall awareness of Army activities and their associated impacts, as well as identify possible approaches to reduce the effects on surrounding communities.

Sound/Vibration Attenuation

Impulsive noise and the resulting vibration of structures near the post can disturb everyday activities and diminish quality of life for affected residents. This strategy seeks to reduce the intrusiveness of post noise by protecting vulnerable land uses, particularly houses and schools.

Attenuation refers to special design and construction practices intended to lower the amount of noise and vibration that penetrates the windows, doors, and walls of a building. (see Appendix 4 for Sample Noise Reduction Standards for Residential Construction) While local governments may require attenuation as part of new construction in affected areas, jurisdictions could also explore funding opportunities with the Federal government to assist current homeowners in retrofitting their homes with sound- and vibration-proofing features.

Real Estate Disclosure

Prospective developers, buyers, and renters, particularly those new to an area, may be unaware of the special conditions that are part of living near active military installations. This tool would require the release of information on possible noise, vibration, air safety, and other operational impacts due to proximity to Fort Riley. Having a real estate disclosure ordinance/resolution in place educates individuals about the potential hazards and nuisances of nearby Army operations and it allows them to make well-informed decisions about property investment around military uses. (see Appendix 1 for a Sample Real Estate Disclosure Form)

Typically, the strongest disclosures take place at the earliest possible point of interaction between the realtor/real estate agent and the interested buyer/renter, such as the initial advertisement or listing of the affected property. To ensure the full and effective release of information, jurisdictions requiring disclosure would work with the local real estate community to develop standard language on noise and other possible operational impacts.

Planning and Public Policy

Planning and public policy tools are intended to guide overall growth patterns within local jurisdictions in ways that support future military/civilian compatibility. In general, these options promote new growth within already developed areas and the conservation of rural/agricultural lands around military installations as a means of reducing future land use conflicts.

Land Use Regulation

These tools control the densities and placement of land use activities within established noise and safety zones around the post to protect the health, safety, and welfare of the public and to maintain compatibility with military operations. These options are intended to accommodate future growth, while minimizing the

concentrations of people and activities that may trigger conflicts with noise and other operational impacts. Since local jurisdictions exercise land use control through zoning, any of the regulatory actions described below would be implemented through the established local government legislative process.

Regulations may include limitations on the density and type of development or the use of innovative tools, such as cluster zoning. Clustering can be an effective tool in promoting land use compatibility around a military installation, particularly on larger parcels that straddle an ICUZ noise or safety boundary.

Conventional zoning typically spreads housing units evenly across a parcel regardless of landscape context. As part of a cluster zone, in contrast, developers must separate the buildable areas of the parcel from environmentally sensitive areas. The district allows more compact lots in the developable portion of the site in exchange for the permanent protection of site land with conservation value.

Cluster subdivisions are usually intended to protect landscape features, such as water bodies, wetlands, wildlife habitat, scenic views, and historic sites. To ensure that this land use tool can effectively reduce future development impacts around Fort Riley, local governments would implement a special provision of cluster zoning that recognizes those portions of a parcel within a noise/safety zone as prime candidates for the application of clustering. The site design would thus set aside areas subject to noise and safety constraints and allow denser, but compatible, development in areas outside of noise and hazard zones. This approach is density-neutral, meaning that it allows the developer to build as many housing units as would otherwise be permitted under conventional zoning.

In addition to density and site location, local governments may use land use controls to regulate the impacts of tall structures, such as cell towers or wind farm structures, on navigable airspace in existing or foreseeable flight corridors used by the military. Regulation would ensure that such structures are properly marked and sited so as not to interfere with safe aircraft operation.

Coordination with the military on the placement and marking of tall structures will be especially critical as the likelihood of joint training activities and the use of additional rotary and fixed wing aircraft on the post increases. The Army should assist local governments in identifying appropriate siting areas for tall structures by mapping general flight corridors around the post.

Conservation

Conservation refers to a series of tools designed to eliminate land use incompatibilities through voluntary transactions in the real estate market and local development process. Conservation strategies are particularly effective because they advance the complementary goals of shifting future growth away from the installation and airports, while protecting the environment, maintaining agriculture, and conserving open spaces and rural character.

A critical first step in implementing conservation tools is to identify areas of protection interest. Laying out preservation priorities around the post is of value in exploring possible partnerships with the Army, the State of Kansas, non-profit conservation groups, and local governments and in requesting future funds.

Noise Easements

Under this tool, local governments would make the platting of land for residential or other noise sensitive purposes in a high noise zone contingent on the signing of a noise easement by the developer. The easement ensures that the developer is aware that military training may produce noise, smoke, vibration and other impacts affecting the property. The party thus effectively grants an easement for the continuance of noise generating activities. (see Appendix 2 for Sample Noise Easement Form)

Military Operations

Just as the spread of growth from nearby jurisdictions can threaten Fort Riley operations, changes in planned military missions, personnel, weaponry, and land use activities at the post can affect the livability of surrounding communities. The purpose of operational modifications is to minimize the noise and safety impacts experienced by communities around Fort Riley, while protecting the viability of the military mission.

The sections that follow identify the specific compatibility tools that would be available to: the overall Flint Hills region; each participating local jurisdiction; and the Army.

It should be noted that this JLUS report is intended as a menu of options for minimizing land use conflicts between Fort Riley and the surrounding communities. The tools identified are the result of a thorough, good-faith effort to assess the existing and foreseeable effects of the post on adjacent land and to draw from the best examples of compatibility actions taken by communities and installations around the country.

All of the entities participating in the JLUS, including the Army and each local government, retain the prerogative of adopting any of the tools based upon the interests of that given jurisdiction,

5.3 Regional Compatibility Tools

The JLUS identifies the following conservation, communication and coordination strategies as options for all of the participating jurisdictions within the region.

Conservation

1. *Seek out conservation partnerships with the Army, the State of Kansas, and non-profit conservation organizations to purchase development rights on environmentally sensitive lands adjacent to the post.*

As part of this strategy, local governments in the Flint Hills region would explore partnerships with the Army, the State of Kansas, and non-profit conservation entities, such as The Nature Conservancy, to purchase development rights from willing sellers of land in proximity to the post. The state is an especially critical partner in this conservation strategy. Non-profit groups require matching funds to purchase the development rights on property. The use of state funds is an excellent mechanism that can leverage the contributions of local governments. As an example, the State of Florida designates areas around military installations as "Areas of Critical Concern," making the purchase of development rights on these properties eligible for special state funds. The local governments of the Flint Hills region should lobby the State of Kansas to determine if similar funding may be available to protect the viability of a major economic engine for the state economy.

With the purchase of development rights, land ownership remains private and land owners are compensated at a percentage of market value for continuing to use land for those activities, such as agriculture or recreation that require minimal development and maintain consistency with post operations. On a national basis, the purchase of development rights equals between 50 percent and 80 percent of the market value of the land based upon local market conditions and site characteristics. The local government or a partnering non-profit agency then holds the conservation easement, which restricts development on the land in perpetuity.

As discussed later in this section, the conservation tool is particularly appropriate for the most affected areas, such as land within Noise Zone II north of the installation.

Communication

2. *Develop new ways to share information on Army operations, the economic impacts of Fort Riley, the effects of encroachment, and ways to promote compatibility.*

Under this communications option, each participating jurisdiction would develop appropriate mechanisms to ensure that residents, developers, businesses, and local decision-makers have adequate information about Army operations, the ICUZ

program, procedures to submit comments, and any additional local measures to promote land use compatibility around the installation.

Examples of such communication tools could include:

- continuance of a JLUS link from existing county or city web sites or creation of such a link when new web sites come on-line;
- creation of a web site where people can search individual parcels for information on noise or air safety issues/conditions and any easements or special development requirements attached to the property;
- joint creation and distribution with the military of a poster/brochure explaining post activities and compatibility issues;
- marking all noise and conservation easements on subdivision plats to ensure enforcement during local development approval processes; and
- joining with business organizations, such as the Chamber of Commerce, to publicize information on the economic link between the military and the region.

Coordination

3. *Participate in a Flint Hills Regional Coordinating Committee to formalize communication among local governments, community stakeholders, and Fort Riley.*

To continue the momentum created by this effort, the local jurisdictions, in collaboration with the Army, would establish a Flint Hills JLUS Regional Coordinating Committee. The committee would consist of select members of the Technical, Steering, and Policy Committees, representing all participating local governments, Fort Riley, and community, environmental, and development interests.

The Regional Coordinating Committee would serve as a forum for public input, the review of major land use proposals both within the military and civilian sectors, and on-going consensus-building to support sound, regionally-based, and cooperative community planning decisions. The local governments would appoint a civilian co-chair to the Committee to maintain focus on community interests and monitor implementation progress.

As part of regional coordination, local governments would notify the Army of specific major proposals requiring local legislative action, such as rezonings and subdivisions, within Noise Zone II, the Land Use Planning Zone or within a 1 mile buffer of the post perimeter. The Army would then have the opportunity to submit written comments for consideration. Community officials, however, would retain the full authority to enact land use decisions based upon locally determined interests

and needs. As described later in this section, the Army would also participate in regional coordination by informing local communities of actions planned on-post and considering local comments.

Other regional issues that could be coordinated through participation in a Regional Committee include the extension of infrastructure and the siting of public facilities, such as schools. New infrastructure, including roads, water, and centralized wastewater treatment can often induce growth in previously undeveloped areas and support higher density development patterns. To ensure that infrastructure systems do not heighten land use conflicts around the post, local governments would review the land use impacts of service extension and infrastructure improvements into those areas that fall within designated noise and safety zones, particularly NZ II, the LUPZ, and a one mile buffer of the post boundary.

To ensure coordination on school sitings, all jurisdictions within the Flint Hills region would consult with Army representatives on the proposed placement of new educational facilities near Fort Riley, particularly if school property is within the Land Use Planning Zone or closer to the post. While the Army cannot supersede the land use planning authority of local government entities, early coordination on siting options allows decision-makers to understand the likely noise exposure and safety risks associated with placement of a school near a post.

4. Sign a Memorandum of Agreement to establish communication procedures.

Efforts to promote regional coordination can be effectively documented with a general Memorandum of Understanding (MOU). The MOU is a "good faith" document that lays out procedures for communicating among affected parties and formalizes collaboration among multiple stakeholders. All participating local governments and Fort Riley would sign a general MOU to be executed at the beginning stages of implementation. Specific MOUs can then be signed between individual jurisdictions and Fort Riley as specific tools are adopted. (see Appendix 3 for a Sample General Memorandum of Understanding)

5.4 Local Government Compatibility Tools

One of the challenges of a JLUS study affecting multiple government jurisdictions is to identify impact reduction strategies adapted to the specific issues and needs of each local community setting. The specific tools below are identified solely for local jurisdiction consideration. Any implementation is at the discretion of the jurisdiction.

Riley County (rural area)

1. *Adopt building codes to implement any appropriate sound and vibration reduction measures.*

Building codes are the most effective mechanisms for enforcing any noise/vibration reduction measures that the county may want to promote as part of new construction for residential and other sensitive uses in noise affected areas.

2. *Include specific language on JLUS coordination as part of the Comprehensive Plan update.*

The Comprehensive Plan is particularly useful because it ensures a firm legal basis for the implementation of compatibility actions that may be taken by the county. Language should emphasize the following elements:

- recognition of the relationship between Riley County and Fort Riley;
- the desire to promote cooperation among the county, Fort Riley, community stakeholders, and neighboring jurisdictions in land use planning decisions;
- identification of those specific areas that are vulnerable to encroachment and clear guidelines about appropriate future land use in those areas; and
- discussion of other complementary land use goals in addition to post/community compatibility, such as agricultural conservation and environmental protection.

City of Riley

1. *Adopt building codes in conjunction with Riley County to implement any desired sound and vibration reduction measures.*

2. *Develop a Future Land Use Map in coordination with Riley County to lay out long-term land use and growth policies for the city.*

With a Future Land Use map, the City of Riley can clearly lay out its priorities for growth, while also coordinating land planning issues with Riley County and Fort Riley.

Clay County

1. *Develop a Future Land Use to lay out long-term land use and growth policies for the county.*

City of Milford

2. *Develop a Future Land Use to lay out long-term land use and growth policies for the city.*

City of Junction City/Geary County

1. *Include language on JLUS coordination as part of any planned Comprehensive Plan update.*

City of Ogden

1. *Include language on JLUS coordination as part of any planned Comprehensive Plan update.*

5.5 Army Compatibility Tools

Conservation

1. *Pursue conservation initiatives, such as the Army Compatible Use Buffer.*

In 2002, Congressional legislation (Agreements to Limit Encroachments and Other Constraints on Military Training, Testing, and Operations) granted authority to the Department of Defense (DoD) to partner with local governments and conservation organizations. The DoD may use this authority to assist in acquiring land near military installations from a willing seller when the acquisition can protect both the environment and the military mission.

The Army can capitalize on this tool by pursuing available funding opportunities within the DoD. Establishing partnerships among the military and local, state, and non-profit entities would enable a quick and effective response when priority real estate acquisition opportunities emerge and can leverage the Army's existing encroachment prevention efforts, such as the Tallgrass Prairie Partnership. It should be noted that any purchase of development rights as part of this strategy would be strictly voluntary.

2. *Pursue Development/Agricultural Exchange opportunities with neighboring farmers.*

The Conservation Division of Fort Riley is also pursuing Development/Agricultural Exchange opportunities with willing adjacent landowners. As part of this initiative property owners agree to restrict development on their land in exchange for access to installation land for production agriculture.

As an example of such an agreement, a landowner assumes a deed restriction that prohibits future homebuilding (other than a personal residence) on the property. If the market values the lost development right at $25,000, Fort Riley would effectively purchase that deed restriction by creating a lease arrangement for hay or crop production rights equal to that value. The exchange thus reimburses the landowner for the full amount of land value lost over a certain number of years.

Farmers participating in the arrangement must still comply with the Army's land use regulations, which outline procedures for when and where hay can be cut and also set guidelines for row crop production.

Noise Monitoring

3. Add a noise monitor to the Keats area.

Fort Riley has a series of noise monitoring devices in place (see Figure 11) west of Manhattan, north of Manhattan Regional Airport, in the City of Riley, in the Bala area at the northwest corner of the installation, and on-post at the MPRC. As noted earlier, monitoring data cannot be used to generate a noise contour and by policy the Army does not typically rely on on-site monitoring except where needed to address a complaint or verify noise levels that have produced a major public controversy. On-site monitoring of noise, however, is useful in particular circumstances, such as:

- checking the accuracy of a noise contour at selected points;
- defining the day-night average contour when the model is known to be inaccurate;
- defining the day-night average contour when no operational data are available; and
- defining the baseline day-night noise average.

Methods for depicting the noise environment surrounding military installations are always evolving. To better understand noise impacts generated by post operations, Fort Riley should continue with plans to add a noise monitoring device in the Keats community and explore opportunities to add other monitoring devices in noise affected areas west of the post.

4. Explore new noise mapping technologies such as peak noise contours.

The Army should also explore the emerging use of peak noise data mapping to supplement the current day-night average noise modeling.

Operational Changes

5. Explore feasible short-term strategies that can reduce the psychological annoyance of noise, such as seeking to limit firing during weather conditions that propagate noise and increasing opportunities to coordinate firing times and/or to reduce the number of rounds fired at critical times, such as at night.

The Technical, Steering and Policy Committees reviewed a series of possible operational measures to reduce noise generated from post activities. This type of noise mitigation generally falls into three categories:

- Source mitigation, which reduces the amount of noise produced by a piece of equipment or an activity; an example of this technique would be the muffling of a weapon.

- Mitigation along the sound path that reduces the amount of noise getting through to the receiver, such as a house on off-post lands; an example of this technique would be construction of a berm to block noise before it travels off-post; and

- Mitigation at the receiver (such as a house) which may involve architectural or site design controls to lower the amount of noise that is heard; this technique may also include means of reducing the psychological annoyance associated with noise.

An essential element of this compatibility strategy is to identify those methods that will bring nearby residents measurable relief from noise exposure, while protecting the ability of Fort Riley to perform its critical training mission. To achieve this goal, Committee members consulted with acoustical engineering experts at the Army's Center for Health Promotion and Preventive Medicine, and the Army Construction Engineering Research Laboratory.

A variety of mitigation strategies seem like intuitive solutions for blocking noise, such as moving noisy operations farther into the post and away from the shared boundaries of adjacent communities; relying more on simulated training, rather than the actual firing of weapon systems; limiting night-time training activities; or constructing a berm around post facilities. Unfortunately, these techniques would either degrade the post mission or they are not technically sound engineering practices and thus fail to limit noise propagation.

Fort Riley's mission accommodates heavy, technologically-complex, long-range weapons systems. Artillery units train with the 155 mm Howitzer and the Multiple-Launch Rocket System, both of which require placing firing points closer to post boundaries. In addition to the long-range and power of American weapons systems, the U.S. military enjoys a significant advantage in fighting at night, which requires training with night vision goggles.

Fort Riley has a long history of working with the National Simulation Center to test new simulation training products. The post is home to a Battle Simulation Center (BSC) in the Exercise Simulation Division (ESD). The BSC contains state-of-the-art equipment to conduct Brigade/Battalion Battle Simulation exercises. While this technology can supplement traditional training methods, there is no substitute for soldiers learning to fire weapons and to operate effectively under the physically confining, noisy conditions associated with actual armored vehicle movements.

Given the impulsive nature of the heavy artillery noise generated at the post, physical barriers such as a berm or vegetated buffer are impractical mitigation options. Such structures would have to be very close to the source of the noise, interfering with the use of maneuver areas on the post, and would also have to be exceptionally high. Even with these structural features in place, the sound waves would tend to bounce off relatively intact from the barrier and continue traveling off-post.

Though there are currently engineering limitations to the noise reduction that can be achieved, the Army continues to research mitigation methods. Fort Riley should also continue to explore other more feasible short-term strategies that can at least reduce the psychological annoyance associated with noise. For example, to the extent feasible, the post should seek to limit firing during weather conditions that propagate noise and explore opportunities to coordinate firing times and/or to reduce the number of rounds fired at critical times, such as at night. Table 10 identifies weather conditions, which are more or less conducive to noise propagation during the firing of large weapons.

Table 10. Meteorological Conditions and Effects on Noise

Good Conditions with Less Noise Propagation	▪ Clear skies with billowy cloud formations, especially during warm periods of the year ▪ A rising barometer immediately following a storm
Bad Conditions with More Noise Propagation	▪ Days of steady winds of 5-10 mph with gusts greater than 20 mph in the direction of nearby residences ▪ Clear days on which "layering" of smoke or fog are observed ▪ Cold, hazy, or foggy mornings ▪ Days following extremes temperature change (20^0C or more) ▪ Generally high barometer readings with low temperatures

Communication

6. *Develop additional methods for sharing information with surrounding communities.*

One of the most effective means for strengthening the relationship between the Army and its civilian neighbors is to help people understand how the military operates and why it generates certain impacts on surrounding areas. Both community and military stakeholders have expressed a strong interest in maintaining open communication and local residents in affected communities greatly value opportunities to participate in noise mitigation and other environmental management initiatives.

Fort Riley currently maintains a web site that includes various installation plans and environmental documents. To support communications and information approaches to land use conflict reduction, the Army would continue to improve public communication through an updated and expanded web site that, to the extent feasible, includes information on planned training schedules, and operational guidelines for night training.

The Army should also increase the visibility of a Point of Contact for noise issues, publicize a staffed 24-hour "noise information line," and create a brochure/poster on post mission and activities, operational impacts and mapped noise contours, and compatibility issues.

Coordination

7. Participate in the Flint Hills JLUS Regional Coordinating Committee.

To support regional coordination, Fort Riley would appoint a co-chair to participate in the Flint Hills Joint Land Use Regional Coordinating Committee. As with local governments, the Army would use this forum to notify all local governments of major actions that may affect the noise environment or produce other operational impacts on the surrounding communities. The military should also explore further opportunities to publicize and seek local public involvement during development of environmental assessment documents, noise management plans and other studies.

8. *Sign a Memorandum of Agreement to establish communication procedures.*

As with the local governments, Fort Riley would sign an MOU that lays out procedures for communicating among affected parties and formalizes collaboration among multiple stakeholders.

5.6 Land Use Compatibility Map

Sections 5.4 and 5.5 mainly identify coordination and communication tools that are appropriate for local governments and the Army. This section now focuses on options intended to address the specific operational impacts of the post on surrounding land.

Communities of the Flint Hills region, like all local governments, use zoning and other policies to protect the heath, safety, and welfare of residents and to advance a compelling public interest. The JLUS recognizes that land use regulations are especially challenging for local governments to implement because they take place in the context of individual private property rights. Indeed, many residents and property owners participating in the JLUS process have expressed concern that compatibility tools, such as required disclosure and density limitations, will diminish property values.

To ensure that tools are well tailored to reduce foreseeable land use conflicts and to make certain that all such actions are thoroughly grounded in an understanding of the noise and safety environment around the post, this section identifies regulatory options based on a Land Use Compatibility analysis.

The Land Use Compatibility analysis follows a three-step inquiry:

What are the environmental and operational constraints that could affect future growth opportunities in the Flint Hills region?

Where can communities grow, while minimizing foreseeable land use conflicts with identified constraints?

What compatibility tools are appropriate for addressing specific areas with identified constraints and where would they be best used in the study area?

The goal of the compatibility exercise is to strike a balance between community growth and the protection of the military mission, which requires an adequate buffer to conduct essential training activities.

Development Constraints

First, to understand what environmental and operational characteristics could affect regional growth, the analysis prepared a constraints matrix that prioritizes features or impacts inventoried in the study area by the relative importance of protection (see Table 11).

Level 1 contained severe constraints, or areas in which immediate, critical protection is warranted and where most growth is not compatible. For example, the analysis assigned Noise Zones 2 and 3 (62 and 70 CDNL) and critical habitats a Level 1 constraint value.

Level 2 contained moderate constraints that indicated where short to medium term protection was important and where certain types of growth were incompatible. The analysis assigned a Level 2 value to the Land Use Planning Zone (57 CDNL) because noise exposure in this area is less severe than NZ II, but could still raise compatibility issues with some land uses.

Level 3 represented low constraints where most types of land uses were compatible although limited protection may be promoted in certain areas. This level contained areas of general conservation interest, such as prime agricultural soils or areas with intact prairie vegetation.

Table 11. Development Constraint Criteria

LEVEL 1 (Severe Constraints; immediate, critical protection needed; most growth not compatible)	
FEATURE	**DATA SOURCE**
Floodplains (100 year)	Federal Emergency Management Agency
Developed Areas	Existing Land Use Maps
Public Lands (state parks, military installation, etc.)	Federal, State, County, The Nature Conservancy
Noise Zones 2 and 3 (62 and 70 CDNL)	Fort Riley
Airport Approach and Transition Zones	FAA
Wetlands	Nat Wetlands Inventory
Environmentally Sensitive Areas	Manhattan Comprehensive Plan
Critical Habitat (threatened and endangered species not including Milford Lake buffer)	KS Dept. of Wildlife/Parks
LEVEL 2 (Moderate Constraints; short to medium term protection important; some growth incompatible)	
FEATURE	**DATA SOURCE**
Floodplains (500 year)	FEMA
Airport Part 77 Airspace	FAA
Noise Zone 1 (57 CDNL)	Fort Riley
Parcels less than 3 acres	Where parcel data is available
Slopes above 20%	US Geological Survey
LEVEL 3 (Low Constraints; limited protection needed; most growth compatible)	
FEATURE	**DATA SOURCE**
Areas of Conservation Interest	The Nature Conservancy
Parcels between 3 and 10 acres	Parcel data if available
Prime Agricultural Soils	National Resources Conservation Service
Bald Eagle Critical Habitat (Milford Lake)	KS Dept. of Wildlife/Parks

As shown on Figure 20 – Growth and Constraint Analysis Map, areas in darker green have Level 1 environmental assets and may warrant more immediate protection. Areas of lighter green show moderate environmental constraints and areas in white feature almost no natural constraints. Areas with dark hatching indicate off-post lands with more severe operational impacts from the post, primarily high noise exposure. Areas of lighter hatching have lesser restrictions associated with air safety issues and noise exposure. The map thus reveals the least constrained land, which represents key opportunity areas for achieving the JLUS planning objectives of balanced growth and post protection.

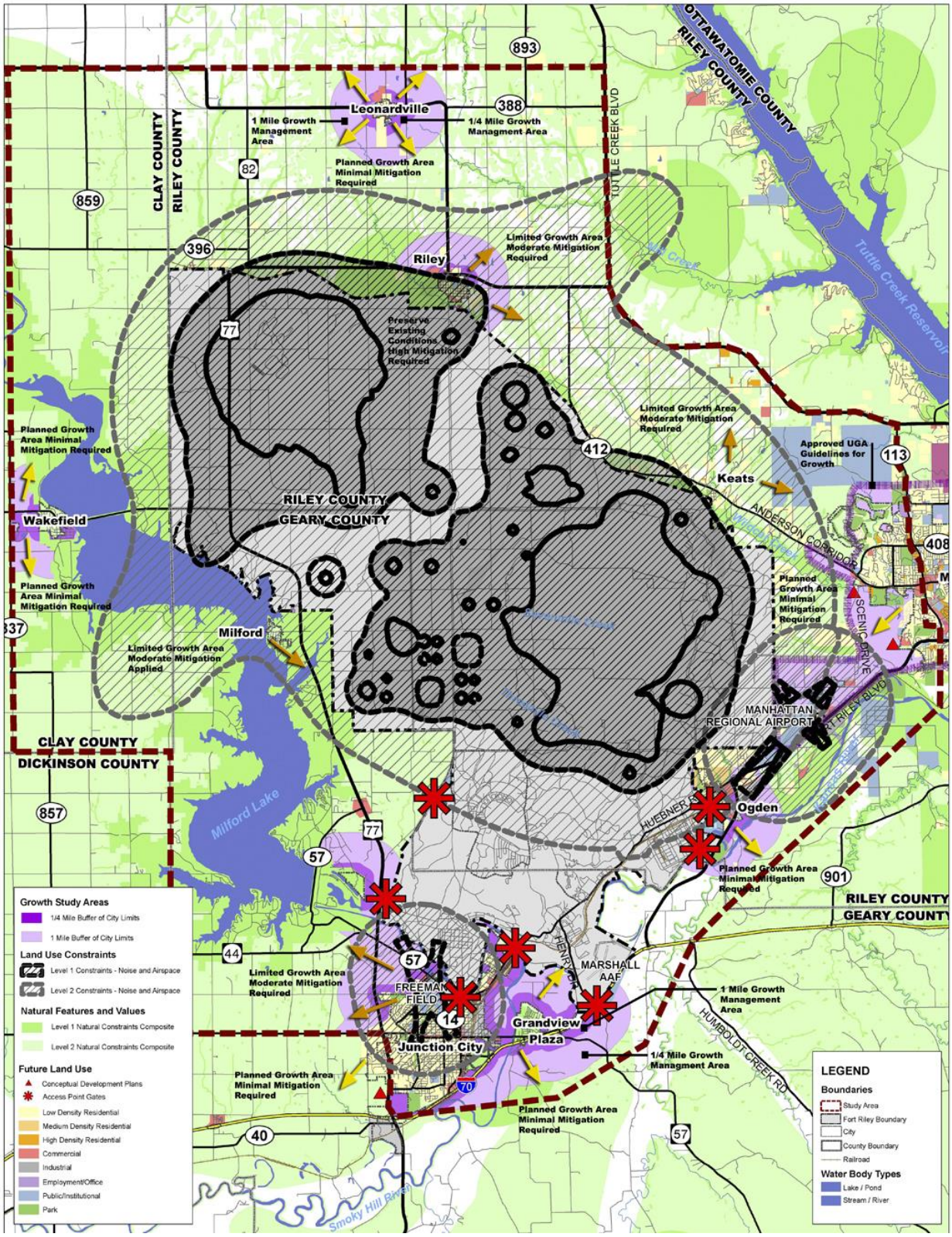
Growth Opportunity Areas

As a second step, the analysis identified development opportunities (or factors that stimulated growth) within the unconstrained areas to understand where and why growth might follow. Development opportunities included:

- Proximity to new or proposed infrastructure improvements, especially transportation
- Adopted Growth Areas
- Existing City Limits
- Existing Zoning
- Proximity to developed areas
- Areas with contiguous parcels over 10 acres
- Trails and Parks

The analysis then combined these opportunities with population projections (see Table 7) that estimated land demand/absorption for each municipality. This approach modeled land areas necessary to accommodate projected growth in each county or city to create possible growth opportunity areas. The analysis sought to place growth opportunity areas on less constrained land that could accommodate expected population increase and resulting development with minimal conflicts (see Figure 20 - Growth and Constraints Analysis Map). Each community as shown on the map received two growth management areas, representing a more compact pattern in darker purple and a more dispersed land use pattern in lighter purple. The map generally indicates that the region can accommodate expected population increases even in more dispersed development patterns without converting extensive lands around the post to developed uses.

Figure 20 Growth and Constraints Analysis Map



The Land Use Compatibility Map and Appropriate Tools

To answer the third and last question about where compatibility tools might be appropriately used within the study area, Technical, Steering, and Policy Committee members refined the Growth and Constraints Analysis Map based on their understanding of growth in the region and stakeholder feedback on likely development patterns and issues in the local communities.

The resulting Land Use Compatibility Map (see Figure 21) should serve as a guide for assisting the development of communities in relationship to Fort Riley and does not in itself control growth in any area. Instead, it organizes the study area into a series of land use categories that reflect operational and environmental issues, current growth patterns, and existing community boundaries. The Land Use Compatibility Map is intended as a framework to minimize foreseeable conflicts, recognize those established communities that experience impacts from the post, and highlight those areas around the post that may warrant conservation due to noise or safety effects. Table 12 takes the additional step of identifying those compatibility tools that are most effective for addressing specific operational impacts within each of the land use categories that comprise the study area.

Figure 21 Land Use Compatibility Map

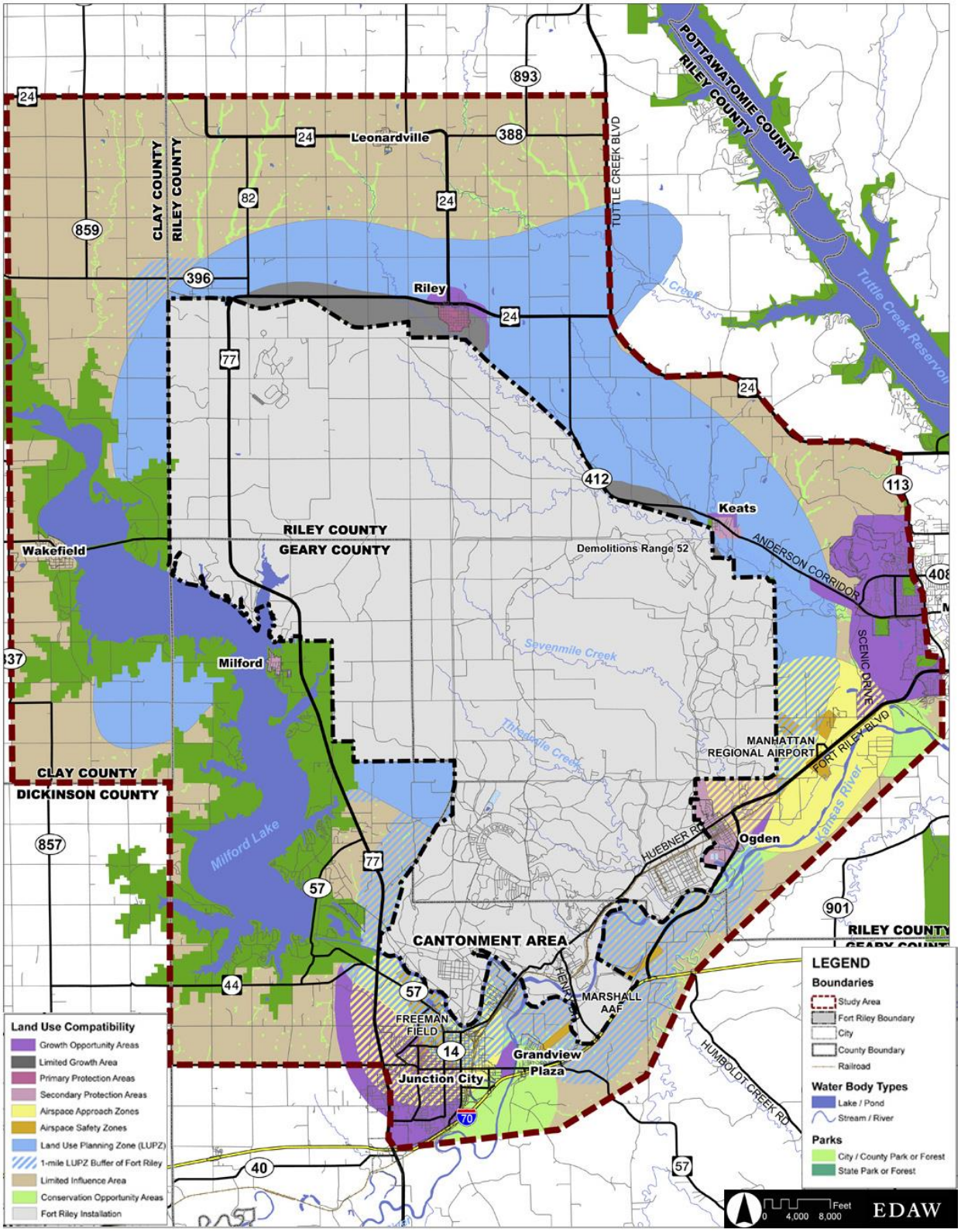


Table 12. Land Use Compatibility Categories and Tools

Category	Purpose	Map Color	Possible Tools
Growth Opportunity Area	To accommodate future development in the community		▪ Comply with existing zoning, comprehensive plan policy, and development standards of the controlling jurisdiction ▪ If property falls inside the LUPZ, encourage real estate disclosure of possible impacts
Limited Growth Area	Corresponds to the Noise Zone II areas off-post and recognizes operational impacts that may be severe enough to affect certain uses		▪ Discourage new development of noise sensitive uses, such as housing, churches, schools, places of assembly or medical facilities ▪ If permitted, encourage construction of noise sensitive uses to incorporate adequate indoor sound and vibration attenuation ▪ Encourage real estate disclosure of possible impacts ▪ Encourage platting of land for residential and other sensitive uses to be contingent upon the signing of a noise easement

			▪ Encourage compatible uses, such as recreational, conservation, agricultural activities ▪ Discourage centralized infrastructure to support residential development within the area ▪ Target area for conservation strategies, such as the purchase of development rights
Primary Protection Area	Corresponds to developed areas that fall inside Noise Zone II		▪ Continue infill residential development of platted land ▪ Encourage the construction of noise sensitive uses to incorporate adequate indoor sound and vibration attenuation ▪ Encourage real estate disclosure of possible impacts ▪ Encourage platting for residential and other noise sensitive uses to be contingent upon the signing of a noise easement
Secondary Protection Area	Corresponds to developed areas that fall inside the LUPZ		▪ Continue infill residential development of platted land

			▪ Encourage real estate disclosure of possible impacts
Air Safety and Air Approach Zones	approach and transitional zones around Marshall Army Airfield, Freeman Field and Manhattan Regional Airport		▪ Comply with FAA regulations for building height and markings in both safety and approach zones to maintain compatibility with nearby air operations ▪ Discourage high density land use activities (i.e. apartment buildings) inside the safety zone (orange) ▪ Encourage real estate disclosure of possible impacts inside the safety zone (orange)
Land Use Planning Zone	Corresponds to the LUPZ and recognizes areas that can be affected by post operations during periods of higher activity		▪ Encourage compatible new growth, including agriculture, industrial, retail, manufacturing and recreational uses ▪ Encourage new residential development not to exceed 1 DU/10 acres ▪ Encourage real estate disclosure of possible impacts ▪ Discourage expansion of

			centralized water and sewer
Installation Influence Area	Corresponds to a one-mile buffer around the installation boundary for those areas that are not already within the LUPZ or Noise Zone II; takes into account areas where close physical proximity to the post boundary can create security and access issues		▪ Encourage compatible new growth, including agriculture, industrial, retail, manufacturing, lower density housing, and recreational uses ▪ Discourage high density land use activities (i.e. apartment buildings) ▪ Encourage real estate disclosure of possible impacts
Limited Influence Area	Includes all of the areas within the original JLUS boundary that do not have identified air safety, noise, or other operational issues due to proximity to post		▪ Comply with local zoning and comprehensive plan
Conservation Opportunity Area	Areas of environmental interest that do not have specific compatibility issues with the post or airfields		▪ Target as secondary conservation opportunities

Note: DU = dwelling unit

Receipt of the final JLUS document is not the end of the planning process for the Flint Hills region and the Army. This document identifies possible compatibility tools that can be adopted by local communities and the installation.

As a first step toward achieving collaborative planning, this Implementation Section identifies all compatibility options described earlier in the report and identifies specific action steps and parties.

Proposed Tools	Action Steps	Implementation Entity
Purchase or Lease of Development Rights (PDRs)	Research potential funding sources/partnerships. Any conservation program should also be based on clearly stated eligibility criteria.	Army, Federal, State of Kansas, Local Jurisdictions, and Non-Profit Conservation Organizations
Voluntary Development/ Agriculture Exchange	Army to identify interested landowners.	Army
Require Noise Easements	Local governments would adopt regulations requiring a noise easement for new residential construction in noise affected areas.	Local governments would also be responsible for enforcing the easement during development approval steps.
Improve Army communications	Update and expand web site content on current and foreseeable activities.	Army
Improve local government communications	Establish permanent web site link and integrate property appraiser's database when feasible. Publish awareness materials. Also work with local business organizations to publicize the economic relationship of the military in the region.	Local Jurisdictions and Business Organizations

Proposed Tools	Action Steps	Implementation Entity
Create JLUS Regional Coordinating Committee	Select representatives from JLUS Technical/Steering/Policy groups to continue collaboration on issues. Should also include members of the development and business community, conservation interests, and landowners.	Local Jurisdictions and Army
Consultation on land use actions.	Establish procedures for consultation in zoning ordinance and Comprehensive Plan. Establish procedures for briefing local jurisdictions on proposed operational changes.	Local Jurisdictions and Army
Sign a Memorandum of Understanding	General MOU to be executed at the beginning stages of implementation. Specific MOUs can be signed between individual jurisdictions and Fort Riley as tools are adopted.	Army and All Participating Local Jurisdictions.
Compatibility standards for density and land uses.	Approval of Local Elected Officials with Implementation by Local Planning and Zoning Staff.; would be implemented through a zoning overlay based on noise and air safety zones around the post.	Local Jurisdictions
Restrictions on Wind Farms, Cell Towers and other Tall Structures	Approval of Local Elected Officials with Implementation by Local Planning and Zoning Staff.	Local Jurisdictions

Proposed Tools	Action Steps	Implementation Entity
Encourage use of current PUD Zoning.	Implementation by Local Planning and Zoning Staff.	Local Jurisdictions
Add more noise sensors.	Army to identify areas that lack on-the-ground noise monitoring.	Army
Other noise measures.	Army to identify technically feasible changes in training that do not compromise the effectiveness of the training mission.	Army
Conduct review of Army operational impacts as part of future school sitings	Include review as additional step in long-term planning decisions and site planning approval process	Local Jurisdictions and School System
Include JLUS implementation and land use coordination in Comprehensive Plan.	Include new language as part of revisions of existing plans or the adoption of new plans.	Local Jurisdictions

Proposed Tools	Action Steps	Implementation Entity
Coordinate the Capital Improvement Plan with Compatible Land Use Map	Incorporate land use compatibility language into plans for infrastructure extensions and improvements.	Local Jurisdictions
Require indoor noise reduction measures.	Work with building industry to develop appropriate standards and incorporate into existing ordinances with the approval of local elected officials. Also require building codes and code enforcement mechanisms.	Local Jurisdictions and Building Industry
Assist current homeowners in noise-affected areas to retrofit homes with indoor noise reduction measures.	Local jurisdictions to explore funding opportunities with the Federal government.	Local Jurisdictions and Federal government.
K-18 Corridor Re-alignment	Cite issues to coordinate in the JLUS Report and in the corridor study.	Local Jurisdictions, KDOT, K-18 Consultant Team
Disclosure of possible impacts as part of a real estate transaction.	Work with real estate and building industry to develop and implement language for inclusion.	Local Jurisdiction and Real Estate-Builders Representatives.

Technical Appendices

Appendix 1 Sample Real Estate Disclosure Form

Appendix 2 Sample Noise Easement Form

Appendix 3 Sample Memorandum of Understanding

Appendix 4 Sample Noise Reduction Standards for Residential Construction

Appendix 5 Land Use Compatibility Standards

Appendix 6 Fort Riley Environmental Documents

Appendix 2 Sample Noise Easement Form

NOISE EASEMENT

Parcel _____ County _____

Grantor (s) Name _____

Grantor (s) Address _____

LEGAL DESCRIPTION:

In accordance with section XXXXX of the Land Use Code/Ordinance for XXXXX County, State of Kansas, approving a plat for residential development on the above described property, and in consideration of such approval, Grantors grant to the owners of all property adjacent to the above described property, a perpetual nonexclusive easement as follows:

1. The Grantors, their heirs, successors, and assigns acknowledge by the granting of this easement that the residential development is situated in a area that may be subjected to conditions resulting from military training at Fort Riley . Such conditions include the firing of small and large caliber weapons, the overflight of both fixed-wing and rotary-wing aircraft, the movement of vehicles, the use of generators, and other accepted and customary military training activities. These activities ordinarily and necessarily produce noise, dust, smoke and other conditions that may conflict with Grantors' use of Grantors' property for residential purposes. Grantors hereby waive all common law rights to object to normal and necessary military training activities legally conducted on adjacent Fort Riley, which may conflict with Grantors' use of Grantors' property for residential and other purposes, and Grantors hereby grant an easement to the adjacent Fort Riley for such activities.

2. Nothing in this easement shall grant a right to Fort Riley for ingress or egress upon or across the described property. Nothing in this easement shall prohibit or otherwise restrict the Grantors from enforcing or seeking enforcement of statues or regulations of governmental agencies for activities conducted on adjacent properties.

3. This easement is appurtenant to all property adjacent to the above described property and shall bind to the heirs, successors, and assigns of Grantors and shall endure for the benefit of the adjoined Fort Riley. Fort Riley is hereby expressly granted the right of third party enforcement of the easement.

IN WITNESS WHEREOF, the Grantors have executed this easement dated this

_____ day of _____, 20 _____

_____

Grantor

Appendix 3 Sample Memorandum of Understanding

MEMORANDUM OF UNDERSTANDING

Between Fort Riley
_____ Counties and

The Cities of _____

This Memorandum of Understanding between Fort Riley, the Counties of _____, and the Cities of _____, is enacted to establish a mutually beneficial process that will ensure timely and consistent notification and cooperation between the parties on projects, policies, and activities. These parties have a mutual interest in the cooperative evaluation, review, and coordination of local plans, programs, and projects in the Counties of _____, the Cities of _____, and on Fort Riley.

The Cities of _____ and the Counties of _____agree to:

1. Submit information to Fort Riley on plans, programs, actions, and projects that may affect Fort Riley. This may include, but not be limited to the following:

- Development proposals
- Transportation improvements and plans
- Sanitary waste facilities
- Open space and recreation
- Public works projects
- Land use plans and ordinances
- Rezonings and variance

2. Submit to Fort Riley for review and comment, project notification, policies, plans, reports, studies and similar information on development, infrastructure and environmental activities within proximity of Fort Riley as defined by _____.

3. Consider Fort Riley comments into local responses or reports.

4. Include Fort Riley in the distribution of meeting agendas for, but not limited to:

- City Council or County Commission Meetings
- Planning Commission Meetings
- Zoning Boards of Adjustment
- Review Board
- Transportation Studies

Fort Riley agrees to:

1. Submit information to City and County representatives on plans, programs, actions, and projects which may affect the city or county. These may include, but not be limited to, the following:

- Installation Master Plan
- Installation Compatible Use Zone Studies
- Noise Management Studies
- Changes in existing installation use that may change off-post impacts, such as noise
- Appropriate data on troop strength and activities for local plans, programs and projects

2. Submit to City and County representatives for review and comment, project notification, policies, plans, reports, studies and similar information on development, infrastructure and environmental activities at Fort Riley.

This agreement will remain in effect until terminated by any of the parties. Amendments to this memorandum may be made by mutual agreement of all the parties. Review process details and appropriate forms may be developed to facilitate uniform and efficient exchanges of comments.

This understanding will not be construed to obligate the U.S. Army, the Cities of _____, the Counties of _____ to violate existing or future laws or regulations.

This agreement is approved by:

_____

County

_____

City

_____

Fort Riley

Appendix 4
Sample Noise Reduction Standards for Residential Construction

Source: "Eastern Carolina Joint Land Use Study, Prepared for Craven County, Carter County, City of Havelock, Town of Emerald Isle, Town of Bogue, Town of Atlantic, and MCAS Cherry Point by the Eastern Carolina Council, Region P council of Governments; November 2002.

Note: Standards differ by geographic region.

SOUND INSULATION IN RESIDENTIAL STRUCTURES

DEFINITION

Sound insulation refers to the use of acoustical related building materials for the reduction of noise for architectural abatement purposes. These materials apply to any areas of a structure that may be part of a sound transmission path including windows, doors, roof systems, ventilation, wall systems (exterior), and utility access points through a building envelope.

CHARACTERISTICS

The application of sound insulation techniques can involve existing and/or planned structures or buildings. Often the benefits for noise control, such as double pane windows have additional benefits in terms of energy conservation and reduced heat loss. The primary objective of an airport sound insulation program is to reduce the sound transmission through the building envelope (e.g., exterior wall, window, and roof system), thereby having lower interior noise levels. The implementation of such a program may be the adoption of a building code or performance requirements established by a public agency.

POSITIVE FEATURES

The primary benefit of a sound insulation program is to protect the noise receiver, while they are indoors. Frequently, there are associated benefits of energy conservation when there is building insulation. Such efforts have the flexibility of applying to both existing structures, as well as buildings that will be constructed. Therefore, it can be more comprehensive than a building code. Since building codes generally are applicable only to planned or new structures.

NEGATIVE FEATURES

Sound insulation controls apply directly to a structure. Therefore it does not improve the outdoor environments, when the individual is outside the home. Often times, sound insulation is considered for selected areas or buildings, rather than being a comprehensive approach.

LEGAL STANDING

Sound insulation programs are frequently mandates for certain geographical areas as a policy of a jurisdiction with matching federal and local funds involved. Since a program is adopted by a jurisdiction it does represent legal standing.

Sound Attenuation <u>Definitions</u>

<u>DNL Day - Night Sound Level</u>:
An average of the cumulative measure of the noise exposure during a 24-hour day.

<u>Exterior Wall Rating</u>:
EWR is a single-number rating for exterior building elements (such as walls, windows, doors, etc.) and represents the effective sound transmission loss capability, in decibels, of each element, It differs from the STC rating in that it is based on aircraft noise rather than office noise spectra. For this reason, EWR is superior to STC for describing the sound-insulating properties of exterior wall elements exposed to aircraft noise. The EWR concept was developed by Wylie Laboratories and has been used extensively in studies of residential sound insulation. It is conceptually similar to the STC rating method. Like TL and SIC, the higher the EWR value, the better the noise reduction.

<u>Noise Reduction</u>:
The quantitative measure of sound isolation between spaces is called Noise Reduction (NR). The NR between two spaces, such as from the exterior to the interior of a dwelling, depends on the TL of the various components in the separating wall, the area of the separating wall, and the acoustical absorption n the receiving room. This value takes more into account than just the sound transmission characteristics of the wall material. Generally, values of NR are determined in one-third octave bands. A higher NR gives a lower noise level in the receiving room, indicating greater noise insulation.

<u>Noise Level Reduction</u>:
NLR is used to describe the reduction of environmental noise sources, such as aircraft. Lt is a single-number metric based on values of A-weighted noise reduction (NR). The greater the sound insulation in a wall, the lower the noise level in the receiving room, giving a higher NLR. The NLR is useful because it is a simpler metric to use than NR; one number is easier to apply than a set of numbers in one-third octave bands. However some building materials and components are more effective at reducing low-frequency noise than other materials or components. Since aircraft noise contains a lot of low frequency sound, it is important to ensure that insulating materials and components perform well at low frequencies. NLR is a good indicator of overall wall performance but may not be appropriate when designing modifications for aircraft noise reduction, especially if a good NLR value disguises poor low frequency insulation.

<u>Sound Transmission Class</u>:
Since working with a series of one-third octave TL measurements can be cumbersome, a single number descriptor based on the one-third octave values has been developed. This rating method is called the Sound Transmission Class (SIC). Like TL, the higher the STC rating for a construction method or component, the higher the sound insulation. Originally, STC ratings were developed as a single-number descriptor for the TL of interior office walls for typical office noise and speech spectra. Now, they are used, often incorrectly, for exterior walls as well. Most acoustical materials and components are commonly specified in terms of their SIC ratings.

Sound Transmission Loss:
This is the physical measure, which describes the sound insulation value of a built construction system or component. It is a measure, on a logarithmic scale, of the ratio of the acoustic sound power incident on the tested piece to the acoustic sound power transmitted through it. The TL is expressed in decibels (dB). Generally, TL is measured as a function of frequency in one-third octave frequency bands. The higher the sound insulation, the less sound will be transmitted, resulting in a higher IL value. Values of TL are determined in acoustical laboratories under controlled testing methods prescribed by the American Society of Testing and Materials (ASTM).

Sound Insulation Objectives

The goal for residential sound insulation is to reduce the dwelling interior noise levels due to aircraft operations. Total "soundproofing" of the dwelling, such that aircraft operations are inaudible, is economically infeasible. Modest improvements over the existing characteristics (i.e. less than 5 dB) may not provide a noticeable improvement for the homeowner and hence are not cost effective. The ideal solution is to provide sound insulation, which lies between these two extremes.

Interior Noise Objectives

The DNL is the best predictor of overall long-term community reaction to noise from aircraft as well as other activities. Exterior noise exposure less than DNL 65 dB is normally considered compatible with residential land use. Noise exposure is normally incompatible above 65 dB unless stated noise reductions are achieved within the dwellings. A 25 dB NLR is required in the noise zone from 65 to 70 dB. From 70 to 75 dB, a 30 NLR is required. Above 75 dB, residential land use is generally deemed incompatible and should be discouraged.

Sometimes, the DNL noise reduction goal in habitable rooms is supplemented by a single-event noise level criterion. This Sound Exposure Level (SEL) reflects the annoyance associated with individual flyovers because of activity interference. The SEL goal is 65 dB in general living spaces and 60 dB in bedrooms and television viewing rooms. These criteria are only applied to homes within the DNL defined noise impact area, not to homes outside the 65 dB DNL contour boundaries.

To use the SEL interior noise criteria, the outside noise exposure level is compared to the interior goal For example, if the dwelling were between the SEL contour boundaries of 85 to 90 dB, then the required NLR to achieve 60 dB in a bedroom would be 30 dB. (The conservative upper bound of the noise zone is normally used to set NLR goals.)

Room Variations

The noise level of different rooms in a house depends on the absorption within the room, as well as on the noise entering from outside. Upholstered furniture, drapes, and carpeting absorb sound while hard surfaces do not. In addition, different categories of rooms vary on how predictable their sound environments are. Living rooms, for example, tend to be consistent from one house to another because they almost always have the same types of furnishings in them. Bedrooms vary because some are guest rooms with less furniture, and some have been converted to other uses. Kitchens tend to vary widely due to the use of different wall coverings, such as cabinets and appliances, or floor coverings, such as tile or carpet. These room

variations act in addition to variation in exterior sound level and sound transmission through the outside wall.

Sound Insulation Concept

Sound Transmission

In order to effectively examine noise control measures for dwellings it is helpful to understand how sound travels from the exterior to the interior of the house. This happens in one of two basic ways: through the solid structural elements and directly through the air. Consider the sound transmission through a wall constructed with a brick exterior, stud framing, interior finish wall and absorbent material (insulation) 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. Vibration energy also bypasses the air cavity by traveling through the studs and edge connections. Openings in the dwelling, which provide air infiltration paths through windows, vents, and leaks, allow sound to travel directly to the interior. This is a very common and often overlooked source of noise intrusion.

Flanking is a similar concept and usually refers to sound passing around a wall. Examples of common flanking paths include: air ducts, open ceiling or attic plenums, continuous sidewalls and floors, and joist and crawlspaces. The three different major paths for noise transmission into a dwelling are air infiltration through gaps and cracks, secondary elements such as windows and doors, and primary building elements such as walls and the roof.

Low-frequency sound is most efficiently transmitted through solid structural elements such as walls, roof, doors, and windows. High frequencies travel best through the air gaps. Within these broad categories, different building materials have different frequency responses to sound and varying abilities to insulate against sound.

Reducing Transmitted Sound

The amount of sound energy transmitted through a wall, roof or floor can be limited in several ways. First, all air infiltration gaps, openings, and possible flanking paths must be eliminated wherever possible. This is the single most important, but occasionally overlooked, step in noise reduction. This includes keeping windows and doors closed and putting baffles on open-air vents.

Some materials reflect more of the incident sound, converting less of it into vibration energy. The mass of the exterior and interior panels influences how much sound will pass through them. The more mass a structural element has the more energy it takes to set it into vibration, so adding weight to a wall or ceiling by attaching a gypsum board layer will make the assembly pass less sound. Then, absorption in the air cavity and resilient mounting of interior finish panels can further reduce the sound transmitted to the room. The primary approaches for improving sound isolation are:

1. Elimination of openings and flanking paths (when accessible).
2. Improvement of windows and doors.
3. Massive construction (build a wall 3 feet thick and 40 feet high around the whole house).
4. Isolation of panel elements through separation or resilient mounting.
5. Absorption.

Problem Areas

Sound intrusion problems are commonly caused by:

1. Building construction components and configurations not providing sufficient sound insulation.
2. Structural elements, such as windows, doors, walls, roofs and floors chosen and combined in an unbalanced way so that some parts are much weaker sound insulators than others.
3. Unintended openings or sound-flanking paths caused by deterioration or improper installation of construction elements.

Balanced Acoustical Design

The most important, or controlling, sound paths must be identified in order to know how to construct or modify a dwelling to meet a specified noise criteria. The ideal sound insulation design would achieve a condition where all the important sound paths transmit the same amount of acoustical energy. This eliminates any weak links in the building's insulation envelope and is commonly referred to as a balanced acoustical design.

In most cases, after leaks and gaps are sealed, the windows are the controlling sound paths. Replacing them with acoustical windows typically does more to improve the sound insulation performance than any other architectural modifications. Once this is done the other elements may become important in meeting specific noise reduction goals. Exterior doors often require improved sound insulation. Ceilings and walls, which face the exterior, may require modification as well, particularly in the higher DNL noise zone.

New Versus Old

Dwellings can vary in their sound isolation performance. Generally, air infiltration, and therefore sound infiltration, around windows and doors tends to be worse for older dwellings. Inadequate or deteriorated weather-stripping and misaligned framing usually cause this. On the other hand, most older construction techniques and materials tend to be more massive than newer lighter-weight construction. As a result, many older buildings tend to perform better with regard to sound transmission through walls, roofs, and floors than do new houses. Homeowner modifications can also degrade the dwelling's sound insulation performance. Examples include home improvements such as skylights, whole-house attic fans, through-the-wall air conditioners, and solariums. In general, it is much more efficient, and cost effective, to take acoustic performance into account when designing and building a home at the start. Remodeling an already built home is more costly and time consuming than anticipating and building for good sound insulation.

While homes, which are well insulated thermally, often perform well acoustically, thermal insulation is not always a good indicator of sound insulation. Many thermal windows, installed in new construction or added as a homeowner upgrade provide little sound insulation when compared to walls or acoustical windows and are frequently the weak link in the building envelope. However thermal treatments usually eliminate air infiltration and may serve to improve the acoustical performance of a dwelling. Thermal insulation batts are often useful in the wall cavities and attic spaces to absorb some sound.

Most homes today are constructed using double pane windows. Although the windows perform well thermally, they usually do not perform well acoustically. The panes are separated by approximately % inch of air space and thin panes of glazing are used. The thin panes of glazing allow for vibration and the vibrations are transmitted through the air space to the interior glazing and into the home.

Recommended Building Requirements

<u>Recommended Building Requirements for a Minimum NLR of 25 dB</u>

Compliance with the following standards shall be deemed to meet the requirements of the compatible use districts in which an NLR 25 is specified.

General:

a. Brick veneer, masonry blocks, or stucco exterior walls shall be constructed airtight. All joints shall be grouted or caulked airtight, except weep holes for drainage.
b. At the penetration of exterior walls by pipes, ducts, or conduits, the space between the wall and pipes, ducts, or conduits shall be caulked or filled with mortar.
c. Window and/or through-the-wall ventilation units shall not be used.
d. Through-the-wall/door mailboxes shall not be used.

Exterior Walls:

a. Exterior walls other than as described in this section shall have a laboratory sound transmission class rating of at least STC-39.
b. Masonry walls having a surface weight of at least 25 pounds per square foot do not require a furred (stud) interior wall. At least one surface of concrete block walls shall be plastered or painted with heavy "bridging" paint.
c. Stud walls shall be at least 4" in nominal depth and shall be finished on the outside with siding-on-sheathing, stucco, or brick veneer.

   (1) Interior surface of the exterior walls shall be of gypsum board or plaster at least 1/2" thick, installed on the studs.

   (2) Continuous composition board, plywood, or gypsum board sheathing at least 1/2" thick shall cover the exterior side of the wall studs behind wood or metal siding. Asphalt or wood shake shingles are acceptable in lieu of siding.

   (3) Sheathing panels shall be butted tightly and covered on the exterior with

overlapping building paper. The top and bottom edges of the sheathing shall be sealed.

(4) Insulation material at least 2” thick shall be installed continuously throughout the cavity space behind the exterior sheathing and between wall studs. Insulation shall be glass fiber or mineral wool.

Windows:

a. Windows other than as described in this section shall have a laboratory sound transmission class rating of at least STC-28.
b. Glass shall be at least 3/16” thick.
c. All operable windows shall be weather stripped and airtight when closed so as to conform to an air infiltration test not to exceed 0.5 cubic foot per minute per foot of crack length in accordance with ASTM E-283-65-T.
d. Glass of fixed-sash windows shall be sealed in an airtight manner with a non-hardening sealant, or a soft elastomer gasket, or glazing tape.
e. The perimeter of window frames shall be sealed airtight to the exterior wall construction with a sealant conforming to one of the following Federal Specifications: TT-S-00227, TT-S-00230, or TT-S-00153.
f. The total area of glass in both windows and doors in sleeping spaces shall not exceed 20% of the floor area.

Doors:

a. Doors, other than as described in this section shall have a laboratory sound transmission class rating of at least STC-28.
b. All exterior side-hinged doors shall be solid-core wood or insulated hollow metal at least 1-3/4” thick and shall be fully weather-stripped.

c. Exterior sliding doors shall be weather stripped with an efficient airtight gasket system. The glass in the sliding doors shall be at least 3/16” thick.
d. Glass in doors shall be sealed in an airtight non-hardening sealant, or in a soft elastomer gasket or glazing tape. The perimeter of doorframes shall be sealed airtight to the exterior wall construction.

Roofs:

a. Combined roof and ceiling construction other than described in this section shall have a laboratory sound transmission class rating of at least STC-39.
b. With an attic or rafter space at least 6” deep, and with a ceiling below, the roof shall consist of closely butted 1/2” composition board, plywood, oriented strand board or gypsum board sheathing, topped by roofing as required.
c. If the underside of the roof is exposed, or if the attic or rafter spacing is less than 6”, the roof construction shall have a surface weight of at least 25 pounds per square foot. Rafters, joists, or other framing may not be included in the surface weight calculation.
d. Window or dome skylights shall have a Laboratory sound transmission class rating of at least STC-28.

Ceilings:

a. Gypsum board or plaster ceilings at least1/2” thick. Ceilings shall be

substantially airtight, with a minimum number of penetrations.

b. Glass fiber or mineral wool insulation at least 2” thick shall be provided above the ceiling between joists.

Floors:

Openings to any crawl spaces below the floor of the lowest occupied rooms shall not exceed 2% of the floor area of the occupied rooms.

Ventilation:

a. A mechanical ventilation system shall be installed that will provide the minimum air circulation and fresh air supply requirements for various uses in occupied rooms without the need to open any windows, doors, or other openings to the exterior.
b. Gravity vent openings in attic shall not exceed code minimum in number and size.
c. If a fan is used for forced ventilation, the attic inlet and discharge openings shall be fitted with sheet metal transfer ducts of at least 20 gauge steel, which shall be lined with coated glass fiber 1” thick, and shall be at least 5 ft long with one 90 degree bend.
d. All vent ducts connecting the interior space to the outdoors, except domestic range exhaust ducts, shall contain at least a 5 ft. length of internal sound absorbing duct lining. Each duct shall be provided with a bend in the duct such that there is no direct line of sight through the duct from the venting cross section to the room-opening cross section.
e. Duct lining shall be coated glass fiber duct liner at least 1” thick.
f. Domestic range exhaust ducts connecting the interior space to the outdoors shall contain a baffle plate across the exterior termination, which allows proper ventilation. The dimensions of the baffle plate should extend at least one diameter beyond the line of sight into the vent duct. The baffle plate shall be of the same material and thickness as the vent duct material.
g. Fireplaces shall be provided with well-fitted dampers.

<u>Recommended Building Requirements for a Minimum NLR of 3OdB</u>

Compliance with the following standards shall be deemed to meet the requirements of the compatible use districts in which an NLR 30 is specified.

General:

a. Brick veneer, masonry blocks, or stucco exterior walls shall be constructed airtight. All joints shall be grouted or caulked airtight.
b. At the penetration of exterior walls by pipes, ducts, or conduits, the space between the wall and pipes, ducts, or conduits shall be caulked or filled with mortar.
c. Window and/or through-the-wall ventilation units shall not be used.
d. Operational fireplaces shall not be used.
e. All sleeping spaces shall be provided with either a sound absorbing ceiling or a carpeted floor.
f. Through-the-wall/door mailboxes shall not be used.

Exterior Walls:

a. Exterior walls, other than as described below, shall have a laboratory sound transmission class rating of at least STC-44.
b. Masonry walls having a surface weight of at least 40 pounds per square foot do not require a furred (stud) interior wall. At least one surface of concrete block walls shall be plastered or painted with heavy "bridging" paint.
c. Stud walls shall be at least 4" in nominal depth and shall be finished on the outside with siding-on-sheathing, stucco, or brick veneer.

    (1) Interior surface of the exterior walls shall be of gypsum board or plaster at least 1/2" thick, installed on the studs. The gypsum board or plaster may be fastened rigidly to the studs if the exterior is brick veneer or stucco. If the exterior is siding-on-sheathing, the interior gypsum board or plaster must be fastened resiliently to the studs.
    (2) Continuous composition board, plywood or gypsum board sheathing shall cover the exterior side of the wall studs behind wood or metal siding. The sheathing and facing shall weigh at least 4 pounds per square foot.
    (3) Sheathing panels shall be butted tightly and covered on the exterior with overlapping building paper. The top and bottom edges of the sheathing shall be sealed.
    (4) Insulation material at least 2" thick shall be installed continuously throughout the cavity space behind the exterior sheathing and between wall studs. Insulation shall be glass fiber or mineral wool.

Windows:

a. Windows, other than as described in this section, shall have a laboratory sound
transmission class rating of at least STC-33.
b. Glass of double-glazed windows shall be at least 1/8" thick. Panes of glass shall be separated by a minimum 3/4" air space.
c. Double-glazed windows shall employ fixed sash or efficiently weather-stripped operable sash. The sash shall be rigid and weather-stripped with material that is compressed air tight when the window is closed so as to conform to an infiltration test not to exceed 0.5 cubic foot per minute per foot of crack length in accordance with ASTM E-283-65-T.
d. Glass of fixed-sash windows shall be sealed in an airtight manner with a non-hardening sealant, or a soft elastomer gasket, or glazing tape.
e. The perimeter of window frames shall be sealed airtight to the exterior wall construction with a sealant conforming to one of the following Federal Specifications: TT-S-00227, TT-S-00230, or TT-S-00153.
f. The total area of glass of both windows and exterior doors in sleeping spaces shall not exceed 20% of the floor area.

Doors:

a. Doors, other than as described in this section, shall have a laboratory sound transmission class rating of at least STC-33.
b. Double door construction is required for all door openings to the exterior. Openings fitted with side-hinged doors shall have one solid-core wood or insulated hollow metal core door at least 1-3/4" thick, separated by an airspace of at least 4" from another door, which can be a storm door. Both

doors shall be tightly fitted and weather-stripped.

c. The glass of double-glazed sliding doors shall be separated by minimum 3/4" airspace. Each sliding frame shall be provided with an efficiently airtight weather stripping material.
d. Glass of all doors shall be at least 3/16" thick. Glass of double sliding doors shall not be equal in thickness.
e. The perimeter of doorframes shall be sealed airtight to the exterior wall construction.
f. Glass of doors shall be set and sealed in an airtight, non-hardening sealant, or a soft elastomer gasket, or glazing tape.

Roofs:

a. Combined roof and ceiling construction other than described in this section shall have laboratory sound transmission class rating of at least STC-44.
b. With an attic or rafter space at least 6" deep, and with a ceiling below, the roof shall consist of closely butted 1/2" composition board, plywood, oriented strand board or gypsum board sheathing topped by roofing as required.
c. If the underside of the roof is exposed, or if the attic or rafter spacing is less than 6", the roof construction shall have a surface weight of at least 40 pounds per square foot. Rafters, joists or other framing may not be included in the surface weight calculations.
d. Window or dome skylights shall have a laboratory sound transmission class rating of at least STC-33.

Ceilings:

a. Gypsum board or plaster ceilings at least 1/2" thick shall be provided
b. Glass fiber or mineral wool insulation at least 2" thick shall be provided above the ceiling between joists.

Floors:

a. The floor of the lowest occupied rooms shall be slab on fill, below grade, or over a fully enclosed basement. All door and window openings in the fully enclosed basement shall be tightly fitted.

Ventilation:

a. A mechanical ventilation system shall be installed that will provide the minimum air circulation and fresh air supply requirements for various uses in occupied rooms without the need to open any windows, doors, or other openings to the exterior.
b. Gravity vent openings in attic snail not exceed code minimum in number and size. The openings shall be fitted with transfer ducts at least 3 ft in length containing internal sound absorbing duct lining. Each duct shall have a lined 90-degree bend in the duct such that the line of sight is interrupted from the exterior through the duct into the attic.
c. If a fan is used for forced ventilation, the attic inlet and discharge openings shall be fitted with sheet metal transfer ducts of at least 20 gauge steel, which shall be lined with coated glass fiber 1" thick, and shall be at least 5 ft long with one 90 degree bend.
d. All vent ducts connecting the interior space to the outdoors, except domestic

range exhaust ducts shall contain at least a 10 ft. length of internal sound absorbing duct lining. Each duct shall be provided with a lined 90-degree bend in the duct such that there is no direct line of sight through the duct from the venting cross section to the room opening cross section.

e. Duct lining shall be coated glass fiber duct.
f. Domestic range exhaust ducts connecting the interior space to the outdoors shall contain a baffle plate across the exterior termination, which allows proper ventilation. The dimensions of the baffle plate should extend at least one diameter beyond the line of sight into the vent duct. The baffle plate shall be made of the same material and thickness as the vent duct material.
g. Building heating units with flues or combustion air vents shall be located in a closet or room closed off from the occupied space by doors.
h. Doors between occupied space and mechanical equipment areas shall be solid core wood or 20 gauge steel hollow metal at least 1-3/4" thick and shall be fully weather-stripped.

<u>Recommended Building Requirements for a Minimum NLR of 35dB</u>

Compliance with the following standards shall be deemed to meet the requirements of the compatible use districts in which an NLR 35 is specified

General:

a. Brick veneer, masonry blocks or stucco exterior walls shall be constructed airtight. All joints shall be grouted or caulked airtight.
b. At the penetration of exterior walls by pipes, ducts or conduits, the space between the wall and pipes, ducts or conduits shall be caulked or filled with mortar.
c. Window and/or through-the-wall ventilation units shall not be used.
d. Operational vented fireplaces shall not be used.
e. All sleeping spaces shall be provided with either a sound absorbing ceiling or a carpeted floor.
f. Through-the-wall/door mailboxes shall not be used.
g. No glass or plastic skylight shall be used.

Exterior Walls:

a. Exterior walls other than as described below shall have a laboratory sound transmission class rating of at least STC-49.
b. Masonry walls having a surface weight of at least 75 pounds per square foot do not require a furred (stud) interior wall. At least one surface of concrete block walls shall be plastered or painted with heavy "bridging" paint.
c. Stud walls shall be at least 4" in nominal depth and shall be finished on the outside with siding-on-sheathing, stucco, or brick veneer.

    (1) Interior surface of the exterior walls shall be of gypsum board or plaster at least 1/2" thick, installed on studs, The gypsum board or plaster may be fastened rigidly to the studs if the exterior is brick veneer. If the exterior is stucco or siding-on-sheathing, the interior gypsum board or plaster must be fastened resiliently to the studs.
    (2) Continuous composition board, plywood or gypsum board sheathing

shall cover the exterior side of the wall studs behind wood or metal siding. The sheathing and facing shall weigh at least 4 pounds per square foot.

(3) Sheathing panels shall be butted tightly and covered on the exterior with
overlapping building paper. The top and bottom edges of the sheathing shall be sealed.

(4) Insulation material at least 3-1/2" thick shall be installed continuously through the cavity space behind the exterior sheathing and between wall studs. Insulation shall be glass fiber or mineral wool.

Windows:

a. Windows other than as described in this section shall have a laboratory sound transmission class rating of at least STC-38.
b. Glass of double-glazed windows shall be at least 1/8" thick; Panes of glass shall be separated by a minimum 3/4" air space and shall not be equal in thickness.
c. Glass of windows shall be sealed in an airtight manner with a non-hardening sealant, or a soft elastomer gasket or glazing tape.
d. The perimeter of window frames shall be sealed airtight to the exterior wall construction with a sealant conforming to one of the following Federal Specifications: TT-S-00227, TT-S-00230, or TT-S-00153.
e. The total area of glass of both windows and exterior doors in sleeping spaces shall not exceed 20% of the floor area.

Doors:

a. Doors, other than as described in this section, shall have a laboratory sound transmission class rating of at least STC-38.
b. Double door construction is required for all door openings to the exterior. The door shall be side-hinged and shall be solid-core wood or insulated hollow metal, at least 1-3/4" thick, separated by a vestibule at least 3 ft in length. Both doors shall be tightly fitted and weather-stripped.
c. The perimeter of doorframes shall be sealed airtight to the exterior wall construction.

Roofs:

a. Combined roof and ceiling construction other than described in this section and Section 3-7 shall have a laboratory sound transmission class rating of at least STC-49.
b. With an attic or rafter space at least 6" deep, and with a ceiling below, the roof shall consist of closely butted 1/2" composition board, plywood, oriented strand board or gypsum board sheathing topped by roofing as required.
c. If the underside of the roof is exposed, or if the attic or rafter spacing is less than 6" the roof construction shall have a surface weight of at least 75 pounds per square foot. Rafters, joists or other framing may not be included in the surface weight calculation.

Ceilings:

a. Gypsum board or plaster ceilings at least 1/2" thick shall be provided where

required by Paragraph 3-6. Ceilings shall be substantially airtight, with a minimum number of penetrations. The ceiling panels shall be mounted on resilient clips or channels. A non-hardening sealant shall be used to seal gaps between the ceiling and walls around the ceiling perimeter.

b. Glass fiber or mineral wool insulation at least 3 1/2" thick shall be provided above the ceiling between joists.

Floors:

The floors of the lowest occupied rooms shall be slab on fill or below grade.

Ventilation:

a. A mechanical ventilation system shall be installed that will provide the minimum air circulation and fresh air supply requirements for various uses in occupied rooms without need to open any windows, doors, or other openings to the exterior.
b. Gravity vent openings in attic shall not exceed code minimum in number and size. The opening shall be fitted with transfer ducts at least 6 ft. in length containing internal sound absorbing duct lining. Each duct shall have a lined 90-degree bend in the duct such that there is no direct line of sight from the exterior through the duct into the attic.
c. If a fan is used for forced ventilation, the attic inlet and discharge openings shall be fitted with sheet metal transfer ducts of at least 20 gauge steel, which shall be lined with 1" thick coated glass fiber, and shall be at least 10 ft long with one 90 degree bend.
d. All vent ducts connecting the interior space to the outdoors, excepting domestic range exhaust ducts, shall contain at least a 10 ft length of internal sound absorbing duct lining. Each duct shall be provided with a lined 90-degree bend in the duct such that there is no direct line of sight through the duct from the venting cross section to the room-opening cross section.
e. Duct lining shall be coated glass fiber duct liner at least 1" thick.
f. Domestic range exhaust ducts connecting the interior space to the outdoors shall contain a baffle plate across the exterior termination, which allows proper ventilation. The dimensions of the baffle plate should extend at least one diameter beyond the line of sight into the vent duct. The baffle plate shall be of the same material and thickness as the vent duct material.
g. Building heating units with flues or combustion air vents shall be located in a closet or room
closed off from the occupied space by doors.
h. Doors between occupied space and mechanical equipment areas shall be solid core wood or 20 gauge steel hollow metal at least 1-3/4" thick and shall be fully weather-stripped.

<u>Methods for Exterior Wall Sound Insulation in New Homes</u>

Typically, most wall construction consists of a 3.5-inch stud cavity with studs spaced 16 inches on center, %-inch gypsum drywall on the interior, 7/16 structural sheathing on the exterior and either siding or brick veneer as the finish on the exterior, Consider using the construction techniques below:

1. Increase the wall stud cavity to 5.5-inches, spaced 24 inches on center. The increased depth of the stud cavity will allow for the installation of R-1 9

insulation.

2. When considering the type of insulation material, consider using cellulose insulation material. This material is of a higher density. The method of installation is a spray method that tends to completely fill the cavity without voids.

3. Prior to the installation of insulation material in the walls, seal all penetrations through the top and bottom plates. Remember if air can enter, so can sound. Seal all penetrations through the bottom plate with caulk. Seal all penetrations through the top plate with caulking materials meeting the requirements of ASTM E-136.

4. Increase the thickness of the interior wall finish from 1/2-inch to 5/8-inch gypsum wallboard.

5. Caulk around all openings through the drywall such as receptacles, switches, plumbing drains, etc.

6. Increase the thickness of the exterior sheathing material to 5/8-inch or thicker material.

7. Consider using brick veneer instead of siding material for the exterior finish. Insure at least a one-inch air space between the brick veneer and the siding.

8. If siding is to be used, avoid using vinyl siding. Choose siding with a higher density such as Hardiplank, or wood siding. Install 30-pound felt between the siding and sheathing lapped 2 inches on horizontal joints and 6 inches on vertical joints.

9. If vinyl siding is a must, install 1/4-thick fanfold insulation board between the siding and sheathing.

10. Avoid large openings or breaks in continuity in the walls, such as large windows.

11. Install bathroom vent and kitchen hood vents on the side of the home away from the flight track. Make sure that vent terminations have an automatic closure on the end. Always use metal pipe for the vent pipe.

<u>Methods for Improving Attic and Ceiling Sound Insulation In New Homes</u>

1. Consider using energy trusses. Energy trusses allow for the installation of ceiling insulation to a full depth along the plate lines at exterior walls.

2. Install baffles on attic vents where practical.

3. Install acoustically absorptive material to a thickness equal to R-38 to the attic space to reduce reverberant sound level buildup. Apply material evenly throughout the attic space, taking care to keep it away from eave vents and openings. Consider the use of cellulose insulation. This material fills the cavity without leaving voids in the material and is of a higher density than fiberglass.

4. Install 5/8-inch gypsum board as the interior ceiling finish.

5. Caulk around all penetrations through the ceiling membrane such as light fixtures.

6. Avoid the use of "can-type — recessed light" light fixtures.

7. Avoid the use of true exposed wood beams on the ceiling. This creates a continuous path for sound through the ceiling structure.
8. Avoid the use of whole house exhaust fans in the ceiling.

Methods for Improving Floor Sound Insulation In New Homes

1. Install R-30 insulation batts between the joists.

2. Seal all penetrations through the floor assembly such as Heating and Air Conditioning supplies; exhaust ducts such as down draft exhaust from dryers and ranges, etc.

3. Install foundation vents of the swing cover awning type instead of the horizontal slider type.

4. Consider a sealed crawlspace and insulate the foundation walls, If this method is chosen, caulk between the mudsill and the foundation.

Methods for Improving Window Sound Insulation in New Homes

1. The most effective method of reducing sound transmission by a window is by increasing thickness of the glass panes. Basically, thicker is better. Thicker glass tends to bend less, and therefore vibrates less when exposed to sound waves. Using 6mm glass combinations or laminated glass is the simplest, most cost effective method of reducing sound transmission.

2. When choosing windows for your new home remember windows are generally the weakest link in sound attenuation

3. Choose windows that are double-glazed with panes at least 3/16 inch thick. Windows shall be double glazed with panes at least three/sixteenths inch ***(3/16")*** thick. Panes of glass should be separated by a minimum one-half inch ***(1/2")*** airspace, and should not be equal in thickness.

4. Double glazed windows should employ fixed sash or efficiently weather-stripped, operable sash. The sash shall be rigid and weather-stripped with material that is compressed airtight when the window is closed.

5. Glass should be sealed in an airtight manner with a non-hardening sealant or a soft
elastomer gasket or gasket tape.

6. The perimeter of the window frames should be sealed airtight to the exterior wall construction with a sealant. The usual installation of windows employs stuffing the void between the window and framing with fiberglass insulation. The use of a sealant on top of the insulation material acts as an air infiltration barrier. Insulation by itself is not a good air infiltration barrier. Remember, if air can pass through, so can sound.

7. Avoid large picture windows and sliding glass doors on sides of the dwelling, which face the flight track.

Methods for Improving Door Sound Insulation in New Homes

1. Double door construction should be considered for all hinged door openings to the exterior. Such doors should be side hinged and shall be solid core wood or insulated hollow metal at least one and three-fourths inch (1-3/4") thick separated by an airspace of at least three inches (3") from another door, storm door. Both doors shall be tightly fitted and weather-stripped.

2. All doors, shall be at least three-sixteenths (3/16") thick. Glass of double sliding doors shall not be of equal thickness.

3. The perimeter of doorframes shall be sealed airtight to the exterior wall construction (framing). Stuff the gap between the doorframe and the framing with insulation and seal with a non-hardening caulk. Remember, if air can pass through, so can sound.

4. Glass in doors should be sealed in an airtight non-hardening sealant or in a soft elastomer gasket or gasket tape.

Methods for Improving Sound Insulation in Existing Homes

The best time to consider sound attenuation is during the construction of new homes. Retrofitting an existing home for sound attenuation can be costly. If one is considering retrofitting for sound attenuation, it is best done during a planned renovation project. As mentioned earlier in this guide, windows are generally the weakest link in sound attenuation. Some of the simpler and easiest ways to attain sound attenuation is by a combination of the following:

1. Add insulation in the attic to an overall R-Value thickness of R-38.

2. Caulk around all penetrations through the interior finishes. (Receptacles, light fixtures, plumbing drains, etc.)

3. Install single pane storm windows over existing single pane windows.

4. Install weather-stripping on all doors.

5. Employ any of the methods described in Methods for Improving Sound Attenuation in New Homes as the project allows.

Methods of Noise and Vibration Control In Residential HVAC Systems

1. Mount the motor/fan at grade level on factory-supplied vibration isolators to minimize vibration transmitted to the house.

2. If fans or other pieces of equipment are located in the attic, use mounting bases and vibration isolators to reduce structure borne noise and vibration transmission.

3. Install flexible duct connectors to limit vibration transmitted to the ductwork or the dwelling structure.

4. Use standard sheet metal ductwork in attics and crawlspaces. Ductwork is exposed to higher levels of aircraft noise in these spaces. Do not use flexible ductwork in attic spaces since it does not have as good sound-insulating properties as standard sheet metal.

5. Supply grilles in rooms should be of the opposed-blade type and be designed for low noise.

6. A duct sound trap (muffler) should be installed just inside the fresh-air inlet opening. The sound trap will reduce any aircraft noise that passes through this opening and will eliminate the possibility of aircraft noise being transmitted via the duct path.

COMPARISON OF COMPONENTS FOR SOUND ATTENUATION

Component	***Regular***	***Sound Attenuation***
Door		
3/0 X 6/8 insulated embossed 6 panel exterior steel door	$ 175.00	175.00
Windows Length X Width United Inch = UI Windows compared are 1 over 1 with grids		
Up to 64 Ul	$214.00	$222.90
64 to 69 Ul	$231.20	$241.10
69 to 74 Ul	$248.40	$259.30
74 to 79 UI	$ 265.60	$ 277.40
79 to 84 U1	$282.80	$295.60
84 to 89 UI	$ 300.20	$ 314.00
89 to 94 Ul	$317.30	$332.00
94 to 99 U1	$334.50	$350.30
99 to 104 UI	$352.00	$368.00
Over lO4 Ul	$3.52 per UI	$3.68perUi
Insulation/Sound Batting **Walls**		
3.5 inch stud cavity: R-13 Fiberglass Batt	$ 0.36 psf	$0.36 psf
3.5 inch stud cavity: R-13 Cellulose Sprayed	$ 0.70	$0.70 psf
5.5 inch stud cavity: R-19 Fiberglass Batt	$ 0.39	$0.39 psf
5.5 inch stud cavity: R-19 Cellulose Sprayed	$ 0.90	$ 0.90 psf
Insulation/Sound Batting **Ceilings**		
R-30 Fiberglass Batt	$ 0.61 psf	$ 0.61 psf
R-38 Fiberglass Batt	$ 0.80 psf	$ 0.80 psf
R-30 Fiberglass Blown	$ 0.40 psf	$ 0.40 psf
R-38 Fiberglass Blown	$ 0.50 psf	$ 0.50 psf
R-30 Cellulose Sprayed	$ 0.32 psf	$ 0.32 psf
R-38 Cellulose Sprayed	$ 0.42 psf	$ 0.42 psf
Drywall		
1/2 inch X 4 ft. X 12 ft.	$ 8.98 per sheet	$ 8.98 per sheet
5/8 inch X 4 ft X 12 ft.	$10.56 per sheet	$ 10.56 per sheet
Miscellaneous		
Seal/Caulk around 3/0 X 5/0 window with non-hardening caulk assuming 3/8-inch crack		$ 5.00 per window
Seal/Caulk around 3/0 X 6/8 doors with non-hardening caulk assuming 3/8-inch crack		$ 6.00 per door
Insulate metal exhaust duct on exterior of duct		$ 2.50 per foot

Values in this table are for comparison only and are not intended to be a guaranteed price quote for any product.

Appendix 5

Land Use Compatibility Standards

GUIDELINES FOR CONSIDERING NOISE IN LAND USE PLANNING AND CONTROL. (FICUN 1980)

	NZ I		NZ II		NZ III		
	0-55	55-65	65-70	70-75	75-80	80-85	85+
RESIDENTIAL							
Household Units	Yes	Yes*	25[1]	30[1]	No	No	No
Group Quarters	Yes	Yes*	25[1]	30[1]	No	No	No
Residential Hotels	Yes	Yes*	25[1]	30[1]	No	No	No
Manufactured Housing	Yes	Yes*	No	No	No	No	No
Other Residential	Yes	Yes*	25[1]	30[1]	No	No	No
MANUFACTURING							
Food Products	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
Textile Mill Products	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
Apparel	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
Wood Products	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
Furniture	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
Paper	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
Printing	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
Manufacturing	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
TRANSPORT, COMMS & UTIL							
Railroad	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	Yes[4]
Motor Vehicle	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	Yes[4]
Aircraft	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	Yes[4]
Marine Craft	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	Yes[4]
Highway & Street	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	Yes[4]
Parking	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
Communications	Yes	Yes	Yes	25[5]	30[5]	No	No
Utilities	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	Yes[4]
Other T, C & U	Yes	Yes	Yes	25[5]	30[5]	No	No
TRADE							
Wholesale Trade	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
Retail - Building	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
Retail - General	Yes	Yes	Yes	25	30	No	No
Retail - Food	Yes	Yes	Yes	25	30	No	No
Retail - Auto	Yes	Yes	Yes	25	30	No	No
Retail - Apparel	Yes	Yes	Yes	25	30	No	No
Retail - Furniture	Yes	Yes	Yes	25	30	No	No
Retail - Eating	Yes	Yes	Yes	25	30	No	No
Other Retail Trade	Yes	Yes	Yes	25	30	No	No
SERVICES							
Finance, Insurance	Yes	Yes	Yes	25	30	No	No
Personal Services	Yes	Yes	Yes	25	30	No	No
Cemeteries[11]	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	Yes[6]
Repair Services	Yes	Yes	Yes	Yes[2]	Yes[3]	Yes[4]	No
Profess Services	Yes	Yes	Yes	25	30	No	No
Hospitals, Nursing	Yes	Yes*	25*	30*	No	No	No
Other Medical	Yes	Yes	Yes	25	30	No	No

Facilities							
Contract Construction	Yes	Yes	Yes	25	30	No	No
Government Services	Yes	Yes*	Yes*	25*	30*	No	No
Educational Services	Yes	Yes*	25*	30*	No	No	No
Misc Services	Yes	Yes	Yes	25	30	No	No
CULTURAL, ENTERTAINMENT & REC							
Churches	Yes	Yes*	25*	30*	No	No	No
Nature Exhibits	Yes	Yes*	Yes*	No	No	No	No
Public Assembly	Yes	Yes	Yes	No	No	No	No
Auditoriums	Yes	Yes	25	30	No	No	No
Amphitheaters	Yes	Yes*	No	No	No	No	No
Outdoor Sports	Yes	Yes	Yes[7]	Yes[7]	No	No	No
Amusements	Yes	Yes	Yes	Yes	No	No	No
Recreational	Yes	Yes*	Yes*	25*	30*	No	No
Resorts	Yes	Yes*	Yes*	Yes*	No	No	No
Parks	Yes	Yes*	Yes*	Yes*	No	No	No
Other	Yes	Yes*	Yes*	Yes*	No	No	No
RESOURCE PRODUCT							
Agriculture	Yes	Yes	Yes[8]	Yes[9]	Yes[10]	Yes[10]	Yes[10]
Livestock	Yes	Yes	Yes[8]	Yes[9]	No	No	No
Forestry	Yes	Yes	Yes[8]	Yes[9]	Yes[10]	Yes[10]	Yes[10]
Fishing	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mining	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other Resource	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Legend:

Yes — Land use and related structures compatible without restrictions.

No — Land use and related structures are not compatible and should be prohibited.

ADNL — A-weighted day-night sound level

NZ — Noise Zone

Yes[x] — (Yes with restrictions) Land use and related structures generally compatible; see footnotes.

25, 30, 35 — Land use and related structures generally compatible; measures to achieve noise level reduction (NLR) of 25, 30 or 35 must be incorporated into design and construction of structure.

25*, 30*, 35* — Land use generally compatible with NLR; however, measures to achieve an overall NLR do not necessarily solve noise difficulties; additional evaluation is warranted.

NLR — Noise level reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.

Footnotes:

* 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.

1 (a) Although local conditions may require residential use, it is discouraged in 65-70 ADNL and strongly discouraged in 70-75 ADNL. The absence of viable alternative development options should be determined and an evaluation

indicating that a demonstrated community need for residential use would not be met if development were prohibited in these zones should be conducted prior to approvals.
(b) Where the community determines that residential uses must be allowed, measures to achieve outdoor to indoor NLR of at least 25 dB (65-70 ADNL) and 30 dB (70-75 ADNL) 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.
(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 particularly from ground level transportation 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 noise-sensitive, use indicated NLR; if not, use is compatible.

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 In areas with ADNL greater than 80, land use not recommended, but if community decides use is necessary, hearing protection devices should be worn by personnel.

DoD COMPATIBLE LAND USE GUIDELINES FOR CLEAR ZONES AND ACCIDENT POTENTIAL ZONES (APZ). (U.S. Army 1981)

LAND USE	**CLEAR ZONE**	**APZ I**	**APZ II**
A. RESIDENTIAL			
Single Family Unit	No	No	Yes[2]
2-4 Family Units	No	No	No
Multifamily Dwellings (Apartments)	No	No	No
Group Quarters	No	No	No
Residential Hotels	No	No	No
Mobile Home Parks or Courts	No	No	No
Other Residential	No	No	No
B. INDUSTRIAL & MANUFACTURING[3]			
Food and Kindred Products	No	No	Yes
Apparel	No	No	No
Lumber and Wood Products	No	Yes	Yes
Furniture and Fixtures	No	Yes	Yes
Printing, Publishing	No	Yes	Yes
Miscellaneous Manufacturing	No	Yes	Yes
C. TRANSPORTATION, COMMUNICATIONS & UTILITIES[4]			
Railroad, Rapid Rail Transit (on-grade)	No	Yes[4]	Yes
Highway and Street Rights-of-Way	Yes[5]	Yes	Yes
Auto Parking	No	Yes	Yes
Communications	Yes[5]	Yes	Yes
Utilities	Yes[5]	Yes[4]	Yes
Other Transportation, Communications and Utilities	Yes[5]	Yes	Yes
D. COMMERCIAL & RETAIL TRADE			
Wholesale Trade	No	Yes	Yes
Building Materials (Retail)	No	Yes	Yes
General Merchandise (Retail)	No	No	Yes
Food (Retail)	No	No	Yes
Automotive, Marine, and Aviation	No	Yes	Yes
Apparel and Accessories (Retail)	No	No	Yes
Furniture, Home Furnishings (Retail)	No	No	Yes
Eating and Drinking Facilities	No	No	No
Other Retail Trade	No	No	Yes
E. PERSONAL & BUSINESS SERVICES[6]			
Finance, Insurance, and Real Estate	No	No	Yes
Personal Services	No	No	Yes
Business Services	No	No	Yes
Repair Services	No	Yes	Yes
Professional Services	No	No	Yes
Contract Construction Services	No	Yes	Yes
Indoor Recreation Services	No	No	Yes
Other Services	No	No	Yes
F. PUBLIC AND QUASI-PUBLIC SERVICES			
Government Services	No	No	Yes[6]

Educational Services	No	No	No
Cultural Activities	No	No	No
Medical and Other Health Services	No	No	No
Cemeteries	No	Yes[7]	Yes[7]
Non-profit Organizations including Churches	No	No	No
Other Public and Quasi-Public Services	No	No	Yes
G. OUTDOOR RECREATION			
Playgrounds and Neighborhood Parks	No	No	Yes
Community and Regional Parks	No	Yes[8]	Yes[8]
Nature Exhibits	No	Yes	Yes
Spectator Sports Including Arenas	No	No	No
Golf Courses[9], Riding Stables[10]	No	Yes	Yes
Water Based Recreational Areas	No	Yes	Yes
Resort and Group Camps	No	No	No
Entertainment Assembly Areas	No	No	No
Other Outdoor Recreation	No	Yes[8]	Yes
H. RESOURCE PRODUCTION & EXTRACTION& OPEN LAND			
Agriculture[11]	Yes	Yes	Yes
Livestock Farming, Animal Breeding[12]	No	Yes	Yes
Forestry Activities	No	Yes	Yes
Fishing Activities and Related Services[13]	No[14]	Yes[13]	Yes
Mining Activities	No	Yes	Yes
Permanent Open Space	Yes	Yes	Yes
Water Areas[13]	Yes	Yes	Yes

Footnotes:

1 A "Yes" or "No" 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 usually acceptable/unacceptable owing to variations in densities of people and structures. For heliports and stagefields, the takeoff safety zone is equivalent to the clear zone and the approach-departure zone is equivalent to APZ I for these land use guidelines.

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

3 Factors to be considered: Labor intensity, structural coverage, explosive characteristics, and air pollution.

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

5 Not permitted in graded area.

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 Concentrated rings with large classes not recommended.

11 Includes livestock grazing but excludes feedlots and intensive animal husbandry.

12 Includes feedlots and intensive animal husbandry.

13 Includes hunting and fishing.

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